Technology Mapping
for
Technology Management

The Development of a Technology Mapping Methodology for the assessment of the Technological Capabilities and the Technology Status in an Industry

and

its Application for Technology Mapping in the Sector of Dwelling Construction for Lower Income Households in Urban Tanzania and Costa Rica.

Emilia L.C. van Egmond – de Wilde de Ligny

Delft University Press, 1999

Series Design and Construction Management Delft are publications issued by the Section Design and Construction Management of the faculty of Civil Engineering and Geosciences of Delft University of Technology, the Netherlands. In these series of publications - to be used in research and education - various authors put forward and discuss relevant issues in the field of construction and design management.

Reeks Civiele Bedrijfskunde Delft is een serie publicaties van de sectie Civiele Bedrijfskunde, Faculteit Civiele Techniek en Geowetenschappen van de Technische Universiteit Delft waarin verschillende auteurs relevante onderwerpen rond de ordening van het bouwproces en het ontwerp proces voor gebruik bij onderzoek en onderwijs aan de orde stellen.

Reeks Civiele Bedrijfskunde Delft
Eerder is verschenen :
M.R. Behesti (red) *Handboek systematisch ontwerpen in de civiele techniek en Bouwkunde*, Delft, 1999

Technology Mapping
for
Technology Management

The Development of a Technology Mapping Methodology for the assessment of the Technological Capabilities and the Technology Status in an Industry
and
its Application for Technology Mapping in the Sector of Dwelling Construction for Lower Income Households in Urban Tanzania and Costa Rica.

Proefschrift

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus, prof. ir. K.F. Wakker
in het openbaar te verdedigen ten overstaan van een commissie,
door het College voor Promoties aangewezen,
op maandag 7 februari 2000, te 16.00 uur.

door

Emilia Leoni Christine VAN EGMOND – DE WILDE DE LIGNY
Bouwkundig Ingenieur

geboren te Amboina (Indonesie)

Dit proefschrift is goedgekeurd door

Prof.dr.ir. R.A.F. Smook	Promotor
Prof.dr.ir. E.J. de Bruijn	Co-promotor

Samenstelling promotie commissie

Rector Magnificus,	voorzitter
Prof.dr.ir. R.A.F. Smook,	Technische Universiteit Delft, promotor
Prof.dr.ir. E.J. de Bruijn,	Universiteit Twente, co-promotor
Prof.ir. R. Brouwer,	Technische Universiteit Delft
Prof. dr. S. Lall,	Oxford University, United Kingdom
Prof.dr.ir. H. Lintsen,	Technische Universiteit Delft
Prof. dr. A. Szirmai,	Technische Universiteit Eindhoven
Dr. P.E. Lapperre,	Technische Universiteit Eindhoven

Published and distributed by:

Delft University Press
P.O.Box 98
2600MG Delft
The Netherlands
Telephone: + 31 15 2783254
Telefax: + 31 152781661
E-mail: DUP@DUP.TUDelft.NL

ISBN 90-407-2009-6

Printed in the Netherlands

Table of contents

PART III The technology mapping studies in urban Costa Rica

PART IV CONCLUSIONS

List of Appendices

List of figures

Part I -figures

Part II -figures

Part III-figures

PART IV-figures

List of tables

Part I-tables

Part II-tables

Part III-tables

Part IV-tables

Acknowledgments

The results of the studies laid down in this thesis have greatly benefited from the support by a number of people. The research was carried out under supervision of Prof.dr.ir. Roger. A.F. Smook of the faculty of Civil Engineering of the Delft University of Technology and Prof. dr.ir. Erik.J. de Bruijn of the faculty of Technology and Management of the Twente University. To them I am greatly indebted for their ongoing stimulating and valuable advice. My colleagues in the faculty of Technology Management of the Eindhoven University of Technology, section of Technology and Development Studies headed by Prof. dr. A. Szirmai stimulated this thesis. Particular gratitude is for dr. Paul Lapperre and drs. Herman Gaillard who have been supporting my research efforts during the past five years. The origins of this research project can be traced to Prof.dr. C.B. Bertholet 's inspiring lectures on the issues of Technology and Development, during the time he was heading the Technology and Development Studies Group at the Eindhoven University of Technology. With Dr. J. Janssen of the Faculty of Architecture, Building Engineering and Urban Development I could exchange the experience of building engineering in developing countries.

Overseas numerous organizations and people have been of great help in data collecting for this research project. In Tanzania I am very grateful for the opportunity to collaborate with Mr. Mista Executive Secretary and the staff members Mr. Mamiro and Mr. Muhegi of the National Construction Council; Mr. Mgewno, director of the Housing Department of the Ministry of Lands Housing and Urban Development, the staffmembers of the ARDHI institute at the University of Dar Es Salaam and many others. In Costa Rica I received very valuable support and collaboration from Prof. dr. Ir. Rosendo Pujol of the faculty of Civil Engineering of the University of Costa Rica and his staff, Prof. Eduardo Paniagua of the CIVCO of the Instituto Tecnologico de Costa Rica and his staff among whom in particular Arch. Katya Blanco Paez and Ing.Ana Gretel Leandro H.; the staff of the National Bamboo Foundation among whom Arch Ana Cecilia Chaves, Prof.dr. Jorge Gutierrez, Ing Guillermo Gonzalez, the staff of the Ministry of Housing and Human Settlements, the Camera Costaricense de Construccion. Much could be learned from the experience of colleagues joint in the CBI's Working Group "Construction Industry in Developing Countries" chaired by Prof.dr. George Ofori.

I wish to express my indebtedness to all the alumni of the Technology and Society M.Sc. course in Technology and Development Studies who have contributed to this research project by means of data collecting during their M.Sc. research period in Tanzania and Costa Rica under my supervision, among whom Jan Buis, Miriam Derks, Bart Dankers, Caspar Esmeyer, Annemarie van Iwaarden, Ivo Jongsma, Arnout Orelio, Pascal Schreurs, Marten Treffers, Miriam Tegelaers, Jeroen Thielemans. Particular appreciation is for Saskia Rijkenberg, Martijn Vis and Jeroen IJgosse who have been my student assistant for a longer period of time. I highly appreciate and express my thanks to Aleid and Joost Veldman for their interest and very helpful feedback.

This work is dedicated to my family and my parents. Special loving gratitude to my husband, colleague and dearest friend Berend for his critical remarks and patient, unfailing, ever stimulating support. Gratitude and admiration goes to our children Marielle, Nicoline and Berend -Jan, who have been confronted with a mother who has been immersed in her work for a (too) long period of time. Last but not least I would like to thank my parents who have been the first and most stimulating people during my whole life.

Emilia L.C. van Egmond-de Wilde de Ligny
Eindhoven, november 1999

Executive summary

The subject matter of this thesis is the status of Technological capabilities and Technologies in production sectors in countries.

This research project was initiated upon the curiosity regarding the particular role of technological capabilities and technologies in the international race for competitiveness of production sectors that should contribute to economic growth and societal development in a nation. International developments gave way to further thinking about the paths to be taken to reach sustainable development goals in countries. The present pattern of globalization leads to an increased international competitiveness to survive. At the same time the recognition of an increased international interdependence has grown rapidly. The recognition of this last aspect was even intensified by the consciousness of a worldwide dependence on the same limited resources that are being exhausted if no preventive actions are taken. Literature showed a particular concern for the specific role of technologies and technological capabilities in processes towards economic growth and societal development. (Bell 1984, Fransman 1984, Lall 1982, 1987, Rosenberg 1986)

The concept of Technological Capabilities is a rather new. Theoretic views -that emerged only since the last two decades -point at the crucial role of technological capabilities for the competitiveness of industries and nations. Adequate Technology Management and Policy making was recommended for an increased competitiveness and socio-economic growth. (UNESCAP 1989) The conclusion was that mapping of the technological capabilities and the technology status in production processes makes sense. The data derived from the mapping studies should support technology management and policy interventions to guide the production performance in the sectors into the desired directions.

The *objective* of this research project was to arrive at a generally applicable methodology to map the status of the technological capabilities in an industry and the technologies in production processes. This so-called Technology Mapping Methodology should represent a useful management tool for technology management and policy making.

The *target groups* for whom the results should be relevant include (a) the management of enterprises and (b) policy makers at sector, national and international level.

Literature studies revealed that the conventional mono-disciplinary approaches which are used in the studies on the performance of production sectors do not give a detailed insight in the status of the technological capabilities and the technologies in production processes. The concepts are complex and require a multi disciplinary approach. (part I chapter 1)
Therefor the decision was made to attempt to develop a *methodology for technology mapping* based upon further extensive literature studies. The analytical framework for *technology mapping* was derived by synthesizing the relevant elements of a number of analytical frameworks utilized in studies of various disciplines. (part I chapter 2) The suitability and general applicability of this methodology in any production sector has been a major pre-requisite. It needs no further explanation that the methodology for the investigation of the magnitude and nature of technological capabilities and the technologies applied in production

processes has a multi-disciplinary character. It also requires a *strong input from the engineering sciences.*
Despite the general applicability of the research frame work in any industry, the *operationalization* of the theoretic framework of the developed technology mapping methodology needed adaptation to the particularities of the industry that is under investigation. This has been elaborated for the construction industry. (part I chapter 3)

The *application of the developed methodology* has taken place in the dwelling construction industry in Tanzania and Costa Rica. The objective of the application of the technology mapping methodology in Tanzania and Costa Rica was twofold. In the first place usefulness and validity of the research framework and the developed measuring instruments had to be evaluated. Secondly, it was expected that the results of the field application point at strength, weaknesses, opportunities and constraints in the present technological production performance of the dwelling construction industry in the countries. This information was expected to support adequate recommendations for technology management focused on the improvement of the technological production performance in this sector.
The reasoning for the selection of the dwelling construction industry in the mentioned countries can be found in the unfavorable housing situation for a large part of the population in developing countries like Tanzania and Costa Rica. The construction industry is a major supplier in the housing delivery system. The technological capabilities in the sector and the technology utilization in the construction projects are considered to have an impact on the technological production performance of the construction industry. Technological Capability Building is expected to contribute to an improved technology utilization and production performance in the dwelling construction industry to the benefit of the housing situation for particularly the lower income households in the countries

The *application and evaluation* of the research methodology in the dwelling construction industry in Tanzania and Costa Rica took place by the execution of several field studies in a period of four years. Adaptations to the basic research methods could be made where necessary during this period. The strength and weaknesses of the technological capabilities, the technology status and the technological production performance in the dwelling construction industry for the lower income households in urban Tanzania and Costa Rica could be identified in a comprehensive way.

The *conclusion* from the studies is that the roots for development in both countries can be found in the potentially available technological capabilities. This insight gave the opportunity to formulate recommendations to devise Technology Management at project- and enterprise level and Technology Policies at national level focused on Technological Capability Building. The major recommendation to the Tanzanian dwelling construction sector is that it should thrive on the potential of its rich stock of not exploited natural resources for its development. The development of the Costa Rican dwelling construction industry obviously has the possibility to find a solid base in its relatively highly educated human resources stock. The actual utilization of these means to improve the dwelling construction performance only can take place provided that the national setting is supportive. (part II and part III)
A comparison of the results of the Technology Mapping studies in Tanzania and Costa Rica led to conclusions that support the various hypotheses with regard to the performance of the construction industry in developing countries in a detailed manner.

A remarkable conclusion could be drawn, although this research project was limited to an investigation in two countries: *the ratio between the national development status in the two countries –expressed in the Human Development Index (HDI)- appeared to be in line with the ratio between the indices for the Status of the Technological Capabilities (STC) and the Technological Production Performance (TPP) in the dwelling construction industry.* No comprehensive empirical evidence on this was found elsewhere in literature. (part IV chapter 1)

The comparison of the findings of this research project with the existing literature on the construction industry in developing countries indicated that the findings of this study comply with the general statements in literature on the performance of the construction industry: the efficiency and effectivity of the construction industry in many developing countries is below expectations. There is a lack of progress in this situation, thus action is required at corporate, industry, national and international level. A problematic housing situation and the limited output of the construction industry -such as delineated in the publications- was also found in Tanzania. Compared to Costa Rica the results of this research have shown that this country has been able to make a move forwards in the alleviation of the housing problems.

Literature further indicated that -as far as could be noticed - most studies covered the various aspects of the performance of the construction only partially. The result of this has been that recommendations for improvement of construction activities addressed only single aspects. Many factors and actors in production sectors appear to be interrelated. This necessitates a management and policy making that address the various deficiencies in the construction industry in an integrated way. The Technology Mapping Studies are found to be useful for this purpose.

Evidence of the *usefulness* of the developed methodology could be noticed from the achievement of the second objective of the field application of the Technology mapping methodology. The technology mapping studies gave valuable information on the performance of the construction industry. With the developed methodology in this research project a contribution could be made in lifting the lid of the black box that is generally named technology in production systems The information from the technology mapping studies is complementary to the data derived from the generally applied socio-economic analyses. (part IV chapter 2)

Socio-economic data sets are generally extensively available in contrast to the technological datasets. This research project has highlighted that a data set on technological capabilities and the technology status in production sectors is indispensable for proper technology management and technology policy making in enterprises, sectors and countries. It is therefor strongly recommended to establish and maintain technological data sets for every sector in every country equal to the socio-economic data sets.

This implies that it thus is relevant and important to carry out Technology Mapping Studies at country and regional level on industries -like was done for the construction industry- with the objective to identify the technological strengths and weaknesses, opportunities and constraints for development. These studies have a multi-disciplinary character with a strong emphasis on the engineering sciences. This means that scholars with various disciplinary backgrounds should collaborate and bridge their disciplinary borders to achieve a uniformity in the collection, analysis and interpretation of the data (questionnaires/ interviews, observations and scoring keys) by using the same research methodology.

It is a challenge to engineers and technologists to fulfill a leading role in these studies.

Part I

I

research design

tanzania

costa rica

Research design

Contents

Chapter 1

Research on Technology: a survey of relevant literature

1.1 Introduction

This research project addresses the mapping of the technological capabilities and technologies in production sectors in countries.

The *origins of this study* can be traced in the curiosity for the role of technological capabilities and technologies in the competitiveness of enterprises and the socio-economic development of nations.

Political and academic concern for the dynamics between technology and societal development increased after World War II [1] The recognition of a worldwide international interdependence grew rapidly. On the other hand -although this may sound contradictory- an increased international competitiveness to survive could be noticed, at least in terms of economic survival. The recognition of these aspects was even intensified by the consciousness of worldwide dependence on the same scarce and limited sources of raw materials, that are being exhausted if no preventive actions are taken. The majority of these natural resources are provided to the international market by the developing countries. These countries have the most problems of economic growth and sustainable societal development. The above points gave way to further thinking about the paths to be taken to reach sustainable development goals in countries.

A number of interrelated factors are mentioned in literature that form the basic arguments for socio-economic growth. A particular concern was indicated for the specific role which technologies play in the processes towards sustainable societal development. (Lall, Rosenberg, Stewart, and others)

[1] The interests of politicians and academics in processes of rehabilitation, societal development and economic growth were enhanced by the great depression in the so-called industrialized countries after World War II. After independence the former colonies became more and more conscious of their problems of getting across a certain backwardness, which led to a desire for increased economic growth and development, following the examples of the rapid growth in industrialized countries during the first decennia after the World War.

Technologies utilized in production processes and the new concept *technological capabilities* are mentioned as important elements for competitiveness of production sectors and societal development in a nation.(Bell 1984, Fransman 1984, Lall 1982, 1987and others)
Adequate *technology management and policy making* was recommended for increased competitiveness and socio-economic growth. (UNESCAP 1989) This on its turn requires insight in the role of technological capabilities and technology in production sectors.

Mapping of the status of the technological capabilities and the technologies in production processes is thus considered an important prerequisite to get a better understanding of what is going on in the production sectors and to what extent they contribute to societal development. The opportunities, problems and constraints for further improvement of the existing production performance become evident once the actual situation is mapped. The data derived from the mapping studies should render the information that is needed for adequate technology management and technology policy interventions to guide the technological and socio-economic developments in the desired direction. It thus makes sense for the benefit of technology management and technology policy formulation to get hold of an adequate methodology for technology mapping.

The ***objective*** of this research project is to determine a useful methodology to map the major characteristics of the technological capabilities and the technologies that are used in production sectors in relation to their contextual environments.

The *major* ***research question*** that is addressed in this research project is:
Which research methodology is usefull for technology mapping ?

The basic *research question* has been divided in the following *sub-questions.*
1. *Which useful methodologies (theoretical viewpoints and empirical application) can be found in literature for technology mapping in production sectors*?
2. *If not: Is it possible to develop a research methodology for technology mapping that is generally applicable in any sector*?
3. *If not: How to fit the basic research methodology to the particularities of a sector like for example the dwelling construction industry*?

Subsequently the determined technology mapping methodology has to be tested upon its usefulness and validity. This took place in the dwelling construction sector in urban Tanzania and Costa Rica. The *research questions in those parts* of research are the following.
4. *What are the results of the field application of the developed technology mapping methodology in the dwelling construction sector in urban Tanzania?*
5. *What are the results of the field application of the developed technology mapping methodology in the dwelling construction sector in urban Costa Rica?*

At last the *final research question* is raised.
6. *Which conclusions can be drawn on the usefulness of the developed technology mapping methodology for the purpose of technology management and technology policy formulation in a sector like for example the dwelling construction sector* ?

A number of sub-studies have been carried out to answer the research questions. The results of these are described in this thesis. *The text is divided in four large parts.* The first is a theoretical part, that describes the research design. The second and third are two empirical parts in which the results of the field application of the developed methodology for

technology mapping in Tanzania and Costa Rica are described. The last part describes the evaluation and conclusions of the application of the technology mapping method.
The first theoretical part of the thesis exists of three chapters. The first chapter introduces the origin and objectives of the research project and describes the findings of an extensive literature study on technology related research. The second chapter describes the development of a research methodology for technology mapping. In the third chapter a description is given of the adaptation of the general methodology to the particularities of the construction industry. The last is necessary for the application of the technology mapping method in the dwelling construction industry in Tanzania and Costa Rica.

In the following sections of this first chapter the findings are described of the literature survey on *research on technology related to socio-economic development.* This was carried out to be able to answer the first research question regarding the existence of a useful methodology to investigate the role of technology and technological capabilities in production sectors. The search focused in particular on a theoretical framework that should be generally accepted, appropriate, well founded and coherent. This theoretical framework should function as a useful basis for systematic standardized comparative research on the status of technological capabilities and technologies in production systems in their sectoral, national and international environments.
Technology related research happened to have been carried out in various disciplines like sociology, economics and engineering sciences. Diversity in theories and starting points was found between and within the different approaches. Apart from the mono-disciplinary studies also multi disciplinary research was carried out on technology related to socio-economic development.

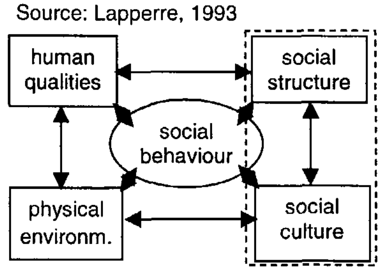
1.2 Technology in Sociological studies

A. Theoretical views

Technology as such has not been a major focal subject in sociological studies although a number of scholars have made attempts to analyze the interactions between technology and societal change.

fig 1.1 Social Interaction

Source: Lapperre, 1993



The main focus of the sociological studies is on changes in societies that are considered to be induced by human actions and interactions. A basic concept is the *social system* that is considered to be composed of a related body of *structural and cultural elements* (deJager & Mok, 1989)
These are grouped together in *institutions (*like the political-, the economic and the educational institution). Each institution has a function and a certain degree of stability, durability; an element of sanctions and cognitive aspects. The institutions are embedded in a *physical environment* and are dependent on the congenital and acquired human qualities of the community. The *social behavior* is specified per institution.[2]. It is determined by the social functions that have to be

[2] *Institution"* is defined as a more or less complete, legitimate, permanent, stabilized, collectively accepted, set of structural and cultural formal rules as well as collective social behavior that determines the ways on which and the means with which specific functions in society are being fulfilled. (Lapperre 1990)

fulfilled within a society The *changes in a society* are seen as changes in a more or less standardized social behavior, enhanced by changes in the structural and cultural elements of the social system. (Lapperre, 1993)

There are *three major sociological lines of thought* on the interrelationship between technology and society:

a. Technology and technology developments are the prime movers for socio-cultural changes (Schumpeter 1934) Technology in these views is an *independent* and *autonomous* factor in society. Basic sciences, research and development result in technology development, which is the cause of societal changes. (Ogburn and Nimkoff 1964, 571-5, Lynn White 1978 and Large 1980). See appendix I-Box 1
b. Technology and technology developments are a resultant of societal forces. (Ogburn & Thomas 1922/1990; reference is also made to the Social Construction of Technology Approach by authors like Bijker, Callon, Latour,Law, Rip) See appendix I-Box 2.
c. The total social system as such, including the technology system in here is determining for the characteristics of technology in production systems in their societal context. See appendix I-Box 3

The last views are developed around ideas of a technological paradigm (Constant 1980, Dosi 1982) and a technological system. (Hughes 1971, 1986, Rosenberg 1976).
Technology from this point of view is seen as a separate institution in the societal system. It then is seen as a systematized, formalized, standardized, coherently applied totality of insights and knowledge regarding the ways and means to reach human objectives in their broadest sense which are accepted in broad circles of society. (Bertholet 1990)
Reality seems to support the last hypothesis: whilst technology can be seen as an essential element in societal development, at the same time it should be recognized to only play a partial role in societal development processes. (Hughes 1987, Constant 1980, Dosi 1982, Rosenberg 1986)

B The empirical application
Literature indicates a long tradition of empirical studies on the impact of technologies -in terms of mechanization and automation- on aspects as employment, labor markets and organizational structures in industries. These studies are carried out by industrial sociologists and those occupied with the sociology of employment and organization. (reference is made to authors like Woodward, Thompson, de Sitter, Kern & Schumann) But Van de Ven and Angle (1989) state that there is no substantial evidence about the explicit nature and extent of technology development over time and its effects on society. This forms a constraint for technology management and policy interventions that are meant to direct the technology developments towards the desired changes in society.

Conclusion
The *conclusion* -that is also mentioned by authors like Koonings and Kruyt (1988). - is that the position and specific role of technology and changes in social systems is still a point of discussion in many sociological theoretical debates on societal development. As far as could have been investigated technology as such has remained a black box in sociological studies. The real nature of technology in production systems remains vague.
Nevertheless the basic sociologist's viewpoints on societies as systems in different levels of aggregation make it possible to analyze the systems or at least to describe their performance. This refers to the description of the performance of the different institutions in the social

system in terms of the characteristics of the elements structure, culture and interactions. These viewpoints are considered useful in this research project. This may facilitate the investigation of the *societal setting* in which technologies are utilized and developed at macro-, meso and micro level of the societies on a systematic basis in diachronic and synchronic perspective.

1.3 Technology in Economic studies

A. *Theoretical views*

Economic studies focus on the analyses of economic decision making and economic processes of production and distribution of goods and services to provide for human needs in a society. (Heertje,1973) Scarce and limited means for processes of production and practically unlimited human needs for goods and services make adequate selection and decision making necessary.

The recognition of the concepts of technology and technology development goes back to the 18^{th} century and has been important for the explanation of the production performance of industries and nations. (Adam Smith, Ricardo, Marx, Schumpeter). An important part of economic studies has been directed to the contribution of technology and technology development to economic growth (see Abramovitz 1956, Solow 1957, a/o.). Various scholars have attempted to outline the history of technology utilization and technological change related to economic growth of nations, trying to indicate the causes, effects, pre-requisites, advantages and drawbacks. (Schumpeter 1934, Marx and Engels 1970, Caldwell 1984, Rosenberg 1976/1982).

Until the late seventies the economist's explanations of profitability and economic growth were based on the *neo-classical theories*. These theories put an emphasis on the behavioral assumptions, which are mathematically formalized in theoretical models to be able to analyze economic growth phenomena. The basic assumptions included (a) the substitutability of input factors capital and labor and (b). the higher the ratio between capital and labor the more advanced technology is used in production. Authors like Rosenberg point at the fact that the last assumption is not always true. (Rosenberg 1986)

After the seventies studies on economic growth and the possible effects by technological developments show a shift from the theoretic orthodox economics, towards a rather new approach emphasizing empirical observation in order to get hold of the dynamics. (Nelson and Winter 1982).
In this so-called *evolutionary economic theory* growth is associated with changes in trade and the selection environment. These changes are considered to take place suddenly and unexpected in contrary to ideas of a balanced economic growth like was supposed in the neo-classical views. See appendix I box 4.
Moreover in the evolutionary theories *technology developments* are not seen as the big inventions only, like in the neo-classical views but more as incremental technology developments which may be generated "on the shop-floor" by the firms that use the technologies in their production processes. The concept of *Technological Capabilities* was recognized as an important factor to capture and maintain a competitive position in an global environment with an increased international competitiveness. (Bell 1984, Fransman 1984, Lall 1987).

Verspagen (1992) states that the evolutionary theories offer a broader view on what is really going on in production systems then the neo-classical theories. The theories are more open to inter-disciplinarity in the analytical approaches.
Duysters (1995) argues that -although promising- the evolutionary theory is still considered to be in a development stage. Various new viewpoints, conceptual definitions and approaches have been introduced from different levels of aggregation (national-, sectoral-, organizational-artifact level). But these can be rather loosely interpreted in different ways. This forms a constraint for a uniform explanation of the role of technology in economics.

B. Empirical applications

The economic evaluation of the *contribution of technology on economic growth* at national level and profitability and competitive production at micro level basically rests on two popular approaches. This type of assessment uses data which are easily available.

1. The *production function* approach, which is based on the concept of substitutability of the production factors. Technology developments are measured in terms of the dynamics of the production function over time. (Amann, Cooper & Davies 1977, Blumenthal and Teubal 1979, Nelson 1982). See appendix I box 5.
2. The *value added* approach, which is based on the computation of the economic value added at a production unit and the subsequent attempts to make interpretations with regard to technology utilization in the production unit by using series of value added based ratios.

Other economic assessments have been and still are using multiple indicators for the technology status, which require substantially more data. The parameters that were used -for example- in this type of studies include: (1) gross expenditures on R&D, (2) R&D % of the value added, (3) R&D per capita, (4) R&D % of sales, (5) share of patents, (6) share of publications, (7) patterns of foreign trade in products - MVA in exports (8) dates of first production of key technologies, (9) rate of diffusion of technologies, (10) pattern of diffusion of technologies in various branches, (11) data on available key items of equipment, (12) technological balance of payments.(Amann, Cooper & Davies 1977, 1982; Patel & Pavitt 1987, Freeman 1987, ESCAP- vol4 1989).
But discussions among economists raised a number of comments concerning the interpretation of the data. These interpretations should depend on the conceptual definitions and basic hypotheses that are used. Consensus is not always present with regard to the basic theoretical starting points, the views rather show opposite ideas. Schmookler (1966) -for example- indicated the market demand (market pull) as major promotional force for technology development, measured through patent statistics. Others favored the ideas of "technology push" following the Schumpetrian ideas measured through R&D investments.

Stewart put forward that measurement problems may occur due to (a) the non-uniformity of the definition of capital, capital is non-homogenate (b) the utilization of monetary values in the analytical framework. For example the *value added computations* may not realistically reflect the technological characteristics since the imperfectness of the economic environment (shadow prices, subsidies) induce price fluctuations. (Stewart 1974) Authors like Rosenberg (1986) mentioned that wrong assumptions were made. This refers for example to the fact that more advanced technology is not necessarily more expensive in terms of fixed assets per employee.
Also the life cycle of the technology influences the input of capital in production. The result is that the explanatory power for the technological causes of the production performance differentials is not very high. (McKean 1968, Pearce & Nash 1981, Stewart-UNIDO 1978)

Conclusions

The economic methods applied in empirical studies are considered useful to evaluate the performance of the productive activities in terms of productivity at micro, meso and macro level.

Macro-economic data analyses on production are useful for the indication of the macro-economic setting of the technologies that are used in production systems.
The notion of the *production function* has been fruitful for an increased understanding of certain phenomena such as the relative income shares, unemployment and some of the factors that influence economic growth. For example the analyses of the labor market situation from macro-economic perspective gives a marginal insight, while additional micro-economic data with regard to the effects of technology development on labor, individual enterprises and sectors might enlighten the insight in the phenomena.

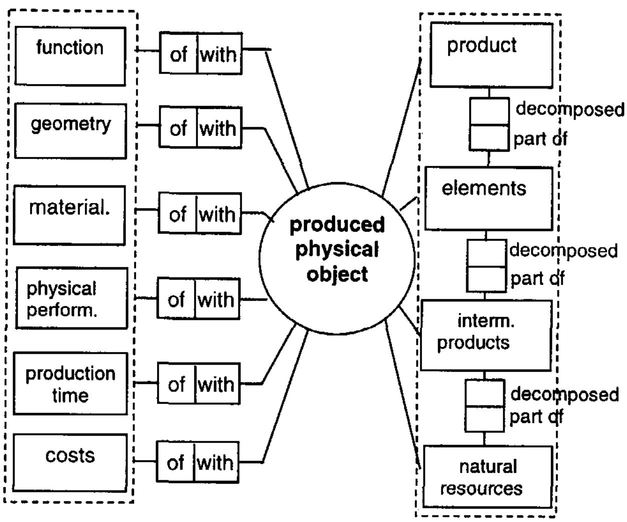
But the methods give no explanation for the differences in production performance from *technological* point of view. No specific answers were given on the nature of the technologies and technology development, indicating their technological efficiency, functionality, effectivity in meeting the terms of reference in technological sense. These can only partly be indicated, analyzed and interpreted through the use of the economic methods and theories.
Rosenberg put forward that generally the input factors and the output factors of production processes are measured but what happens in between remains a black box. When one would like to know more about the phenomenon of technology utilization and technological change itself, then the basic concepts of the economic theories are less helpful. (Rosenberg1986).

1.4 Technology in Engineering studies

A. The theoretical views.
Research on technology in the engineering sciences is carried out with the objective to determine - out of a range of technological solutions - (a)the products with particular product-technological features that effectively respond to a certain set of specifications and (b) the most efficient and effective ways for the production of these products. The studies thus are of a more practical than theoretical nature.
The theoretical basis of research on technology in the engineering disciplines can be found in the natural sciences and mathematics.
The basic concepts in the engineering sciences are the technical specifications of the products and production processes.

The *specifications or terms of reference for the products* are generally a combination of requirements for the products, which are set by the customers in the market, by the designers in the preparatory phase of a product development trajectory, by the engineers and the consultants for particular aspects of the products and by the managers in the decision making processes in a production unit (enterprise). This combination of requirements is generally laid down in documents such as (standard) product specifications, and drawings of basic details of the product. The specifications of the product describe the product's technological characteristics regarding the product's function, geometry, materialization, physique-technical performance, production complexity and costs. (ISO-TR/1994) Each product is composed of parts that can be seen as products of foregoing production phases. (See figure 1-2 right column).

fig I-2 Product technology components Source: ISO-TR 1994



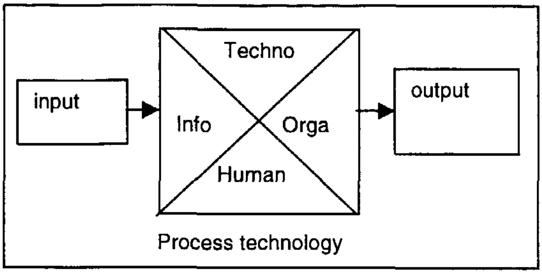
Products are the output of processes of attuning the specification of the market demand with technologically feasible solutions

During production processes the inputs like natural resources and intermediate products are transformed into the desired production output in a certain production environment.
The *transformation processes* comprise a totality of determined actions, which are various treatments of the natural resources and intermediate products. These treatments can be classified in separate mechanical, physical and chemical processes or a combination of the three. The production process takes place with the application of *process technologies*. The production process technologies are composed of a complex of inextricably interrelated process technology components: Technoware (equipment, tools, machines), Humanware (manpower), Infoware (documented facts) and Orgaware (organizational framework). (ESCAP 1989)

Tools and equipment are applied to substitute and reinforce human power to carry out the job. Human energy is transmitted via a tool or through equipment to reinforce the energy for the execution of a transformation or replacement task. In fact production involves "a determined application of energy" to transform or replace an artefact. Daily evidence shows that through the application of the engineering sciences man in the course of time has been able to withdraw his own energy completely from the production activities, by making use of either natural or "artificial" sources of energy.

A certain extent of *control of the production process* is required to be sure that the production output meets the product specifications. Control of the production process can be achieved by guiding, fixation of the tool that is used in the right direction or by application of a cutting off valve or a rebate. This can be done manually, mechanically, hydraulic, electric and electronic. The last cases involve the utilization of machines. The difference between *machines* and tools is that a machine is a tool constructed with many different components (individual tools). The machine is expected to yield a qualitatively and quantitatively better production output than the simple hand tools that only substitute human energy. A machine can also substitute *human control of the action*. Human power or energy is even nearly excluded in some machines.

fig I.3 Process technology in the production system
Source: ESCAP 1989



In the course of time the products -desired in the market- required production process technologies with an *increased complexity*. In contrast to this, the requirements for the skills and knowledge of the labor force in the production process could have been reduced by the application of information and documentation systems of increasing advancement coupled to the more advanced production equipment.

The specification of the production process technologies is determined by the terms of reference for the product technologies. Still the specified products can be produced in various ways. This means that it will be possible *to identify a range of production process technologies* that can be applied to produce the required product. It is possible to distinguish a gradual optimum of the range of process technologies: (1) theoretic –technical optimum, set by engineering variables (2) economic optimum set by macro economic variables, (3) market technical optimum set by affordability and willingness to buy in the market (4)operational optimum set by labor skills, (5) process technical optimum set by the availability and level of process technologies tools, equipment and information. The range of process technologies indicates the boundaries within which the production of the required products can take place.
The above delineates the theoretic lines of thought along which the engineering studies are carried out in order to determine the best practice products and processes to meet the market demand. The analytical framework in the engineering studies is complex. During the studies generally three categories of (clusters of) variables are taken into account: (1) *engineering variables* (function, physique-technical features of the materialization like velocity, temperature, volume, geometry), (2) *intermediate or physical* variables (like pieces of equipment), (3) *economic* variables (economically valued physical inputs like labor, capital).
In practice it is the entrepreneur who finally selects the process technology for the production that meets the market demand as efficiently and effectively as possible. This happens in general by carrying out engineering analyses on the range of alternative production processes, taking into account the availability of production factors, versus the costs of the different alternatives. The economic criteria often set the ultimate boundaries for the selection of the technologically optimal production process that is going to be applied.

B. The empirical application

The engineering analyses take place at micro level or even at artefact level.
Ex-ante engineering analyses of technology result in technological solutions for societal problems or market demand. These analyses form the basis for the final design of an object or service.
Ex-post engineering analyses on the efficiency and effectivity of the existing and utilized ranges of technologies give useful insights and understanding of the technological features of the technologies in use in the production systems in a country. Technologies can be described into physical detail, which gives an advantage to the statistical approaches used for the planning of production activities.

The pure engineering studies utilize uniform, generally accepted neutrally defined engineering variables to offer a range of alternative technological options for evaluation upon usability This means that the results tend to be *non-sensitive to the prevailing economic condition in any area* covered in the study. Compared to economic analyses of production processes the basic engineering data have a wider applicability across the different nations. Inter-country difference in structure of relative prices can then superimpose on the basic physical universally applicable data for final economic evaluation of the real alternatives. In practice the results of the engineering studies are directly inter-linked with the societal terms of reference to make the ultimate choices for the technologies to be used. This exercise is generally carried out by the engineers and technologists themselves based on the data acquired from the sociologists, economists, marketing experts, etc. In the majority of cases the cost aspect prevails as dominant indicator of societal feasibility.

Conclusions

The engineering analyses are considered useful in investigations on the explicit nature and meaning of technologies in production sectors.

Through engineering analyses technologies can be described into physical detail, which gives an advantage to the statistical approaches that are in use for the planning of production activities. The results of the pure engineering analysis (that leave out of consideration the socio-economic valuation) have a universality for application.

A disadvantage of the engineering approach in the evaluation of technologies in their societal context is the necessity of an extensive engineering data set. Economists and sociologist generally apply technology indicators in a more aggregated form.

1.5 Technology in Multi disciplinary studies

Literature showed that in the course of time a reasonable deal of multi disciplinary studies was carried out. Mono-disciplinary scientists have started working beyond their own disciplinary boundaries. The basic theoretical foundation of most multi disciplinary studies is to be found in one or two monodisciplines. The studies can be classified in: (a) engineering based studies, (b) economics based studies, (c) production management studies, (d) comparative production performance studies and (e) science and technology studies. In empirical studies attempts are made to merge the variables of the mono-disciplines with each other. The *major aspects and conclusions* of the literature study on technology related research with a multi disciplinary character are given below.

a. Engineering based multi disciplinary studies.

Engineers and technologists in practice merge the engineering variables -that are applicable to their technical solutions and based on the *theories of the engineering sciences*- with the socio-economic variables to sort out the feasibility of these technological solutions.

In the *empirical application* the technical solutions are placed within the socio-economic context in which the technology is to be applied. In the past numerous examples of western technologies that are applied in developing countries have illustrated the difficulties to offer at the right time and location the right technological solutions that meet the actual demand. The complexity of the socio-economic environments -in which the technologies are to be used- and the variety of factors that have to be taken into account requires a thorough insight and knowledge of the socio-economic forces that have an impact on the technology utilization in production processes. Engineers therefor have to collaborate with social scientists like sociologists, economists, and anthropologists.

b. Economics based Multi disciplinary studies.

In economics based multi-disciplinary studies engineering analyses were applied to find physical explanations for phenomena like economies of scale and factor substitutability (Chenery 1949, Moore 1959, Pack 1974). The *theoretical basis* is to be found in the economic theories of factor substitutability to explain the phenomena like profitability and economic growth.

In the *empirical application* the engineering analyses were applied predominantly to the single continuous type of production process and others with fairly standardized continuous techniques of production. Production processes with a more discrete multi-stage character required too complex analyses. In the course of time a number of studies were carried out with the intention to make further methodological developments and extensions to the original Chenery method. These studies include a number of (1) input-output engineering studies, (2) studies on factor substitutability in discrete processes, (3) technology progress studies, (4) technology choice studies, (5) technologically based studies, (6) engineering type studies (Pack, H 1974). See appendix I boxes 7-12.

Conclusion: According to Whitehead (1990) the extensions and developments made to the Chenery ideas in all these studies illustrated the difficulties that generally occur to materialize new methodological developments. The complexity of the technologies in particular in multi-stage production processes formed a hindrance for the application of a more generalized technique such as an engineering production function approach.

c. Production management studies.

The *theoretical basis* in production management studies is to be found in the assumption that improved production performance in terms of (technological) efficient and effective production management can be associated with *firm level* economic profitability and competitiveness.

In the *empirical application* of this assumption the technological features of the production system in terms of engineering variables are generally merged with the economic variables like value added per employee, per unit of employee compensation, per unit of gross output and profit as proportion of the value added.(Chase & Aquillino 1992.). The studies take place at enterprise level

Conclusion: The focus of these studies is on the management aspects of the production performance.Though useful these studies only partially give an explanation of the performance of individual production systems. The real nature of technology in use in the production system is generally not addressed.

d. Comparative studies on the performance of production systems

In a variety of separate studies, attempts were made to gain an overall insight in the various actors and factors that can have an impact on the organizational performance. This took place by *comparative investigation of production systems* in a country at different levels of aggregation (micro-, meso and macro level). The objectives of this type of studies have been the following. (a) the identification of the major variables and the correlation between these to explain the performance of organizations and production systems on sectoral, national and international level and (b) the improvement of the competitiveness of organizations, sectors and nations. The studies had an explorative nature. The major interest in this type of studies is on the existence of a correlation between the variables.(van der Zwaan 1984).

The *theoretical basis* for the studies can be found in the assumption that the structural (organizational positions and structure) and cultural aspects (norms, standards, policies, regulations) of the organizations and their environment have an impact on the production performance of the organization. An improved production performance in terms of (technological) efficiency and effectivity is associated with economic profitability and competitiveness at *sector and national level.*

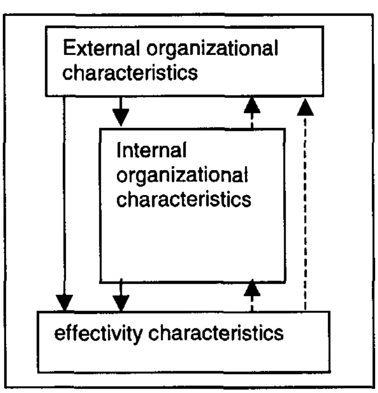
By comparison of the organizations it becomes possible to distinguish a coherence between the particular characteristics of organizations. Statistical techniques like multi-variate analyses and factor analyses make it even possible to trace causalities between the characteristics (van der Zwaan 1984).

The *analytical frameworks* are necessarily a combination of those applied in sociology, economics and industrial engineering. Technology as such however remained a black box. The studies deal in majority with the firm level organizational aspects. A relative extensive data set is necessary. These data are collected with series of subsequent studies at different levels of analysis. Different research methodologies are used that are basically derived from sociology, economy and (sometimes) the engineering sciences The variables that are investigated show a broad variety. Each study had its individual analytical tools that were considered to contribute to the understanding of the performance of the production system under investigation.

The type of comparative research on the functioning of organizations in their sectoral, national and international environment has been applied on large scale in the past decades. A large number of organizations have been investigated in the course of time in this way. In the beginning the studies have been executed in a rather scattered way on ad hoc basis. The approach in the research was primarily at micro level or enterprise level, after which the data were placed in the sectoral, national and international environment in which the production takes place.

Most of the comparative studies gave a general profile of the organizations. The research generally is limited to a cross section of a totality of aspects in a certain group of organizations at a certain moment of time. No indication is given of the process of any changes of and in the organizations over time. Criticism has also been put forward on the *lack of a theoretic foundation* in these studies: an appropriate theoretical framework that could function as a useful basis for systematic standardized comparative research on the functioning of organizations in their particular sectoral, national and international environments was missing. Only since late seventies more structural systematic multi disciplinary studies on production sectors were carried out. (Bertholet & Gaillard 1978)

fig I-4 Organizational performance
Source: Bertholet & Gaillard 1978



Based upon an extensive literature survey on comparative studies of production systems Bertholet & Gaillard (1978) designed a general model in which the major variables which play their impacting role of the effectivity of the functioning of organizations in comparative perspective were indicated and operationalized. The role of technology was only mentioned as an integral part of all organizational elements in this model. The elements were expected to contribute to the effectivity of the organization. The *empirical application* of the theoretic model has taken place in a number of field studies in various sectors and in various countries. Predominantly the socio-economic variables were investigated empirically. In the course of time the research instruments could have been adapted and improved. The technology status is only indicated by taking indicators like production complexity, rigidity and energy requirements.

In a number of comparative studies of organizations, sectors and nations the *evolutionary economic theories have formed the basis* to investigate the performance of national and sectoral production systems with a focus on their effectivity and international competitiveness at supra macro- and macro- level. The particular conditional factors of the environment that have an impact on the competitiveness of production systems and the nations in which these are located are specifically taken into account. (Porter (1980, 1985, 1986,1990), Freeman, Lundvall (1992), Nelson (1991), Rosenberg(1991), Justman and Teubal (1991), Teubal(1996)).

Porter brought together a number of variables that exist in the interrelated network of the so-called Porter Diamond. These models are being taken over by a number of researchers now-a-days and offer a seemingly useful framework for the analysis of the current situation in industrial sectors (see for instance Jacobs, SMO, 1992). Technology still is treated as a black box in these models as well.

The *empirical application* of these theoretical views takes place on a descriptive basis and the focus is on the socio-organizational characteristics that should include the technological, financial and managerial features of the organizations. The used parameters do not really reveal the nature of technological progress in terms of technical specifications of products and processes from technological point of view.

The type of *systems approach of production systems* is presented in the methodologies developed by UNESCAP (1989). Scholars joint in a project of the UNESCAP organization designed a framework which indicates explicitly the concepts of technological capabilities, technology status in production, production performance and national development targets. The *theoretic foundation* is rather deterministic and finds its origin in the engineering sciences for the analysis of the technological variables as well in the economic evolutionary theory. Thereby the variables of the socio-economic environment of the production systems, which are considered to have an impact on the production performance are taken into account. The objective of the UNESCAP project has been to indicate the importance of the state of art of technological capabilities, technology utilization and technology changes for socio-economic development of nations. The next objective has been to determine the technology gap that needs to be bridged in order to catch-up in the international competitiveness race. The findings are considered useful for a contribution to the formulation of technology based policy and management plans. (UNESCAP 1989).

UNESCAP scholars carried out studies to elaborate the concepts, determine sets of variables for the concepts and operationalize these. The analytical tools are necessarily of multidisciplinary nature for the measurements of technology and technological capabilities related to competitiveness. This method as far as could have been traced is the only one which addresses the interrelated aspects of technology, technological capabilities and societal development in a comprehensive manner.

The *empirical application* of such a comprehensive model has shown to be rather difficult, although little evidence is found of the application of the model. The one which was encountered in this literature survey has been a study by Westphal cs. in Thailand (1991). A number of statistical bottlenecks were mentioned by them in their evaluation of the study. Westphal criticized the method upon its shortcomings, by putting forward that the important means for systematically incorporating the findings from the microscopic research to identify the key capabilities at macro level is missing. Problems rose by investigating and comparing the technological capabilities in various sectors at a too high level of aggregation. The consequence is that an overall science and technology policy making at national level is a troublesome exercise. It was put forward that although microscopic research is an expensive and extensive activity it is preferred for the time being to gather enough data that can be aggregated to a higher level for policy purposes. (Westphal 1991)

e. Science technology and society studies (STS)

Since the last decade also a number of multi disciplinary studies in the field of science technology and society studies (STS) are carried out. The focus is on the dynamics between scientific and technology development and societal change approaching the issue from different angles (Jasanoff, 1995, Bijker, Carlson & Pinch 1990; Bijker, Hughes & Pinch 1987) The field of science technology and society studies (STS) is still emerging. The studies are carried out at different levels of the social system (at national- (macro), sector- and regional- (meso) and enterprise or organization (micro) level. In a number of studies the phenomena and the main indicators along which both societal and technology development can be measured were determined and analyzed.

The scholars in the field of science technology and society studies (STS) stress the point that the boundaries between the paradigmata of different mono-disciplines need to become more vague. Not to say that they should disappear to be able to get hold on the phenomena of interrelated dynamics between technologies and society. The dispute is still ongoing with regard to its form, divisions, boundaries. Nevertheless a number of scholars from a diversity of backgrounds have claimed STS as their primary intellectual basis.

In this literature study no evidence is found of an empirical application of the theories which indicates a set of indicators for the measurement of the dynamics between science, technology and society, that could be useful for the technology mapping studies.

1.6 Conclusions

In the sections above a description was given of the literature study that was carried out to gain insight in the conceptual frameworks and research tools which have been utilized by scholars of different disciplines in their technology related research projects. The theoretic assumptions and empirical applications of these were investigated upon their usefulness for the intended technology mapping studies. The *major conclusions* include the following.

There is an overemphasis on theoretical work. There are *various theories and different disciplinary viewpoints.* Many studies have been carried out by using various mono-disciplinary approaches. In the investigated studies one had to deal with (a) the multiple attributes of technologies and (b) the multiple attributes of societies. The complexity of their interrelationship needs no further explanation. Literature also showed a variety of different views on the relevant concepts in the technology related studies.

There is *no consensus* yet regarding the *theoretic viewpoints* on the actual dynamics between technology, society and production for development. Moreover "a relative neglect seem to exist of empirical measurement of science and technology per se, not to speak of the measurement of its contribution to growth and development". (Bhalla and Fluitman 1980, 1985 and quoted by authors like Romijn 1996). Neither is much evidence of the measurement of the status of technological capabilities and technologies in production systems.

From this literature study the same conclusions can be drawn. The classical socio-economic theories of development are rather aggregated and generally rely on available socio-economic data sets.
A majority of technology related research is carried out by economists by measuring the input factors and the output factors. What happens in between remains a black box (Rosenberg1986). The "how" and "why" questions with regard to the production operations remain un-answered. A number of micro and sector level economic studies gave qualitative evidence of a part of the technological capabilities (for instance Teitel 1993, Romijn 1996)
Macro level empirical economic studies presented quantitative data by using the common macro-economic indicators of science and technology, such as R&D input and output figures (Westphal 1984, Verspagen 1992).
These indicators do not give precise information about the technologies and technological capabilities and do not explain their existence at national level. Discussions are still on-going with regard to a representative and valid set of indicators for technological capabilities. (Romijn 1996).
The *mono-disciplinary approaches* covered the issue of technology related to development from single perspectives and indicated single aspects. The complexity and variety in nature of the issues and concepts require a multi-disciplinary approach.

On the other hand the literature study on technology related research offered valuable insights in the theories on socio-technological dynamics and research methodologies.

The *basic sociologist's viewpoints* on societies as systems in different levels of aggregation make it possible to analyze the systems or at least to describe their performance. This may facilitate the investigation of the *societal setting* at macro-, meso and micro level of societies on a systematic basis both in diachrone and synchrone perspective.
The *economic methods* applied in empirical studies are considered useful to evaluate the performance of the productive activities in terms of productivity at micro, meso and macro level. But the interpretation of data should take into account various factors that influence the capital/output ratio like for example the life cycle of technology which influences the input of capital in production. Macro-economic data analyses on production are useful for an indication of the economic setting of technologies in production systems in their economic environment. The notion of the production function has been fruitful for an increased understanding of certain phenomena such as the relative income shares, unemployment and some of the factors that influence economic growth.
The *engineering analyses* take place at micro level or even at artefact level and are generally of a practical rather than of a theoretical nature. The *pure engineering analyses* have the advantage of utilizing uniform, generally accepted neutrally defined variables to offer a range of alternative technological options for evaluation upon usability. In real practise engineers directly interlink the results of the engineering studies with the societal terms of reference to make the ultimate choices for the technologies to be used. This exercise is generally based on the data acquired from the sociologists, economists, marketing experts, etc. In the majority of cases the cost aspect prevails as dominant indicator of societal feasibility. Engineers thus actually cross the borders of their own discipline and carry out multi-disciplinary work.
Multi disciplinary studies and their analytical models cover the theoretic viewpoints on the interrelationship between technology and society best. They offer the best opportunities to get hold of the technological capabilities and technology status in production related to production performance and the achievement of development targets.

A disaggregated comprehensive techno metric analysis of the technological capabilities and technology status complementary to the generally applied socio-economic analysis seems to render the best insight. .
In the literature study only a limited number of multi disciplinary studies on technology were encountered that assess the technology status in industries by using a techno metric approach. The reference point in these assessments have been the Technological Standards. (Grupp, Hohmeyer, Kollert & Legler 1987)
Most promising seems the model developed by UNESCAP, although this model seems to be difficult to operationalize and requires a rather extensive data set.

*The **final conclusion*** in answer to the first research question is that the literature survey has indicated a number of valuable elements in the existing theoretical models and research tools. These could be applied in systematic standardized comparative research on the technological capabilities and technologies in production systems in their particular sectoral, national and international environments. As far as could have been investigated the existing methodologies only partially revealed the characteristics of technology in relation to society.
Given the starting point in this research regarding the importance of technological capabilities and technologies in production systems for the production performance, competitiveness and socio-economic development it is considered worthwhile to further explore the possibilities to develop a ***research methodology for technology mapping***. Such a methodology could possibly be found by merging the valuable elements of the investigated methodologies.

Chapter 2

The development of a Technology Mapping Methodology

2.1 Introduction

The findings of the literature survey described in the foregoing gave rise to the *research question* that is addressed in this chapter. The question concerns the *possibility to develop a useful research methodology for technology mapping that is generally applicable in any sector.*To find an answer to this question first a synthesis of the theories on technology and socio-economic development is discussed. In the section that follows thereafter a description is given of the attempt to develop a generally applicable theoretical framework. In the last section of this chapter the operationalization of the theoretical framework for technology mapping purposes is indicated.

2.2 Synthesis of literature findings on technology and development

2.2.1 Nations and societal development

Nations have developed over time, gaining more and more control over nature, by transforming the natural environment into the goods and services that are required by its communities of people. But there is an obvious widespread variation of the degree to which development has taken place in societies (Harris,G.,1992). Over years societies made attempts to streamline the processes of change in the desired directions to reach their development goals.

Development is generally used to indicate the phenomena of change in a society. The principal national development goal in countries is in general the achievement of a high and rising standard of living for their inhabitants. (Goulet1977, Porter1990). Development from one stage to the other should have been induced by economic growth, thanks to injections of capital and technology or in other words "mobilization of domestic and foreign saving to generate sufficient investment to increase economic growth". (Rostow 1960).

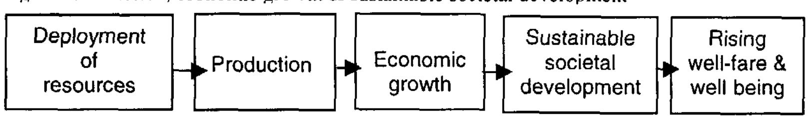
Societal development is different from economic growth, although this is not always explained and understood as such. Most economic policies after World War II were based on the conventional economic theories - focused in one way or the other on the capital - labor production function - emphasizing economic growth and the interaction of this with the state policies.

Evidence in industrialized countries have justified these approaches. There is a common experience that can be drawn from the industrial history of countries like those in Europe, the United States in the nineteenth century, Japan after world war II and South Korea since in the last decades of the twentieth century. The industrial growth of USA and Japan followed the economic wealth which was rested in just a few European countries some 90 years ago.(Rosenberg 1990). These nations prospered from the industrial revolution of the Victorian age and its technological changes. But economic growth does not necessarily lead to qualitative improvements in life on a sustainable basis.

Sustainable societal development implies the achievement of better living conditions in a nation to ensure the improvement of the quality of life for both present and future generations. This requires economic growth and at the same time the efficient and effective deployment of resources to. (WCED in DGIS 1990).

The statements above imply the preservation of available resources, which is in contradiction to the sole objective of reaching economic growth. It is endorsed that it is undeniable that economic growth is needed. It is also recognized that capital (natural resources, intermediate products and technologies) is needed for the productive activities that lead towards the economic growth. This relation is indicated in figure 2.1.

fig 2.1 Production, economic growth & sustainable societal development



The process of societal development -from this point of view- envisages the optimal deployment of resources, without harming the opportunities for future generations, for the upward mobility of all groups of society. The results of this may be perceived in the attainment of a higher level of capabilities and opportunities of people, institutions and production activities. (UNESCAP 1989). This indicates a *challenge for resource management.*

2.2.2 Technology, production and industrialization

The foregoing also indicates a *challenge for the development and utilization of technologies* to optimize the allocation and scale of the use of capital in production processes. This should contribute to the enhancement of societal development. The arguments for this can be traced in the following.

Technology is an inextricable element in human life and technologies are being developed on on-going basis. A large range of technologies for various fields of application has become available. The range stretches from very traditional grass-root technologies to the highly advanced modern technologies produced and equipped with the newest information technologies. Since far back in history man has applied technologies in *production*: to transform the natural environment into goods and services to meet either the local or the export market demand. Man has been increasingly able to improve the transformation processes and move towards an industrialized production.

Industrialization is the process of standardization, systematization, regulation and control of the transformation processes. The objective is to achieve an optimization of the use of inputs and of production technologies in order to better meet the requirements for the production output both in terms of quantity and quality. This could be achieved by application of technologies and technology developments. The application of technologies involves the substitution of human energy by "artificial" energy and a higher and more standardized production output. The achievement of an even higher quality standard of the production output could be realized by substituting human control of the production process by machine control.

T*echnology developments, industrialization and improved production performance* undeniably have tremendously contributed to societal development and better living conditions for many people, despite the criticism about some negative effects.

Although it is endorsed that technology is an important element in societies, the precise meaning of technology is often not clear. The conceptual definition of technology often is mixed up with words like technique and know-how, although the word technology itself is known to a broad audience.
The concept of technology has been defined in numerous ways each with their own implicit meaning and consequently showing different conceptual approaches. (See Appendix I-2) Most of the definitions only take into consideration the technology on production (micro-) level in its function as transformer of inputs into outputs. Stewart (1974,1977) explicitly mentioned that technology has a double meaning. She made a distinction between *product - technology* and *process-technology.* In this research project this view is followed. The following definitions of technology are further used in this research project.

(1) ***product technology*** refers to the complex of technological attributes *embodied in the output* of the production processes required by a society in which and by which it is being used.
(2) ***process technology*** refers to the *"transformer"* applied for the production of goods and services in the context of transformation of inputs in production processes.

The product technological attributes of a product refer to the coherent complex of the product's (1) *function* - mono or multi functionality, flexibility of application, (2) *geometry* - size & shape, (3) *materialization*, (4) *physique-technical performance*, in terms of strength, durability (5) *complexity* in terms of number of components and production requirements related to (6) *cost* aspects.

The process technologies are composed of a coherent complex of components including (a)Human ware: a body of knowledge and skills embodied in man, (b) Technoware: artefacts, tools, equipment and machines, (c)Infoware: documented facts , (d) Orgaware: an organizational framework.

Technology is also seen as a sub-system in society equivalent to the totality of production sectors in a country. Alike any other sub-system in society the technology sub-system has its particular function, structure, culture, infrastructure and infra-culture, which interacts with other sub-systems in society. (Bertholet 1989, see also App I-2 table 2.2). The technology institution or sub-system has an important function in society, that can be sub-divided in an
a. *Internal function: to* serve its "own objectives", in coherence and mostly executed simultaneously: (1) the management of technology inputs in production processes; (2) the implementation and development of the indigenous technological capacity (technology

stock and capacity for autonomous technology generation); (3) the optimization of efficiency and effectivity of the production output by optimization of the allocation and scale of the use of capital (resources) in production processes.

b. *External function:* to serve in various embodiments (products and services as well as process technology components) as an input in society. It is then oriented to demands that exist in other institutions, optimally integrated at national level, subservient to (1) the national cultural features; (2) the structural features of economics, politics, education, religion, kinship, etc.

2.2.3 Technology development

Technology development refers to the changes in the product technology (outputs), changes in the processtechnology (transformer) of a production system and changes in the technology sub-system. Product technology developments are the changes in the attributes of the production output. Process technology developments are the changes in the attributes and composition of the four process technology components (technoware, humanware, infoware and orgaware). Changes in the technology sub-system are the changes in and between the actors in the actor network of the various production sectors.

Technology developments can be of *incremental nature*, which refers to the change in attributes of the technology based upon the existing one. They can also be of a *radical nature*, which refers to completely new sets of interrelated attributes of product technologies or process technologies. The concepts "innovation" and "invention" are nearly similar to technology development and are often mixed up with it.

Process innovations are the successfully introduced and adapted changes in the production process technologies (Rosegger 1980). Inventions are considered similar to primary or radical technology changes. A distinction has to be made between technology development and normal investments made by an organization: not every acquisition of new equipment involves technological development.

The *objective of technology development* is to yield an increase in production output, higher productivity, higher overall efficiency, or qualitative improvements. The changing terms of reference of the production targets (quantitative and qualitative requirements for products) - in general determined by market forces - defines changes in the range of process technologies, which can be applied for production. (Woodward 1959). The majority of technology developments at enterprise level is directed to product innovations, in order to better suit the dynamically changing requirements of the market. In reality innovations of process technology go more or less hand in hand with new product design and change of market requirements.

Technology development takes place through indigenous technology development efforts or through international technology transfers.

Indigenous technology development refers to local efforts and activities with local means (such as local R&D activities, on-the-job innovative activities in the enterprises, education programs) regarding the (1)adaptation and improvement of existing technologies, like technology changes in established and existing product- and process technologies; (2) generation of new technologies through basic research, either in-house/ on-the-job in enterprises or in R&D and scientific institutes and (3) local investments in new plants : introduction of new techniques, product-technologies and process technologies.

The R&D institutes and enterprises are the major sources of technology developments. These are in an ideal-typical situation supported by the so-called *technology promotion agents* to diffuse the new technologies.

The technology promotion agents include among others the national government, educational and training institutes, design and management consultancy companies, documentation and information centers, libraries, statistical organizations, patent and registration offices, museums, testing, certification and standardization laboratories, development organizations, banks, venture capital banks. (see app I-2 table 2.3)

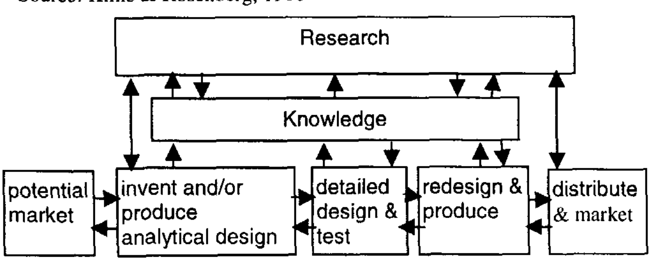
International technology transfer refers to technology investments and introduction of new techniques, product-technologies and process technologies through selection, acquisition and adoption of these from foreign sources. Through international technology transfers technologies were spread all over the world, although not all nations are in the position to make use of these.

The *process of technology development* is not an uni-linear process from market to the research laboratories or the reverse, although policy making processes have been based on these assumptions during the past decades. In the so-called *technology push model (Schumpeter)* technology development basically is seen as a direct product of scientific activity. The linearity of the model also implies that any investment in R&D should consequently result in technological changes. A higher productivity and competitiveness is expected when these changes are is applied in the production processes. A majority of policy thinking about technology and economic development has been based on this linear model. The policy implications are also straight forward: investment in activities of R&D and scientific institutes are given full attention, as these institutions are seen as leading actors to bring about new technologies

Policy thinking based on the linear *technology pull model (Schmookler)* on the contrary implies that the role ascribed to R&D and scientific institutes is a rather passive one. Within such a policy framework these institutes may depend on the mercy of the market forces. A problem arises when the leading actors in the market (enterprises and industrial organizations) do not have a culture of systematic investment in R&D and innovative activities. A reasonable level of *technological knowledge and insight at enterprise level* is an important prerequisite to forecast market dynamics and the resulting need for technology developments in order to maintain competitiveness in such a policy framework.

The shortcomings of the linear technology development models were often stressed by various authors. Technology development should be seen as an *on-going cyclic process* in a number of stages (from innovation-, maturity-, standardization-, to the decline stage). This may result from R&D activities to develop new technologies with (recent)-acquired knowledge and from driving forces of the market to find solutions for the demand for particular products and techniques.

fig 2.2 Interactions in the process of technological change & innovation
Source: Kline & Rosenberg, 1986



(Rosenberg & Kline 1986)

Technology policy formulation should thus be based on the cyclic model of technology development processes. This requires insight and understanding of the state of art of technology and the strength of the promotion agents which enhance the improvement of these. Technology managers and policy makers should also take into account that the requirements for the inputs in the technology development processes -such as the technological and financial inputs- and the volume and revenues of the output of technology development processes change during the life-time of the technology. (Abernathy & Utterback 1978). The general national setting (in particular the political-economic situation) is important as a facilitating framework to create a favorable climate for technology development.

2.2.4 Technology status

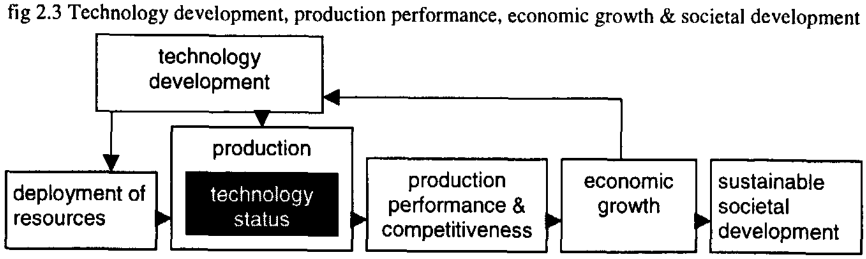
Ranges of technologies with increasing degrees of technological advancement came into existence as a result of technology development efforts over time.

The *status of process technologies* refers to the degree of advancement within each of the four process technology components.(Woodward in Pugh 1958, Timar 1958, Sutcliff 1971, ESCAP 1989). The *status of product technologies* refers to the degree of advancement of the coherent complex of the product attributes. A higher degree of product technological advancement refers to the rate to which the product technology meets the increasing complexity of the standards that are set for them -often by the market-, thus compared to foregoing similar technologies.

The categories of technologies in sequence of increased sophistication can be classified in an aggregated form in *traditional - intermediate and modern technologies.* Another classification that is often used is the *Pavitt taxonomy of technology* (Pavitt 1987) He made a distinction in five classes for product technologies. This is mainly based on the status of the technologies in the life-cycle (ranging from mature, price sensitive products to science based- research intensive products).

History has shown that technological development has had a significant influence on economic development in the industrialized countries. (Lilley 1980 , see appendix I-2, table 2.4). At *micro(production) level* empirical evidence suggests a direct correlation between increased degrees of operational complexity of used facilities, the ratio of indirect labor force, percentage of academically educated staff, quality and quantity of documented facts in use, and diverse "spans of control". At *macro level* important empirical findings are published on the common wisdom that technology development contributes to economic growth and is essential for economic growth. (Solow 1967; Denison 1967, 1985; Thirwall 1972; Kendrick 1977; OECD 1980b). It is also known that growth rates differ *between countries* and between groups of countries. This is apparently a result from the technology status in the countries. (See Arrow, Chenery, Solow referred to in Verspagen 1992, Freeman1982, Dosi 1988, Nelson 1988, Weiss 1990).

fig 2.3 Technology development, production performance, economic growth & societal development



The *conclusion* from the above is that through empirical evidence is acknowledged that technology development can be considered to be an important prerequisite for effective and competitive production.(see fig. 2.3)

Production performance highly depends on the status of technologies utilized in production. Increase of the production performance requires technology developments. This is necessary to respond to the dynamics of societal development that are reflected in changes in the demand for goods and services in a country and on the international market. Current views indicate innovativeness in enterprises, industries and countries that bring about technology developments of high importance for competitiveness of both firms and nations societal development. (Porter M 1985, 1990).

There will be an on-going trend of increasing international competition in trade, new technologies, more efficient management of longer existing technologies, that result in price and quality advantages for nations and industries with a higher technological potential. This illustrates the on-going need for improvement of the technology status.
But empirical evidence also has shown that technological change in itself is not the key to successful economic growth. It was noticed that development is not only a question of just the application and on-going sophistication of the technologies in production to improve productivity and thus economic growth. Neither it is a question economics or the quantitative measurement of income, employment or inequality. It has been admitted that in fact technology development and societal changes go hand in hand. (Todaro 1997). The findings seem to be confirmed by the pattern of development in the industrialized countries.
Technology developments for industrial purposes have been concentrated so far in the advanced industrialized countries. Evidence from the past has also shown that technology developments in these countries indeed have undergone an improved production performance in various production sectors and that these had a significant influence on economic growth. The majority of nations that have been able to maintain or capture their position in the group of nations with a higher technological and industrial advantage belong to the group of already industrialized or newly industrialized countries (NICs).

2.2.5 Technological dependence in developing countries

Many *developing countries* face formidable obstacles in their development process on the contrary. Constraints like local inflation, material scarcity, slowly developing native technical and managerial talents, heavy international debts and world wide inflation are dramatically affecting the development programs of the developing countries. They are more or less forced to rapid reinforcement of their production, adapted to the rapid changing socio-economic setting, population growth in developing countries and the acceleration in world wide industrial competition -in speed and in costs.
Development policies in developing countries consequently have put an emphasis on the enhancement of growth in the "modern" sector through capital investments in attempts to follow the example of the path towards development and economic growth of the western industrialized countries. Technological traditions, utilized in particular in the traditional sector, thus became more and more neglected and even eliminated (not only in Third World countries). The policies implied that they had to acquire new technologies from abroad - through channels of international technology transfer - rather then develop them domestically. The result is that these countries heavily rely on foreign sources for their products and process-technologies for productive activities. Most technologies in these nations stem from the industrialized countries. The reliance on imports of technology from the international technology market in the long run caused a situation of dependency.

The *technological dependence situation* is seen as a position of sub-ordination and as an asymmetric form of relationship between countries. The technology dependency situation is considered to be enhanced by *in-appropriate technology choices*. This is reflected in the fact that the basic needs of a majority of the population are not met. (Stewart 1979 see also Appendix I-2.7).

The concept of *appropriate technology* refers to the technology mix contributing most to economic and social objectives in relation to the resource endowments and conditions of application in each country. The concept was stressed as being flexible and dynamic, respective to varying conditions and changing situations in various different countries. Appropriateness of technologies is a relative concept that depends on various factors. The appropriateness of a technology differs for each country, due to the widely divergent conditions in the countries. This means that in every case a broad spectrum of technologies should be considered and examined before application in industry. Technology choices in developing countries are often "in-appropriate". (Stewart 1977, Bertholet 1989, see also appendix I-2.8).

At national level the national development objectives in the country have an impact on the ultimate choice. The question is whether these development goals cover issues such as the fulfillment of basic socio-economic needs of the whole population - in particular those of the poorer communities and the provision of adequate employment opportunities. In many developing countries the needs of the population will seldom be congruent to the effective demand, due to lack of capital to full fill all needs. At national level the prioritization of the societal needs which are to be full filled depend from the particular social group from which the needs are originating and from the existing political powers to decide upon the priority of these specific technological needs. Also the characteristics of *the international technology market* are found to be due to the dependency situation in developing countries. (Stewart 1990; Vernon 1990). The international technology market is characterized by its oligopolistic nature with a limited number of suppliers of technology and a rather extensive demand. The result is that the technology receiving countries are confronted with too high costs, unprofitable terms and conditions in technology transfers contracts -like restricted property rights and high technology transfer prices- and often *in-appropriateness* of the transferred technologies.

Thus the *choice for an appropriate technology* should be based on a thorough deliberation of various factors. These include: (1)the size of the potential market; (2)the optimal utilization of available natural resources; (3 national sovereignty in such utilization, taking into account the environmental implications; (4)the role of public and private sectors; (5)an appropriate scale of production; (6)the desirability of geographical dispersal; (7)capital- and labor intensity in relation to national availability; (8)the use of appropriate sources of energy. (Stewart 1977, Bertholet 1989). A "correct" selection of appropriate technologies may imply the use of both large scale technologies and low-cost small technologies.

2.2.6 Technological capabilities: the core element for societal development?

The research findings on the international development differentials, the underdog position of a majority of developing countries and their dualistic system of technologies in production have become a common wisdom. (see table 2.5 App I-2).

The important question -regarding the major factor that determines the technology utilization in production and the rate of technology development for production in contribution to the competitiveness of a nation- seems to be answered only since the two last decades.

At the end of the seventies it was already indicated that a less favorable socio-economic situation could be seen in countries with nearly no endogenous science and technology base (Stewart 1978, Sagasti 1979). By this was meant that no supportive basis or network seem to be existing for proper selection, acquisition, application and development of technologies for production. Following these ideas the major bottleneck to properly streamline policies and to support linkages between science and technological development and production is formed by a non existence of *capabilities* that should exist in a network of interrelated organizations, institutions and enterprises that exchange technologies in its different embodiments. In other words nations should dedicate efforts to the development of a technological structure, culture and infrastructure - a certain *technology creative system-* in order to decrease their technology dependency position and create a *technological self-reliance situation.* (Fransman 1984, Lall 1987, Stewart 1978, Rosenberg 1990, see also Appendix I-2.9).

Technological self-reliance is the autonomous capacity to make and implement decisions and control over areas of partial technological dependence or over a nation's relations with other nations. (Stewart 1978). Due to a lack of a strong technology infrastructure with technological capabilities, a country may fail to use its scarce resources efficiently, resulting in rather high costs to enterprises and to the national economy. This implies an inefficient use of the existing facilities, a declining productivity over time, a high and continuing degree of dependence on imported inputs and of technologies from abroad, a lack of local technological infrastructure and therefor limited integration in industry.

A new assumption entered the technology and development studies during the last decade: "*The technological capabilities and the potential which is to be found at the different levels of economy to control as well as respond economic change is a core element for development*". This hypothesis, has been a new starting point in many of the recent research activities (Bell 1984, Freeman 1982-1988, Fransman 1984, Lall 1987-1990, Rosenberg 1986-1990 see also Appendix I-2.10)

Also the concept of *technological capabilities* -alike the concepts of technology and technology development - has been defined in numerous ways..(See App. I-2, table 2.6) In the majority of definitions the technological capabilities are defined by mentioning a number of *activities* without any indication of the particular nature of the capabilities. In other words no indication is given *which* particular capabilities are needed for technology acquisition, selection, utilization, development. Further thinking on this issue lead to the following conceptual definition that is considered workable for this thesis. (A justification of the definition in this research project is described in appendix I-2.11)

> The concept of ***Technological Capabilities*** refers to the total stock of national resources that can be committed to the production system in the country, giving the necessary inputs for efficient and effective production.
>
> This ***stock of national resources*** should supply the country with the means, skills, know-how and knowledge not only to select, master and adapt the technologies needed and most appropriate to the social system of the country. But the technology stock should also enable the country to develop and generate its own new technologies (self-reliant technology generation)"

The stock of national resources includes (1)the range of available technologies (technology stock), (2). the available human resources (3), the available and exploited natural resources. (4) the technology infrastructure of institutionalized R&D, education & documentation facilities, technology and intermediate products producing and supplying enterprises and organizations supplying the financial resources to the production system to support production activities.

Technological capabilities -in terms of the *available resources that can be used potentially* to be able to efficiently and effectively carry out processes of technology utilization and technology development- become evident in (1)the utilization of technologies and its results in terms of the efficiency and effectivity of the execution of production processes, (2)the search for available and alternative technologies; (3)the selection of most appropriate technologies; (4)the adaptation of technologies to suit specific production circumstances; (5)the improvement of technologies (incremental developments); (6)the execution of basic research and R&D for technologies either in-house or through institutionalized facilities. (Lall,Fransman, Stewart, et all) Any deficiencies in these thus point at a certain lack of technological capabilities.

2.2.7 Technological Capability Building

Upgrading of technological capabilities to benefit the productive sectors in a country seems to be a most obvious way to reach socio-economic development. Thus technology management and technology policies should be directed to technological capability building.

Technological capability building, is defined along the definitions that are given to the concept of technological capabilities, which in majority point at the concept in terms of human and institutional capabilities. This is why technological capability building often is defined as "the accumulation of human and institutional capabilities" and also is equated with "learning" in literature, which is considered to encompass more than only "experience with the production system". Technological capability building was considered to include *the set of processes by which firms accumulate technical knowledge, know-how and experience relevant to the planning, construction, operation, adaptation, improvement and replacement of production processes.* The ultimate objective is to increase the production output qualitatively and quantitatively. (Maxwell, 1976, pp 19-210)

Technological capabilities in this research project are represented in the complex of four components: (1)technology infrastructure, (2)human resources, (3)natural resources, (4)range of available technologies. Therefor following the definition for technological capability building is used in this thesis

> *Technological capability building* refers to the efforts to increase of the quantity and quality of the complex of the four components of technological capabilities.

Optimal technological capability building cannot take place without support from a national setting with national policies dedicated to technology development and with the availability of physical infrastructure that support the production system. Countries may use various means to build up their capacity to create and diffuse new technologies, including the adaptation of technologies developed in other countries. The selection of these means depends on the technology management and technology policies.

2.2.8 Technology Management

The concept of *technology management* can be interpreted at different levels of aggregation: at enterprise or micro level, at national or macro level and even at international or supra-macro level.

In this research project ***Technology management at enterprise or micro level*** refers to the planning, formulation of management plans, implementation and control of (1).the performance, productivity, effectivity and efficiency of the production systems, (2)

technology utilization and technology development through the adoptation, adaptation, improvement and generation of technologies in and for production processes.
***Technology policy** is equated with technology management at national level (and sectoral level).* It refers to planning, formulation, implementation and control of technology utilization and development through the adoption, adaptation, improvement and generation of technologies in and for production systems in relation to socio-economic developments.

The major *objective of enterprise level technology management* is to improve the production performance that is reflected in aspects like a larger market share and higher value added. The *objective of national technology management* is to achieve the national development goals through improved production performance in sectors.

A comprehensive insight in the totality of the existing capabilities and technologies used in the production processes is needed for adequate technology policy and technology management. It thus makes sense to get hold of a useful methodology to map the status of technological capabilities and technologies in production processes.

In a number of studies methodologies were applied to assess the technological capabilities and technologies in relation to the production performance (see for instance Lall, Nelson, Romijn, Weiss, Westphal,) It was expected that this research project could thrive on the experiences from these studies.

2.2.9 Conclusions

The synthesis of literature findings that was described in this section led to the following conclusions.
The importance of the *role of technology and technological capabilities* in production and industrialization to contribute to the achievement of societal development goals is fully endorsed.
Adequate use of technologies is a prerequisite for an efficient and optimal deployment of resources in all institutions of society in order to achieve sustainable societal development.
Technology developments over time have enhanced the improvement of production processes and a tremendous improvement of human living conditions in many nations.
New technologies have given the opportunities to create new firms, jobs and wealth based on existing internal resources
Enterprises and countries are confronted with *a growing international competitiveness* and on the other hand although this may sound *contradictory a growing international interdependence.*
Competitive performance to meet the market demand -in qualitative and quantitative sense- is considered to be directly related to the appropriateness of the utilization and development of technologies in their respective socio-economic environments, which results may be perceived in the attainment of a higher level of capabilities and opportunities of people, institutions and production activities.
Countries that possess an endogenous complex of scientific and technological capabilities forming national technology creative systems are considered to be more competitive on the international market
In-appropriate technology choices and the features of the international technology market have caused a less favourable development and technology dependency situation in developing countries
The *interference between technology and societal development is complex.* It has been admitted that in fact technology development and societal changes go hand in hand.

The ***major conclusion*** is that one factor can be considered to separate the winners from the losers in the nations and between them: *technological capabilities*. In other words:

> The achievement of a strong international *competitiveness* which at the same time safeguards sustainable development depends on the status of technologies in use in production. The status of the used technologies is determined by the ***technological capabilities***.

Technological capability building offers obviously a gateway to sustainable development. But a first requirement should be the availability of a full set of information on the current status of technological capabilities and the technologies in production to be able to distinguish the opportunities problems and constraints for improvement of the technological capabilities and the technologies in production systems. This should facilitate the interventions by technology management and technology policies.

Technology Mapping is therefor needed and useful for a well-founded formulation of technology policy and technology management plans. This also indicates the necessity of a tool-kit to be able to collect the needed information for Technology Management.

2.3 Development of a research methodology for technology mapping

2.3.1 Objective and target groups of a theoretical framework for technology mapping
The *objective of the development of a theoretical framework* is to provide the foundations for the analytical tools for technology mapping.
The *target groups* for whom the technology mapping methodology is developed include (a) the national and sectoral policy makers, (b) the management of enterprises.

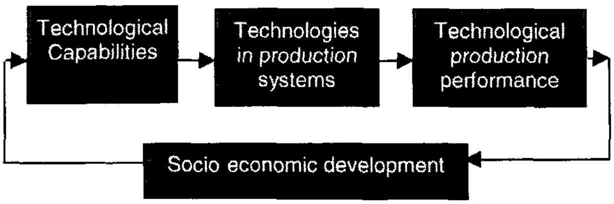
2.3.2 Requirements for the theoretical framework for technology mapping
The theoretical framework should in principle meet the following requirements:
It should provide a *generally applicable frame of reference* for a systematic comparative study and evaluation of technology management in production units, irrespective of sector, region, nation or time.
It should be comprehensive and contains all variables that together provide an overall and integrated picture of the effiency and effectivity of technology management in production units in different socio-economic and geo-physical settings. This includes the internal and external functioning of production units as well as the effectiveness of this functioning. A consequence of this is that the theoretical construction is *interdisciplinary*
It should be possible to translate the variables -which are included in the framework- into measurable entities. Each variable of the framework is defined unambiguously
The framework is supposed to be useful for the *identification of the opportunities, problems and constraints* for an improved production performance of an individual enterprise, the particular sector and country in which the production processes take place.

2.3.2 The key-concepts
The view points and analytical tools -that are used in the sociological-, economic-, engineering - and multidisciplinary studies on production management and the organizational performance- were merged for the development of a theoretical framework for technology mapping. The starting point has been:

Technological capabilities determine the technology status in production and the both are the core elements for the production performance in production sectors and sustainable societal development in countries. (See fig 2.4)

The key-concepts and the assumed relation between these are described below.

fig 2.4 Technological Capabilities Technologies in production systems, Technological production performance and Socio-economic development



I The status of technology in production (STP) is defined as the complex of characteristics of the totality of product- and process technologies that are *actually* utilized in the sector.
The *indicators* for the technology status are the complex of characteristics of

a.the *product technologies (Produtec)* These are determined by the products properties regarding its (1)function (2) geometry, (3) physique-technical performance, (4)materialization,(5) production complexity and production time, (6) relative costs. (STProductec)

b. the *production process technologies(procestec)* These are determined by the properties of the components of the process technologies, which are (1) the *technoware* -artefacts, like tools and equipment-, (2) *humanware* -persons, that represent the manpower-, (3)*infoware* - documented facts, which serve as source of information and documentation-, (4) *orgaware*, -organizational framework, that serves to guide and control the production processes in the desired directions. (STProcestec)

The technology status is to be measured at production unit level and can be aggregated to sector level, provided that a correct and representative sample of production units in the (sub-) sector is investigated.

II. The technological effectivity (T effect) of production processes is determined by the degree by which the realized production output corresponds with the planned production output in terms of quantity and quality. (appendix I-box 2.7)

The status of the production output (STProdutec) - evaluated along the technical criteria by using the engineering variables- should be corresponding with the market demand and the technological standards for the production output. The last form the Terms of Reference of the Product Technology (TOR produtec)

$$\textbf{Teffect} = \textbf{STProdutec} / \textbf{TOR produtec} \quad (0<\textbf{Teffect}<1)$$

III. Technological efficiency (T efficy) of production processes is expressed as the ratio of the actual utilization of process technologies (STProcestec) and the best practice utilization of process technologies(BPprocestec) that is necessary for the transformation of natural resources and intermediate products into the desired and intended production output. The specification of a required product technology (production output) determines in essence the range of process technologies that potentially can be applied for its production.

$$\textbf{Tefficy} = \textbf{STProcestec} / \textbf{BP procestec}\ (0 < \textbf{Tefficy} < 10)$$

Sector level effectivity and efficiency characteristics can be derived by aggregation of the data set from the micro level studies. National level technology effectivity refers to the extent to which the sectoral production meets the national objectives.
Technological effectivity and efficiency is not necessarily equivalent to the socio-economic effectivity and efficiency. *The economic effectivity* is expressed in terms of value added, profit, sales, market share. It depends on the costs of production and the *affordability* of the customers and their *willingness-to-pay*. The *economic efficiency* is reflected in the productivity, allocation and scale of use of capital in the production processes and depends on the direct availability, accessibility of the necessary inputs in the production processes. *Social effectivity and efficiency* are measured on macro level. *Social effectivity* depends on the societal development targets relevant for the production activity, such as scale of sectoral employment, income distribution, know-how and skills, satisfaction, absenteism. *Social efficiency* depends on the extent to which the use of social means is optimized and is reflected in (un-)employment ratio, ratio of availability and utilization of local and foreign resources in the production processes

IV. The technological production performance (TPP*)* in the sector is determined by the status of efficiency and effectivity of the technologies (STP) utilized in the production units of the sector to meet the sectoral market demand for goods and services. (See App I-2 Box 2.8)
The technological production performance in the sector is seen as the product of technological efficiency and effectivity.

$$\textbf{TPP} = f\ (\textbf{Teffect}, \textbf{Teffic})$$

The technological production performance (TPP) in a sector depends on the particularities of the environment (setting) in which the production processes take place. A distinction is made upon order of aggregation level in (a) the sectoral technology setting, (b) the national technology setting, (c) the international technology setting. (See App I-2 Box2.9)
Improvement of the technological production performance -in terms of efficiency and effectivity of technology utilization in a production process- requires not only a thorough insight in the production process but also insight into the precise setting under which the processes take place.

V. The sectoral technology setting is determined by (a) the sectoral *technology needs* and (b) the sectoral *technological capabilities*.
Both form the complex of factors that determine the terms of reference for technology choices to be made in the production units in the sector.
The sectoral technology setting (STN + STC) determines the *technology status in production* (TSP). Both are the core elements for *technological production performance in production* sectors (TPP) and *sustainable societal development* in countries, which is reflected in the national development status.

VI. The sectoral technology needs (STN) in a country are determined by (1) sectoral market forces between supply and demand and (2) the policy interventions in these.

VII The sectoral technological capabilities (STC) represent the sectoral potential to invest, produce and innovate in production activities.

Technological capabilities are composed of the complex of components including the (1) range of technologies in stock (TS); (2) natural resources stock (NR); (3) human resources stock (HR); (4) technology infrastructure.(TI)

$$STC = f(TS,NR,HR,TI)$$

The nature and way on which sectoral technology setting (STN + STC) and thus the production performance of a production sector changes or differs from country to country can be explained by the characteristics. of the (a) *national technology setting* (NTS) and (b) the *international technology setting* (ITS). In other words the complex of variables that determine the technology needs, technological capabilities, the status of technologies in use in production and the production performance of the sector depend on the complex of variables that determine the national and international technology setting.

VIII The national technology setting (NTS) is the operating environment of the production units in the country.

This is determined by (a) the social system characteristics (socio-economic development status , development policies) and (b) the geo-physical system characteristics (geography, climate, natural resources, demography, infrastructure), (c) historic backgrounds of the country in which the production sector is situated.

IX The international technology setting (ITS) is the operating environment of the production units in the world.

This is determined by the international socio-economic, political- and technological position of the sector and the country under investigation.

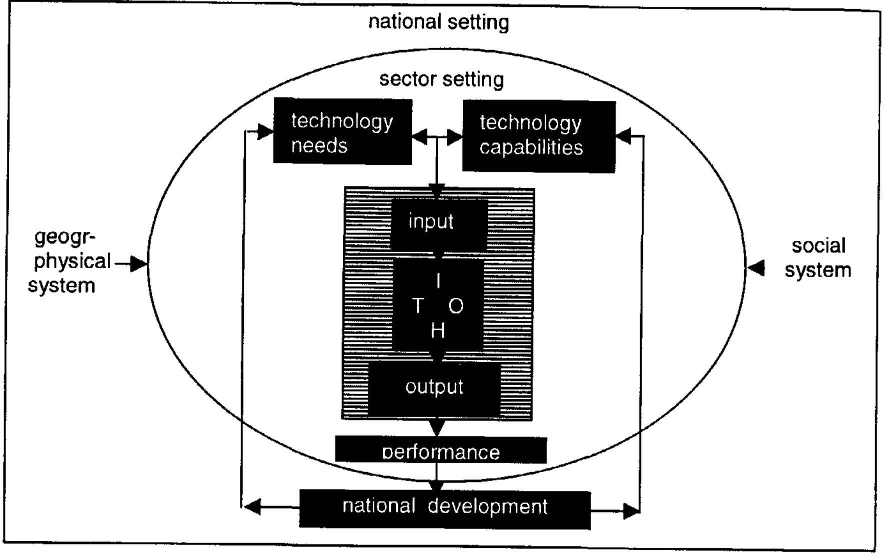
X. The sectoral contribution to the national socio-economic development is reflected in the (1) gross value added, (2)gross fixed capital formation, (3) employment, (4) income distribution, (5) re-investments, (6) fulfillment of local basic needs, (7) rate of foreign dependence, (8) migration.

2.3.3 The theoretical framework

The above presented views form the basis of the theoretical framework that is assumed to be useful for technology mapping purposes. (see fig 2.5)

With the operationalization of this framework in empirical studies insight can be gained in the strengths and weaknesses of the status of technological capabilities and technologies utilized in production. It should then be possible to explain the differences of the production performance in the sector, between the sectors in a country. Improvement of the status of technological capabilities in a sector (Technological Capability Building) and improvement of the status of technologies in use in production (Technology Development) is considered to improve the production performance of the sector quantitatively and qualitatively. This means that policy interventions should be directed to (a) an increase and improvement of the sectoral technological capabilities (b).an improvement of the status of technology utilization. First of all the status of technological capabilities (STC) and the status of technologies in production (STP) should be mapped. To indicate the technology status in an industry in a country one should dis-aggregate the production processes into the product-, input- and process technology- components.

fig 2.5 The theoretical framework



2.4 Application of the research methodology for technology mapping

2.4.1 Sub-studies

The theoretical framework is applied in technology mapping studies. Technology mapping includes the following studies by which the concepts of the theoretical framework are investigated. To start with a number of **baseline studies** are to be executed, to give a static description of the respective settings of the production system and of the actual and the desired status of Technological capabilities (STC), Technologies in Production systems (STP), and Technological Production Performance (TPP)

Evaluations are carried out next by comparison of the found data of the actual and desired state of art of the sectoral production performance, the sectoral technology status and the sectoral technological capabilities against the background of the operational environments of the sector under consideration. Thus the evaluations include comparisons between the actual and desired situation with regard to (1) . the sectoral production performance, (2) the sectoral technology status, (3) the sectoral technological capabilities. These excercises should result in conclusions on the opportunities, problems and constraints for improvement of the situation and recommendations for technology management and policy interventions to streamline the production performance towards the achievement of national development. (see table 2.1)

The studies as proposed in this research project are of comparative descriptive nature. The field studies can be seen as ad-hoc sample surveys. During these studies the major characteristics of a particular production sector are investigated and described to get more insight and understanding of the Status of the Technologies in Production (STP) in relation to the Technological Production Performance(TPP), Technological capabilities (STC), Technology Needs (STN) and National Technology setting (NTS) and the International Technology Setting (ITS) in a country.

Table 2.1 Technology mapping sub-studies

A. Baseline studies	an assessment of the general national and international technology setting an assessment of the general sectoral setting and determination of technology demand an assessment the status of technologies utilized in the individual enterprises in the sector. an assessment of the sectoral production performance an assessment of the sectoral technological capabilities
[illegible]	[illegible]
C. Synthesis	a synthesis of the findings and formulation of recommendations for technology management

It needs no further explanation that the research projects for technology mapping comprise a relatively extensive data set derived from the baseline-studies. These studies are necessarily of different disciplinary nature and mutually supportive. This is to ensure a meaningful integration of the various socio-economic and technological components which play their role in the actual situation with regard to Status of Technological capabilities (STC), STP, PP in their STS, NTS and ITS related to the socio-economic development in the country. The disciplinary approaches from which data sets in principal are derived in the technology mapping studies are the engineering sciences, including industrial engineering and management sciences, sociology and economics. Additional data sets might be required from more in-depth studies on specific issues approaching the matters from other relevant disciplines.

A remark should be placed here: It is seldom the case that all the different studies are executed by only one researcher. This will also not be the case in this research project. Taking into account the disciplinary background of the researcher -involved in this project- the reasoning may be given for the accent on the studies of technological nature. For the data that result from other studies such as those from sociology and economic studies this research will make use of secondary resources.

2.4.2 Empirical aspects

Technology mapping is supposed to take place for a sector or even a sub-sector at a time. This gives the opportunity to form a basis for the improvement of a sectoral policy at a time and subsequently building a body of sectoral policies if possible in coherence with each other. This approach seems more feasible than the development of national technology policies for all sectors at a time. A comprehensive national technology mapping excercise is not very realistic in countries without a basic technology infrastructure where technology policies are to be formulated for the first time, in particular in countries with a lack of available and reliable data on the performance of production sectors.

The suggested sectoral technology mapping studies should form the first step *towards an overall national technology map.*

The selection of the first sector to start with can be made on pragmatic basis or by taking the strategic importance of the sector in national and international perspective into consideration.

The developed general theoretical framework and set-up for empirical application are to be applied and tested in field studies. A number of *research instruments* were developed for the execution of the various studies of the technological mapping framework. The research instruments have to be adapted to the sector in which the methodology for technology mapping is applied. (See next chapter)

2.5 Conclusions

The development of the theoretic framework for technology mapping is based on the hypothesis that
Technological capabilities determine the Technology Status in Production and these are both the core elements for the Technological Production Performance in sectors that on their turn determine the route to sustainable development in a country.

Technology mapping is necessary for technology management
An integral method for the analysis of technology utilization in production systems in their respective environments at different levels of aggregation (micro, -meso-, macro- and supra-macro level) is necessary to achieve an appropriate formulation and implementation of technology policies and strategies in a nation.

The Technology Mapping Studies have an *interdisciplinary nature.*
A *comprehensive assessment* of the Status of Technological Capabilities (STC) and the Sttuas of Technologies in Production sectors (STP) related to the sectoral, national and international technology setting should include approaches from a number of disciplines that are assumed to yield complementary data. This implies that the technology mapping studies include a number of studies of different disciplinary nature.

The studies require first of all a thorough understanding of the specific technological discipline applicable to the sector under investigation to be able to analyze the technologies that are applied in production. Subsequently knowledge and insight in the fields of social sciences is needed to fit the set of technological characteristics within the frame of reference of the social system in which the technologies are applied.

This kind of extensive exercises in practice can seldom be carried out by a single researcher. A single researcher will carry out in-depth studies that are based on his/her disciplinary knowledge and collaborates with researchers with other relevant disciplinary backgrounds or derives the additional necessary data from reliable sources.

For the operationalization of the developed theoretical framework for technology mapping adaptations should be made to fit the research instruments to the particularities of the sector under investigation for the collection of the necessary data.

Taking into consideration the disciplinary background of the researcher in this project the testing of the technology mapping methodology could take place in the construction industry. The basic tools for the in-depth analyses of the utilized technologies are derived from the realm of the construction engineers. Complementary data (e.g. macro-economic and sociological data) are derived from other sources

The operationalization of the theoretical framework for technology mapping and the development of the adapted research instruments-to fit the particularities of the construction sector- is discussed in the next chapter of this part of the thesis.

Chapter 3

Research design for Technology Mapping in the dwelling construction industry.

Part I
Chapter 1
Chapter 2

3.1 Introduction

In this chapter the basic research methodology for technology mapping is further elaborated and adapted for the field application in the construction industry. The developed theoretical framework for technology mapping is considered to be generally applicable in any production sector. However, the research instruments that are to be applied need to be adapted to the particularities of the sector that is investigated. The organization and type of production processes that takes place within the specific sectoral setting varies from sector to sector. Therefor the particularities of the sector need to be determined. This chapter is centered on the question

> *How to elaborate the basic research methodology in such way that it fits to the particularities of a sector like for example the dwelling construction industry?*

In the next section first the reasoning is given for the selection of the dwelling construction industry for the lower income households in which the technology mapping methodology has been applied. Then the specific aspects of the dwelling construction industry are discussed to be able to define the key concepts of the developed theoretical framework for technology mapping adapted to the construction industry. At last the set-up of the research design for the application of the technology mapping methodology in the dwelling construction industry for lower income households is introduced.

3.2 On the research focus at housing and the dwelling construction industry

The *scope of the field studies* has been limited to the sub-sector of *dwelling construction for low income households* in Tanzania and Costa Rica. The reasoning for selecting this sector in the mentioned two countries is the following.

Housing is one of the basic needs of man. World wide *the housing problem* has a tremendous magnitude. The *housing situation* in global perspective shows over a billion people in the world (which represents almost a quarter of the total world population) who are inadequately housed. Of these more than 100 million are even absolutely homeless. (UNCHS 1994). The majority of the homeless people live in developing countries, but the phenomenon is present in the industrialized countries too. During the next decades the developing countries will experience an emerge of super-cities also named Grand Metropolitan Areas. This will form a major problem for many of the city managers to provide for the housing needs for many households living in these cities.

The *housing problem* is reflected in the nominal lack of houses. The nominal lack of houses is determined by the effective housing demand minus the existing stock of houses at a certain moment of investigation. The *existing stock of houses* includes the adequate houses, houses at sub-standard level and houses inadequate for habitation. In general many lower income households live in the last categories of houses. The actual deficit of houses refers to the nominal lack of houses including the houses inadequate for habitation. (see appendix I-3 on the adequacy and affordability of houses)

Adequacy and affordability are seen as the major determinants of the terms of reference for a house. The basic requirements for an adequate dwelling should be equivalent to the product technological attributes of the output of the construction process. In most countries the basic requirements for housing facilities are set in building regulations.

The housing problem is most acute and worsening in the Urban Areas in the developing countries. These have to face a situation of many unemployed people, inhabitants who live in absolute or relative poverty, lack of basic facilities such as water and sanitation and a far from favorable development prospect. The situation is most problematic for the *lower income households in developing countries.* The higher income groups can better afford the increased costs for the scarcely available dwellings. (see appendix I-3 on lower income households)

Housing supply largely depends on the production output of the construction industry. Thus the *construction industry* has the challenging task to contribute to the alleviation of the housing problems for the lower income households. In a situation of a need for specific (lower income) housing facilities that exceeds the supply the construction companies are urged to improve their production performance and lower the costs of construction to better suit the market. In other words an improved production performance of the dwelling construction industry should contribute to solve the housing problems.

Following the theoretic viewpoints adhered in this research project an improved production performance depends on the status of technologies in the construction processes and the technological capabilities in the dwelling construction industry. Data sets on the status of technologies in the construction processes and the technological capabilities in the dwelling construction industry are expected to set a frame of reference for proper technology management and policy interventions to improve its production performance.

The conclusion is that Technology Mapping in the dwelling construction industry for the lower income households in urban areas makes sense to be able to improve the production performance in the dwelling construction industry.

The housing situation in particular in many developing countries points at the need to bridge a *tremendous gap between the supply and the demand of adequate housing* for the lower income households.(UNCHS 1994) This is also the case for *Tanzania and Costa Rica.* Both countries belong to the so-called *developing countries.* In terms of income level Tanzania belongs to the countries with the lowest income per capita in the world. Costa Rica belongs to the middle income countries. Despite the tremendous efforts put in by governments and other housing related agencies a rather tremendous gap still exists between the supply and the demand of adequate housing to the common man. It is assumed that a careful preliminary comparison can be made between the two countries. Hereby is also assumed that the development status of the countries has an impact on the production performance.

More pragmatic reasons for the chosen research focus on the dwelling construction industry in the mentioned countries are

a. the disciplinary background of the researcher in this project that makes that the testing of the technology mapping methodology could best take place in the construction industry. The basic tools for the in-dept analyses of the utilized technologies are derived from the realm of the construction engineers. Complementary data (e.g. macro-economic and sociological data) are derived from other sources.
b. the opportunities for the researcher in this project to have a reasonable access to data sources thanks to the collaboration with organizations, institutes, enterprises and government agencies in the mentioned countries.

3.3 Particularities of the dwelling construction industry

3.3.1 The dwelling construction industry

The dwelling construction industry is a sub-sector of the construction industry. Definitions for the construction industry were formulated in numerous ways. (See appendix I-3 for an overview of definitions) In this research project the following definition is considered useful.

> *The construction industry* comprises "all enterprises, institutions and persons which are involved in the realization of a building construction project on-site, this includes those activities that lead to the shaping of a man-made built environment which meets the human needs for shelter and infrastructure".(ISIC 1968)

The *function of the construction industry* is to produce the artefacts that constitute all kinds of shelter and infra-structural works that are needed by the society. There is a wide variation of *finished products* in the construction industry. Each has its particular function and each is constructed upon terms of reference that are derived from the specific demand for it.

Table 3.1: Market segments of the construction industry, Source RIBA/SfB 1968

Environmental works	Land, planning, landscape in general
Public works	Civil engineering works, transport and infrastructure
Buildings	Transport & industrial buildings
	Administrative & commercial buildings
	Health and welfare buildings
	Refreshment, entertainment & recreation buildings
	Educational, cultural & scientific buildings
	Residential buildings in general
	Religious buildings
	Buildings, architectural spaces in general

It is the market that really sets the terms of reference for each individual product in the construction industry. The products of the construction industry can be classified in a number of market segments among which the market of residential buildings. (table 3.1) The number of market segments that are served by the construction sector obviously remain unchanged overtime.

3.3.2 The building construction process

The process of building construction can be seen as the translation of a client's needs and intentions: first into documents and other information and later into a physical item. The following definition is considered useful in this research project.

> The *construction process* involves *all necessary activities and the interactions between the parties involved in construction with the objective to establish a building and/or a built environment responding to human needs.* (Ofori 1990)

A construction process can be compared with the production processes in the manufacturing industry. There are a number of differences though. A most remarkable difference is that nearly every end-product of a construction process has its own characteristics -based on individual terms of reference (specifications)- and nearly none of the end-products is composed out of exactly the same components. Another particular characteristic of construction processes is that every finished product requires *adaptations to the specific location and terms of reference* set by the potential owner, client or architects and construction engineers. Moreover buildings rarely can be moved and thus are bound to the location where the production process has taken place.

In contrast to processes in the manufacturing industry the *construction process takes place in and is organized around projects.* Project executing organizations deal with the fact that there is not necessarily a continuous follow-up of one project after the other. Every project consists of a process of *interrelated activities and interactions* that take place in sequence between the involved parties with beforehand planned and specified goals, scope, costs, time span, performance criteria, which on their turn are intimately related. The process may be organized in several ways and the sequence of activities may also differ from one project to another. The major differences between general production processes and the processes in the construction industry are indicated in table 3.2.

Table 3.2: Production in industry viz-a-viz production in the construction industry
Source: Smook, RAF, et all, 1997 TU Delft CT

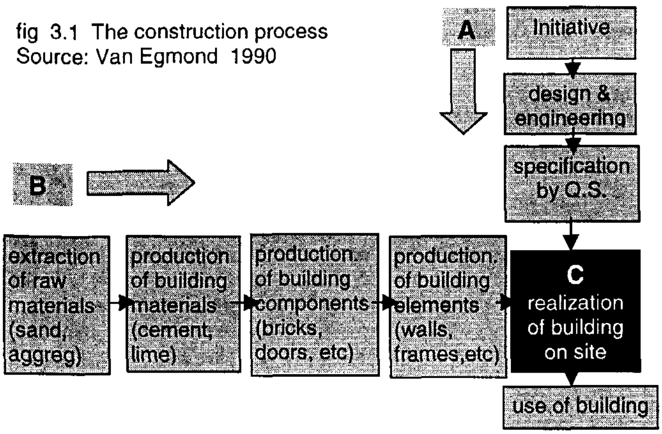
	PRODUCTION PROCESS	ACTIVITIES & ACTORS
INDUSTRY	.Supply oriented .Batch production .Stock of finished products .Production located in factory .Transport of final products to market	Initiative: entrepreneur design: entrepreneur production: entrepreneur purchase: client
CONSTRUCTION	.Demand oriented .Unique products .Project-based process .Production on site .Final product on site of client	initiative: client design: client + consultants production: contractor purchase: client

The construction process is a *multi stage process,* that involves a number of subsequent activities and sub-processes in various stages of the construction project.(see fig 3.1):

A. planning, designing, engineering, specification, tendering, preparation and organization
B. production of the physical construction components.
C. physical realization of the construction project.

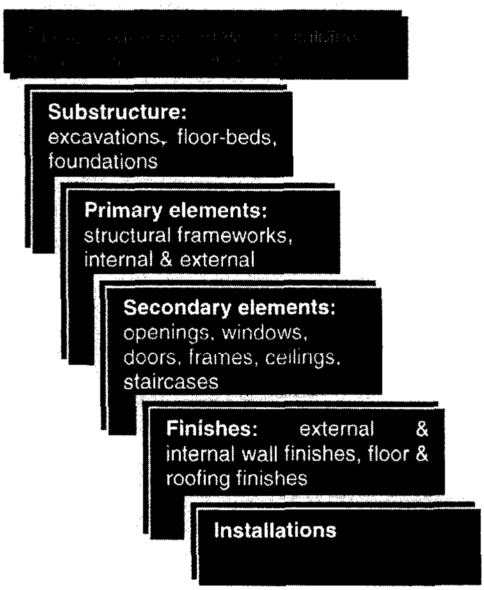
This last stage generally takes place *on site* and is mostly unique due to the ever needed adaptations to the particular functional requirements and the physical circumstances

fig 3.1 The construction process
Source: Van Egmond 1990



The activities take place in, around and in connection with a facility from the time of its initial conception to the time of its destruction. (see also appendix I-3)
In this study the focus will be on the construction processes on site that are (generally) carried out by a contractor. Activities that take place during the early phases of a construction project set the framework for the production process on site. This means that also the site production performance is affected by the outcome of the foregoing activities.

3.3.3 Construction technologies



Alike in any other production process, *construction process technologies* are used to transform the material inputs into the desired *output.* The final production output of a construction process is the total building.

The building can be de-composed in the building components: (1) construction products (building materials), (2)work sections (building components), (3) elements (ISO/TR 14177:1994)

During the different phases of the construction process the building elements are produced in sequence:
(1)Substructure,
(2)primary elements - main structure, external and internal walls, floors, roofing structure,
(3)secondary elements e.g. openings, windows, doors, ceilings, staircases
(4)finishes - external and internal wall finishes, roofing.
(5)installations

In this research project a distinction was made between the *complex of product technological characteristics of the building* and the complex of *process technological components.* (see part I-chapter 2)

The *product technological characteristics in the construction industry* are the properties and features of the built objects and their components, including construction products, work sections, elements and whole facilities. The major characteristics include (1) functionality, (2) geometry, (3) nature of materialization, (4) physique-technical properties, (5) production complexity, (6) costs. (see also ISO/TR 14177:1994 (E) The attributes of the components determine the attributes or *product technological features* of the final product.

Construction process technologies are regarded as the complex of four components. Object embodied technology (Facilities or techno ware), person-embodied (Abilities or Human ware), document embodied (documented facts or infoware), organization embodied (frameworks or orgaware) applied to the construction process on- site. Any transformation process only can take place when a minimum is present of all four components of technology. All four components can be marketed separately. (UNESCAP 1989) In each of the stages of the construction process on site a different complex of process technology components can be applied.

A classification can be made of these process technologies *based on the rate of advancement of tools* used in the transformation processes in terms of (a) the rate of substitution of manpower and (b) the potential to control the production process.

The following classification is used in this project. It represents a sequence of increasing advancement: (1) hand tools, (2) powered tools, (3) powered tool with control mechanism, (4) totally mechanized tool: man only needed for making the tool run (push on a button), (5) tool which can be programmed manually, in order to reach identical end-product, (6) tools grouped in a certain efficient sequence to handle multi-staged production processes efficiently, (7)(CAD/CAM tools. In general only the first three categories of tools can be found on the construction site.

The terms of reference for the quality and the quantity of the final construction output (in terms of functional, esthetical, materialization, physical, durability, production complexity and costs aspects) determines the choice for a certain set of process technological components. For every construction project it is possible to choose from several possible combinations of technologies that fit the terms of reference for the quality and the quantity of the final construction output. The possibility to choose the simple technologies out of the range is one of the reasons that the construction industry has a rather low entrance barrier for new production units. Capital investments can be kept rather low in this way.

Construction technologies are as old as man himself. In industrialized as well as in developing countries a mixed combination can be found of modern and traditional technologies, that are complementary to each other.

The sophistication of the construction technologies increases with the nature of the construction project. (Ofori, 1990). Ofori even states that in the construction industry the level of technology used is a function of the development status of the country and thus also indicates the level of technology capabilities. This is in line with the theoretical viewpoints that are adhered in this research.

Table 3.3 Product- and Process technological complex

product technological characteristics complex	1. functionality 2. geometry 3. materialization 4. physique-technical qualities 5. production complexity 6. costs
process technological components complex	1. technoware (plant, equipment & tools) 2. humanware (man embodied knowledge & skills) 3. infoware (documented facts) 4. orgaware (organizational framework)

3.3.4 Actors in the construction projects

In each stage of the process often *different participants* are engaged each with their own tasks, responsibilities and functional interests. One can distinguish ***direct and indirect** actors* who can be involved in a construction project. (see figure 3.2).

I. The *direct actors* in the construction industry -like in any other sector- can be classified in two directly involved aggregated groups:

Ia. the *demand-side actors* (public sector clients, private owners, property companies, investors) and

Ib the *supply-side actors* (the construction units)

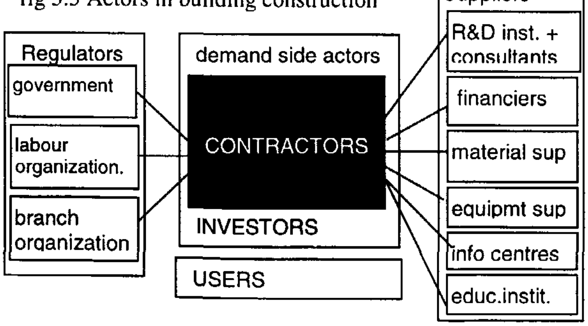
II. *Indirect actors* in the construction industry include:

II a. *technology supplying institutions* (R&D institutes, educational institutes, architects & consultants, building materials suppliers, equipment suppliers and plant hire firms)

II b. *technology supporting and regulating institutions*

(financing institutions, the national government and public agencies, branch organizations and labor unions)

fig 3.3 Actors in building construction

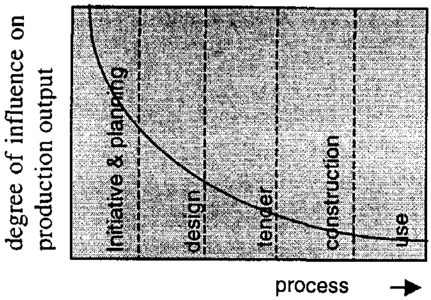


The physical realization of the houses on site can be carried out by formal or informal sector building contractors. Also various other parties can be involved. These form the actor network or the *technology infrastructure* of the dwelling construction sector. Financing organizations, property and real estate developers, governments and sometimes even also the owners are involved in the process. The *different parties in the dwelling construction industry* have their influence on the price, quality and quantity of the supply of houses. The motives and objectives of the different parties do not always comply with each other, in many cases are even contradictory. Acceptance, application and implementation of technology developments, innovations and improvements in the construction industry therefor slowly come to pass.

Construction management, which involves the attuning of the various tasks and responsibilities of the various parties in the construction process, becomes rather important for the ultimate efficiency and effectivity of the construction process.

In other production sectors the initiative to produce a certain product, the design and engineering of the product, (which determines the price and quality) and the production process all are generally in one hand.

fig 3.3 Degree of influence on production output



The involvement of many of the actors other than the contractors generally takes place *until* the tender phase in the construction industry. (see fig 3.3 and appendix 1-3 for additional notes on the actors in the construction industry.)
For the contractor this means that he has to inform himself on these preceding phases as much as possible. This will especially apply to any information, like drawings and documents on which he basis his tender and further (cost) planning.
Problems and constraints in the first phases of the construction process generally constitute negative factors for the site performance of the contractor. Moreover, the existence of problems and constraints within the individual contracting firms may hinder the attempt to limit the impact of external constraints. For example in-adequate diffusion of technologies by external actors (an external problem element) may fully affect the contractor's performance if he does not have a certain technology status to carry out the project properly.(internal constraint). So, from the tender phase on the contractor has to avoid the existence or coming into existence of any of such internal problem and constraint situations.

The above indicates that the factors that have an impact on the construction project performance on-site can be classified as (a) *Internal factors* that occur within the construction project and the construction process carried out by the contractor. and (b) *External factors*, like the results of activities of other actors in the preceding phases of the construction processes on site.

3.3.5 Technology development in the construction industry

Historically building construction heavily depends on the craftsmanship of the labor force involved and is rather labor intensive. But construction enterprises are more and more forced to optimize their price-quality ratio to compete on the market and to be able to reach an output which meets the market demand. Enterprises thus need to either undertake R&D activities themselves or join those carried out by research institutes to come to innovations in both building products and building processes. (Ofori, 1990).

The *production of prefabricated building components* (doors, windows frames etc) and *building elements* (walls, roofs, etc) is one of the solutions which contributes to an improved construction site performance. At least a certain quality of the finished product can be guaranteed.
This development was enhanced by a rapid increase of demand for construction output due to population growth and industrialization effects Operation procedures for building construction were introduced similar to those for industrial production processes, including project development procedures, marketing and sales procedures, logistics and distribution procedures. Construction process technologies changed and the processes evoluated towards a more and more industrialized way of production. It became a process of assembling of industrially produced components that facilitates the on-site activities of building construction

and thus could result in a better price-prestation ratio. In order to stimulate this evolution further also the product technologies had to change. Hereby the terms of reference for buildings were generalized and translated to selected prototypes for certain market segments (end-users / target groups), that can be built by using optimal construction process technologies and by reduction of material inputs.
The *rationalization and optimization of the utilized production process technologies* on the construction site, implied (a).the move of building construction activities from the site to the factory and (b). the standardization of building components and construction technologies. Through this industrial production of components it has been possible (a) to improve the quality of the components and the finished building; (b) to reduce production throughput time on site thus to achieve a higher production output from quantitative point of view; (c) to reduce construction costs although the cost-effectiveness of the industrialization of the production in the construction sector still depends from the scale of operations.

The construction industry has made progress in the standardization and even mass production of building components. However this has not yet happened to the same extent as in the other production sectors like the manufacturing industry.

Technology developments in the construction industry take place at a rather slow pace. A major reason is the involvement of many participating parties in the construction projects.

The construction industry shows a *low output of formally recorded R&D* efforts compared to that in most other sectors of the economy. But in real practice innovative efforts take place on a continuing basis in each construction project on the shop-floor. These are often not recorded as such. Thus the yield of the efforts is generally considered to only include *unimportant low-technology* issues.

The output of innovative efforts that is really taken into account in the statistics are those research activities that are formally carried out by central public owned research organizations, universities, private firms (Atkinson 1989, Furukawa 1980, Horiya 1990).

Another phenomenon can be noticed in the construction industry that is different from that in other economic sectors. Once new technologies have been introduced in most other industries, then the older ones become obsolete and often are completely replaced by the new ones. This is not the case in the construction industry: the old ones stay existing next to the newly developed technologies and materials.

The diffusion of technology developments generally faces quite some constraints within the construction industry. These are induced by a reluctance to change, a tendency to conservatism, due to the risks and marginality of profits; the array of regulations and standards, often unduly conservative and prescriptive, the variety of contractual agreements and the separation of responsibilities in the construction process. (Nam&Tatum 1988, Moavenzadeh 1974, Ive 1983 ,Ofori 1990). The uniqueness of each construction project on the other hand provides an impetus for technology development. This is for example possible through the integration of technology improvements in the project planning. And since construction operations are rather transparent, easy to copy and have the opportunities for job-site training, the industry has an extensive scope for technology transfer from other projects and industries (Hillebrandt 1984, Tatum 1986, Chow 1990)

Against *international technology transfer* of construction technologies is even more reluctance in the construction industry than in any other sector of economy (Abbot 1985). This is in line with the resistance to any technology development in this industry. *Joint* *ventures* seem to offer the best possibilities for international transfers of technology (World Bank, Andrews, 1984, Chow 1985).

The *lack of coordination and information* regarding the formulation, execution and evaluation of R&D programs and the dissemination of the results to beneficiaries forms a real constraint to production performance improvements in the construction industry.

3.3.6 Production performance in the construction industry

The idea that *production performance* in building construction depends on the technology status in the construction projects induced that technology developments and improved technology utilization were launched to improve the project production performance. Empirical evidence showed that widespread performance improvement at the project level result in growth on sector and national level. It also appeared that cost effects seem to depend on the scales of operation.

The production performance thus depends on the quantitative, qualitative and cost attributes of the construction output versus the utilized means and procedures applied in the construction processes for the transformation of inputs into the desired output.

The quality and price of a building is determined by the totality of attributes of the finished building (the product technologies) including the way on which individual attributes are related, balanced and integrated in the whole building and its environment for an acceptable period of time and which enables it to perform a stated task or to satisfy a clients given needs.(see also Atkinson1995). The duration of the construction process in man-hours may serve as an indicator for the *quantitative features* of the construction performance.

Atkinson puts forward that to achieve a satisfactory construction performance for the market it is at least necessary to (a) identify the quantitative and qualitative needs of the target group and their characteristics ; (b) clearly identify and specify the roles and responsibilities of the teams involved in the building construction process; (c) recognize the need for quality in the total system of building construction to achieve a satisfactory end-product, including building materials production, design and engineering and construction on site, which requires for total quality management. (Atkinson, G. 1995). The first aspect which is put forward by Atkinson refers to the terms of reference of the production output (the *product technological features).* The last two aspects refer to the status of the utilization of the *process technology.* Thus alike in any other sector the effectivity of the production output and the efficiency of the use of process technologies determines the technological production performance.

3.4 Research design for technology mapping in the construction industry

3.4.1 The assessment of the technological production performance

In the *assessments of production performance* of a construction project a single construction project is seen as *production system.* This is assumed to be independent. In reality one may see that factors of larger systems (the company, sector and country) influence the production performance of the project on site. The existence of the production system is fixed in time (duration of the construction project) and space (geographical location) since the production process takes place on site during a predetermined period of time and location.

The (site) *output* is a building of which the quantity and quality is specified by the client.

The *input* comprises all resources that are directly needed on site during the realization of the site output. The so-called direct input factors include material-inputs and process technologies (labor, equipment, information, management and subcontracting). Since the inputs are of different type, monetary units are generally used to aggregate them. This has not been done in this research project.

Quality and quantity are fixed output aspects from a contractor's point of view. The contractor determines the most realistic, efficient and effective combination of inputs, needed to realize the output as desired by the client who specified the required quality and quantity of output. The construction cost price, includes a certain margin for the contractor. The final choice on a certain combination of inputs will determine the monetary value of the site output from the viewpoint of the contractor. Thus the contractor fixes the quantity and quality of inputs. The final cost Price is fixed after an agreement between client and contractor has been reached on this matter. The total value of the output could be expressed as 'Q(uantity) of output x P(rice).(deJong 1968) Strictly speaking, the value of the site output can thus not be changed afterwards by the contractor.

A review of various publications dealing with performance and productivity of construction projects indicates that these are mainly of *economic nature* and focused on labor productivity (Calvert 1970, Drewin 1982, Oglesby 1989). Construction Project Performance (CPP) in *economic terms* is defined as: the ratio of the value of the project output to the costs of the direct input factors, used to realize this output during the production process on site:

$$\text{CPP} = \textit{Value of the site output} \,/\, \textit{Costs} \,(\, M + T(L+E+I+ \textit{Man} + \textit{Sub}))]$$

(M = materials, T= technology, L= labor,, E= equipment, I= inform, Man= managemnt, Sub= subcontr)

The conclusion from this is that an improvement of the site productivity level has to take place by decreasing the costs of the direct input factors. But sole economic assessments of productivity or production performance expressed in monetary values do not reveal the exact features of the chosen technologies in production. Even when the characteristics of the project output are specified, still a range of alternative transformation technologies are theoretically applicable to produce the required product. Each of these technologies has particular characteristics regarding effectivity and efficiency from technological point of view. These do not necessarily comply with the economic terms of efficiency and effectivity. Thus the choice for utilizing a certain transformation technology needed to realize the output as desired by the client depends from the available range of technologies known and accessible to the contractor. Therefore an alternative definition for construction technological production performance from techno-economic perspective suitable for technology management purposes should be:

> *"The degree to which the realization of a required and predetermined construction project can be realized efficiently and effectively within the framework of the output predetermined costs and construction period".*

The *effectivity of production projects* in technological terms then refers to the rate to which the production targets regarding the product technological characteristics of the desired output are achieved qualitatively and quantitatively.(See additional remarks in Appendix I-3). Effectivity thus can be measured in terms of technological quality and quantity and in terms of economic values. The technological effectivity can be expressed as follows

Techn Effectivity = O i/ O r (Oi= idealtypical output, Or= real output)

The *efficiency of production projects* in technological terms refers to the ratio of actually utilized versus the theoretically possible utilization of means and procedures for the transformation of inputs into desired outputs.

Techn .Eff = THIOr / THIOi (THIOr= real THIO , THIOi = idealtypical THIO)

T=technoware (equipment and tools), H=human ware (labor force) ; I= infoware (documented facts); O=orgaware (organizational framework)

The improvement of the production processes in terms of a higher degree of efficiency and effectivity can be reached through the application of further advanced production process technologies. An improvement of the process technology in a production system has proven to contribute to the efficiency of the production process. But the above counts only partially for the construction processes on site. Improvement of the construction process on site has also been the result of the development of *intermediate* product-technologies. *Building-components* like windows, doors and casements and even *building-elements* like complete parts of a wall structure, roofing structure, etc are produced off-site in standardized industrial processes. This has enhanced the quality and quantity of the final construction site output. Thus in the calculation of the efficiency coefficient the product technological status of the building components and the building elements have to be taken into account. It can be expressed as Minput or as a certain coefficient β.

Techn.Efficy = β.THIO r / THIOi

β= Material input; THIOr= real techn. inputs , THIO i = idealtypical techn input)

Technological construction project performance is then the product of efficiency and effectivity of the construction process

TPP = βTeff x T effect. = β x THIOr/THIOi x Oi/Or.

3.4.2 The assessment of the status of product- and process technologies in the construction projects

The assessment of the product technological features of the output of the construction project can take place by taking the terms of reference (specification) for the building as measure stick to evaluate the realized product technological attributes of the building.

The procedure that can be followed for the assessment and evaluation of the process technologies in the construction process of houses includes the next steps.
The production process is to be subdivided into the different phases of construction of the building elements. The next step is to assess the status of the Technoware and the Humanware components of the production process technologies that are applied in each of these phases. The infoware and orgaware component of procestechnology are to be assessed for the whole construction process at once. The organizational framework of the construction projects can be classified as (a). International operating contractors, (b). conventional large contractors, (c). conventional medium or small local contractors, (d). very small and informally operating construction workers.(Ofori 1990)

By assessment of the status of the product- and process technologies and the resulting technological production performance in this way it is possible to identify the internal factors that determine the production performance of construction projects.

Next to this a number of **external factors** in the operational environment of the construction project have an impact on the technological production performance: the factors of the sectoral technology setting, the national and international setting

The major variables that determine features of the sectoral technology setting are the sectoral technology needs and the sectoral technological capabilities. The both set the terms of reference for the technology choices to be made in the sector.

3.4.3 The product technology needs in the residential construction sector

The determination of the technology needs in the construction industry is not always an easy task. This counts in particular for the residential construction sector. The market of the construction industry differs from that of other production sectors in terms of (a) market segmentation, (b) its diffuse character with many different participants in both the supply and demand side of the market. Moreover the effective demand for the number and type of dwellings to be supplied highly depends on the *affordability* and the ultimate *willingness-to-pay* by the potential buyers of the houses in the market.

To calculate the exact quantity of the needed houses various models have been developed. A *simplified method* to determine the potential effective demand for houses involves an estimate of (a) the population growth and (b) the increase of number of households differentiated by households size, income level and rural-urban status, by assuming that the existing households already are adequately housed. The last is not always true. The features of the existing housing stock have to be taken into account. This housing stock also includes (a) houses at sub-standard level and (b) houses inadequate for habitation and non-repairable. (see appendix I-3)

The technologies that are needed by the actors on the supply-side of the residential construction sector depend on the status of the technological capabilities that is discussed in the following. The actors on the *supply side* of the housing market belong to the technology infrastructure of the sector. A distinction can be made in (a) *Private sector* actors: contractors, property development agents, real estate exploiters, financing institutes, firms , house-owners and (b) *Public sector* actors: governments and parastatals.

3.4.4 Technological capabilities in the construction industry

The state of art of the technological capabilities can be assessed by investigating the complex of characteristics of the national stock of (a) technologies, (b) exploited natural resources, (c) human resources, (d) technological infrastructure that can be committed to the construction industry.

The *assessment of the status of the technology stock* should take place by investigation of the quality and quantity of the available range of technologies of the technology sub-system. This range includes the (a) process technologies and (b) product technologies that can be committed to construction processes in the dwelling construction sector.

The indicators to be used for *the assessment of the human resources stock* are 1.the population figures, 2. the age structure, 3. the educational profile, 4. the employment profile, 5. the skill profile in terms of labor force employed as researchers, teachers, managers/engineers, specialized technicians, crafts persons (skilled), laborers (semi-skilled & unskilled). This status is supposed to indicate the (a) availability and nature of human resources relevant for the sector, (b) the capabilities to make use of the necessary numbers and educational backgrounds of persons in various production activities judiciously.

The major indicators that can be used for the *assessment of the natural resources stock* in the construction industry are the attributes of the natural resources for the major inputs in a construction process (land, water, energy, forest, metallic and non-metallic mineral resources). The status is supposed to indicate the (a) availability of exploited natural resources relevant for the sector, (b) the capabilities to exploit these natural resources judiciously.

The *assessment of the status of the technology network* (technology infrastructure) serves the purpose of getting information on the complex- and the outcome of interactions between the technology utilizing organizations and firms of the construction technology sub-system and the other technology supporting, promoting agents and groups. The assessment of the status of the technology infrastructure includes the (1).Identification and classification of the institutes and organizations belonging to the sectoral technology network; (2).assessment of the major features of the institutes and organizations belonging to the sectoral technology network; (3). assessment of the linkages among the of the institutes and organizations belonging to the sectoral technology network. The institutes, organizations and enterprises that generally belong to the construction industry are discussed in detail in Appendix I-3.

3.4.5 The national (NTS) and international (ITS) technology setting of the construction industry

The particular features of *the national environment* in which the production takes place have an impact on the performance of all production sectors. The construction industry forms no exception. The national setting of productive activities in a country is determined by (a) the social system characteristics, (b) the characteristics of the geo-graphic physical system (c) the historic backgrounds of the country.

The *social system variables* of importance for the construction industry are (a) the political system, (b) the economic system, (c) the educational system. The political stability and national policies, regulations (standards, building codes, etc.) have an impact on the construction industry (see appendix 1-3). The economic situation (income level, inflation, interest, trade balance) in the country determines the abilities to invest in construction. The educational situation (literacy and enrollment rates, type and quantity of education programs) determines the availability and development potential of skills and knowledge for construction.

The *geographic-physical variables* of importance for the construction industry are (a) the geographic location of the country, (b) geology, (c) physical infrastructure and (d). demography and urbanization

The *geographic location* of the country determines its accessibility and its *climatological features*, which is of high importance for the specification of the product technologies in the construction industry.

The *geological features* in a country determine the nature of the soil, the occurrence of earthquakes and volcanic eruptions that have to be taken into account for the specification of the product technologies in the construction industry.

The *physical infrastructure* in terms of road-, railway- and waterways- network is of importance for the construction industry, since its production processes are location bound. Moreover a fully fledged communication network like the present electronic networks is nearly indispensable in any sector of production now-a-days.

The *demography* determines the availability of manpower for construction and the urbanization pattern determines the concentration and the location of the supply and demand for construction.

Insight in the *international technology setting* of the construction industry compared to other countries gives explanatory data for the technological performance of an industry in the country. The GDP/capita index indicates the level for potential savings and investments in the construction industry. The Human Development Index (HDI) level of the country also implicitly indicates the level of education (knowledge and skills) compared to that in other countries. Production and trade figures indicate the dependence situation on foreign capital (goods). These are used to indicate on aggregated level the international technological setting in terms of the status of the technological capabilities and technologies in the production system relative to those in other countries. Insight in these elements may facilitate the optimization of the use of opportunities and the alleviation of problems and constraints to fill any technology gaps by international technology transfers. The international relations of the country and the existence of international disputes, wars, etc indicate the international political setting in which the construction industry has to operate. A war in a neighboring country may imply an influx of refugees, which puts some pressure on the supply of shelter by the construction industry.

3.4 6 The impact of the construction industry on socio-economic development

The construction industry is unique in its ability to facilitate societal development by providing directly for human needs for all kinds of shelter, be it shelter for housing or shelter for the execution of economic activities. (Moavenzadeh 1987). Literature indicates that the construction industry with all its key sub-sections: design, supply, assembly, maintenance is one of the biggest employers of semi-skilled and unskilled labor, it contributes significantly to GNP, fixed capital formation and to government revenue.
The contribution of the construction industry to *Gross Domestic Product* accounted for approximately 10% in the European Community (EEC 1991) and in developing countries between 3-9% (Turin 1973, EEC 1991). In terms of production output the construction industry proves to be one of the largest industries. Also the tendency towards an increasing contribution of this sector to the GDP as development continues has been indicated in a number of research publications. *Employment* figures show that the construction industry counts for more than 6% of total employment in OECD countries, 3% in Africa, 4% in Asia, 6% in Latin America.(UNIDO 1993) (see appendix I-3)

The *conclusion* of the above is that the construction industry can play a crucial role in the socio-economic development of a country. This means that the investments in the construction industry provide for long term socio-economic benefits in a nation. The close relationship between the construction industry and the socio-economic situation in a country may indicate that the particular construction technologies which are used to provide for the needs for shelter and infrastructure will have an impact on almost every aspect of its society.(e.g. housing, education, health, communication, industry, economy, etc) The effective execution of dwelling construction requires the efficient and effective mobilization of the technological capabilities in the sector. A tremendous gap between demand and supply of adequate and affordable housing indicates that its performance does not meet the expectations. This implies that the potentials of the sector might not be used adequately.
These aspects formed the challenge in this research project to investigate the exact reasons of the problems and constraints to an effective performance of the construction sector and to identify the strength and weaknesses of the sector in order to determine ways for the development of the local construction industry.

3.4.7 Concluding remarks

The basic research framework for technology mapping requires adaptation to the particularities of the industry that is to be investigated. Attention was given to the following considerations regarding the adaptation to the construction industry.

The *construction output* -the building- is composed of a number of components. The technological attributes of the individual components determine the attributes of the final product. It is possible to produce each of the components on site, out of the raw materials. Improvement of the production performance could have taken place in the course of time by replacing the production of components but also the production of elements -and in western countries also of complete buildings- from the site to the factory. This still is not the case in many developing countries in particular in the sub-sector of dwelling construction for the lower income households.

For the assessment and evaluation of the *status of technologies utilized in production* the major adaptations concern the particularities of the product technologies in the construction industry.

For the assessment of the *site production performance* has to be taken into account that the particular requirements for the process technologies on site follow the attributes of the inputs of the building components. This requires an adjustment of the originally proposed calculation model for production performance. (see chapter 2 of this part of the thesis)

By means of the assessment of the site production performance in this dis-aggregated way the *internal opportunities, problems and constraints* for improved production performance can become evident.

Next to this one should investigate which *external factors* affect the site production performance. This means that the respective sectoral, national and international setting of the construction projects should be investigated. Included in the sectoral setting are the sectoral technological capabilities. This is seen as the core element for efficient and effective construction project performance and thus deserves a thorough investigation.

For the assessment of the sectoral product-technology needs in the dwelling construction sector one should take into account the particular characteristics of the households.

The *potential* utilization of the raw materials in the building construction industry should be taken into account in the assessment of the stock of natural resources as part of the technological capabilities.

The optimization of the technological production performance (TPP) requires anticipatory actions to be taken for the execution of construction projects. This implies *proper technology management and planning* in the construction units based on detailed information on the technologies applied in foregoing processes and those which are to be used in forthcoming construction processes in order to alleviate the internal problems and constraints and make use of any opportunities.

3.5 On the application of the technology mapping methodology in Tanzania and Costa Rica.

The *major objective* for the execution of the field studies was to determine the usefulness of the developed method for mapping the status of the technological capabilities and the technologies used in production systems by its application in field studies.

The results of technology mapping studies are expected to facilitate the identification of the strength and weaknesses of technological capabilities, the technology status in production activities and the technological production performance in a dis-aggregated way in the production sector under investigation. These should also enable the identification of the opportunities, problems and constraints for the improvement of the technological capabilities, the technology status in production activities and the technological production performance.

The execution of the field studies in this research project thus included a *second objective:*

> to offer insights in the possibilities for management and policy interventions directed to bring about the improvements in the weak elements of the sectoral technological capabilities and technologies in production in order to achieve the development targets for the successful performance of the sub-sector in question.

The technology mapping studies –as carried out in this research project- include a *number of separate studies* that are necessarily of a different disciplinary nature. The studies are mutually supportive, to ensure a meaningful integration of the various socio-economic and technological components which characterize the actual situation regarding the status of technological capabilities and technologies in production in their respective technology settings in the country. The technology mapping studies are of a *comparative descriptive nature* and can be seen as ad-hoc sample surveys during which the major characteristics of the particular production sector are investigated and described.

Research instruments were developed and adapted to the particularities of the sub-sector of dwelling construction to collect the necessary data. (see appendices II and III)

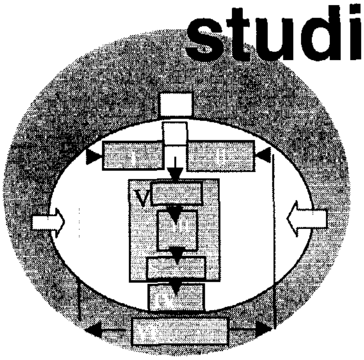
Many data were collected from secondary sources. Most attention was given to the collection of *primary data* on the status of technologies in the dwelling construction projects and the resulting construction project performance. The basic *research unit* in the mapping studies of the technology status was the dwelling construction project for the lower income households. The number and accessibility of the construction projects and the construction units involved in the dwelling construction projects for lower income households were determining for the decision to investigate either the *total population or just a sample.* Further details on the applied sampling method, the methods for data collection, the sources of the data, data analyses and interpretations are given in the following parts of this thesis.

The *data collection* during the field studies was carried out in collaboration with various institutes, organizations, enterprises and government agencies in Tanzania and Costa Rica, which made the collection of the extensive data set possible.

The *results* of the application of the methodology for technology mapping in the dwelling construction industry for lower income holds in field studies in Tanzania are described in part II and the results of the field studies in Costa Rica in part III of this thesis.

Part II

Technology Mapping studies in Tanzania

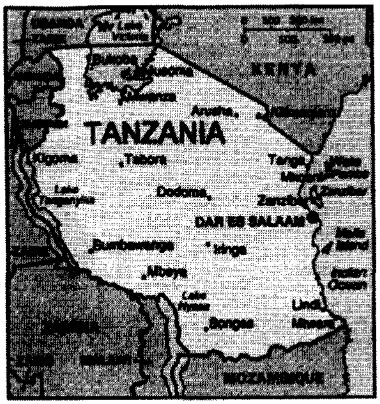


An Application of the Technology Mapping Methodology in the dwelling construction sector for lower income households in the Urban areas of Dar Es Salaam in Tanzania

Contents

Chapter 1

Empirical aspects of the Technology Mapping Studies in Tanzania



part III

1.1 Introduction

In this part of the thesis a description is given of the results of the application of the developed technology mapping methodology in studies on the sector of dwelling construction for lower income households in Tanzania.

Tanzania is the largest country in East Africa. The country still has a predominant rural character. Dar es Salaam is the Tanzanian capital, located in the coastal region bordering the Indian Ocean. It is the most urbanized region in the country. The application of the Technology Mapping methodology took place in the urban areas of Dar Es Salaam.

The aspects that had to be taken into account during the application of the technology mapping studies in Tanzania are discussed in the following sections of this first chapter.

1.2 Research procedure and sub-studies

The technology mapping studies involved the execution of a number of *sub-studies* at different levels of aggregation. *Baseline studies* were executed first resulting in a relative extensive data set for the static description of the actual and desired state of art of the key-elements of the Technology Mapping model. Next *evaluations* were carried out by comparison of the actual situation against the desired situation regarding (1) The sectoral Technological capabilities (2) the sectoral technology status, (3) the sectoral technological production performance of the sector. At last the *conclusions* on the opportunities, problems and constraints for improvement of the technology situation in the sector are discussed and the implications of these for technology management in the Urban Area of Dar Es Salaam in Tanzania.

The housing situation in urban Tanzania was investigated first. Based on this the Sectoral Technology Needs (STN) could be determined, which is expressed in the quantity and quality of the needed houses as described in chapter 2. Then a study was made on the Technological Capabilities (STC) for the dwelling construction sector (chapter 3). In chapter 4 the data are given that result from the mapping studies on the status of technologies (STP) in dwelling construction projects in the urban areas of Dar es Salaam. Chapter 5 describes the determination of the sectoral technological production performance (TPP).

Table 1.1 Sub-studies in the research project

SUPRA-MACRO & MACRO LEVEL	The country to investigate: a. the international setting of the country and the construction industry b. the national setting of the dwelling construction activities
MESO LEVEL	The housing sector and the construction industry a. to investigate the sectoral technology needs b. to gather data on the technological capabilities in the sector. c. to investigate the general setting in the construction industry
MICRO LEVEL	The construction projects a. to investigate the project setting b. to investigate the status of the technologies

In chapter 6 the findings on the sectoral technology setting (STS) of the construction industry as major actor in the provision of houses in Tanzania are described. The particularities of the national technology setting (NTS), and the International Technology Setting (ITS) of Tanzania that are considered to have an impact on the technological production performance are described in chapter 7. A synthesis and discussion of the findings on the opportunities, problems and constraints for the optimization of the performance of dwelling construction sector for the lower income households is given in chapter 8. The overall conclusions on the implications of the findings of the technology mapping studies for technology management in the dwelling construction sector in Dar Es Salaam in Tanzania are described in chapter 9 of this part II.

1.3 Population, sample and research instruments

The in-depth field studies on the Technological capabilities at sector level and the technologies used at project level in the construction processes for (and by) the lower income households in the urban area of Dar es Salaam in Tanzania took the major part of the efforts in this research project. These studies are basically of technological nature. Secondary sources have been used for the majority of data resulting from studies that were executed by researchers in other disciplines.

The population of the mapping studies of the technologies at project level included those dwelling construction projects for the lower income households that are located in the urban areas of Dar es Salaam. The sampling procedure that was applied for the micro level research is indicated in chapter 4 of this part II. The research instruments that were used are given in appendix II.

1.4 Data collection, analyses and interpretation

Data collection methods that were applied during this research included literature studies, unstructured interviews with key persons and experts, structured interviews and non-participant direct observations. (See appendix II-1 table II-1) The data could not be collected by means of one method. It was also necessary to crosscheck the reliability of the found data. *The data sets* were derived from: (1) primary sources like contractors and house owners involved in the construction projects for the data collected through field studies with the assistance of students, in particular on the state of art of technology utilization in the dwelling construction projects in the urban areas in Dar es Salaam; (2) secondary sources like data sets from internationally recognized sources like the World Bank and UN statistics as well as from the locally available resources within the collaborating organizations and institutes overseas.

The data sets of the own field studies in Tanzania were compared with the data that were found in several publications. This counts in particular for data on the product- and process technologies and detailed data on the backgrounds of the participating parties in the dwelling construction projects for the lower income households.

Data collection in Tanzania was extra difficult due to the practically non-existence of data banks on the information that was needed in this research project. Most of the projects were not registered and even built on illegally. Most of the houses happened to have been built by the type of (petty-) contractors who are also not registered and therefor difficult to trace. Moreover record keeping did seldom take place and appeared to be unusual in the dwelling construction industry.

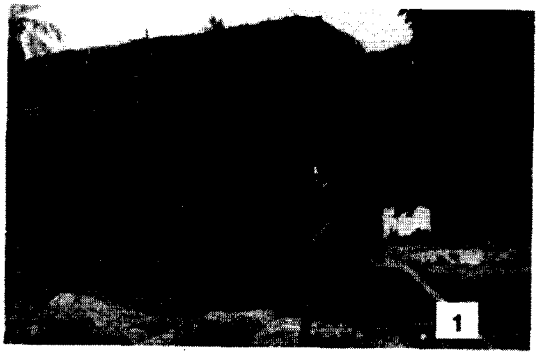
The collaboration with various institutes, organizations, enterprises and government agencies in Tanzania facilitated the execution of the field studies. Support was given by 'key-persons' from institutes like the National Construction Council, the Ardhi Institute, The University of Dar es Salaam, the Ministry of Lands Housing and Urban Development, The Dar Es Salaam City Council, The National Bureau of Statistics and many others who made the extensive data collection possible.

Final year students of the Eindhoven University of Technology assisted in the data collection under supervision of the researcher of this project. Also Tanzanian students contributed and often acted as interpreters. The language problem was solved by translation of the questionnaires in Swahili, (checked with a re-translated version) and by the assistance of interpreters. Pretests were executed in Mbagala (one of the city areas) after which slight corrections to the instrument were made, to properly investigate the other projects.

Data analyses are made with (1) the sample mode as central tendency measure and (2) the sample range as measure of dispersion. The mode and the range provide a serious indication of the characteristics of the dwelling construction sector for lower income groups since the sample and the methods of data collection ensure a substantial data set collected in the countries, that provides useful relevant information.

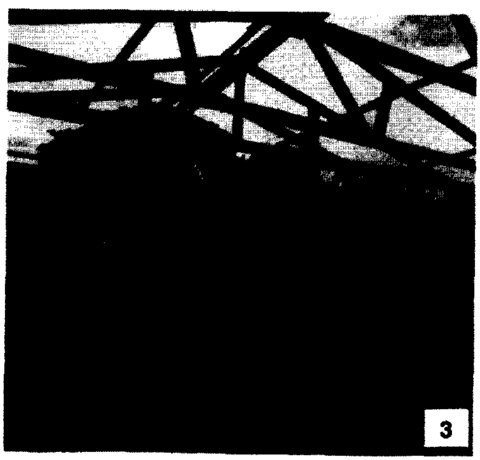
Interpretations are carefully checked with experts and findings in foregoing publications.

Housing in Urban Tanzania



Picture 1 Traditional house: mud-and poles system

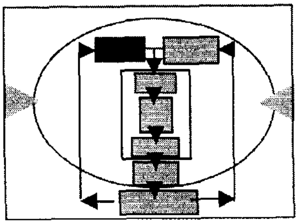
Picture 2. Modern houses
Picture 3 Sand cement blocks system
Picture 4 Sand cement blocks



Chapter 2

Housing and Technology Needs in urban Tanzania

part II



2.1 Introduction

This chapter discusses the characteristics of the particular socio-economic problem that is addressed in this research project: *the present housing situation.* The specific technology needs result from the need for houses in urban Tanzania. Houses in this project are seen as being equivalent to *products* (the output of a production process in the construction industry). Each of these has its particular product technological features. The description below focuses on the quality and quantity of houses that are needed (product technology needs) in urban Tanzania. The determination of the ***sectoral product technology needs*** (STN) renders a frame of reference for the range of process technologies and material inputs that are applicable in the dwelling construction processes. These needs set the terms of reference for the technological capabilities and technology status in construction projects. Secondary sources were used to determine the ***sectoral product technology needs*** (reference is made to Part I Chapter 3).

2.2 Housing in Urban Tanzania: past and present

In pre-colonial times the inland human settlements were scarce and often non-permanent, although not very much more is known about the early history and human settlements of the inland regions of the country. The first *urban* settlements during the pre-colonial period were concentrated along the coastal strip of the Indian Ocean, functioning as trading centers for the Arab and Portuguese traders. During the colonial period the more urban settlements were established serving as residential enclaves for colonial administrators and as trans-shipment centers. Dar Es Salaam was established as capital of Deutsch Ostafrika in 1891.

Traditional housing reflected the different ethnic backgrounds of the Tanzanian population, as well as the varying climatological and environmental circumstances. Many different *forms and shapes* represent the technical solutions that suited the socio-economic and geo-physical situation of the population in the areas best.

At present a large part of the Tanzanian population - according to criteria of the Ministry of Development Planning about 80% of the Tanzanian population- lives in housing units below standard. It is estimated that between 50-70% of housing in urban areas is in squatter settlements with a lack of basic services. Moreover the ways in which housing units are constructed obviously result in a short lifetime of the units due to the low technological quality, in terms of materialization, building construction, their strength and durability. The utilization of particular building materials depends to a large extent to their availability close to the site, especially in urban areas. The houses are often vulnerable to demolition and need then to be rebuilt. Moreover the units require constant maintenance and repair. (CHS 1995) The majority of low quality houses are to be found in rural areas.(Hoek-Smit 1991). The deplorable housing circumstances in Tanzania are in particular applicable to the poorest section of its society. A higher income and an urban location apparently can be associated with dwellings of better quality. Evidence shows that as soon as it is financially possible a non-earthen floor will substitute an earthen one, an iron (or another more durable like tiles and cement) roof substitute a thatched roof and more secure types of windows will substitute having no windows at all or uncovered windows. (Ferreira, 1995:26)

The settlements and housing problems have much to do with the macro socio-economic and political situation in the country. The strong deterioration of the economic situation and an annual population growth at a rate of 2.8% per annum -which is one of the highest in Africa- is reflected in the settlements and housing situation of the past decades in Tanzania. The determining factors of the housing problem have more and more become the diminishing volume of resources that are necessary for the construction of adequate shelter for all sections of society. Factors that in particular affect the housing situation are: (a) the continuing increase of construction costs and building materials prices; (b) the employment situation; (c) the level of household income and the inability to save; (d) the poor purchasing power of a rather high percentage of the population and their financial capacities to acquire decent housing facilities implies no access to the housing market; (e) the high interest rates and the lack of public funds and options for financing of the housing units against interest rates which comply with the financial capacities of the households; (f) the procurement procedures for land and lack of planned shelter delivery systems in particular in urban areas. The problematic housing situation should thus not be seen as a stand-alone phenomenon, given the above mentioned interrelated factors that affect the housing situation in the country. Improved housing construction, both in terms of quality and quantity thus should meet the requirements of such an integrated approach of poverty alleviation.

Table 2.1 Residential areas and population in Dar es Salaam
Sources: Marshall Macklin Monaghan Ltd, 1979, CHS 1995, SDP 1995 in Treffers/TUE 1996

		planned	unplanned	total
1978 residential area	Absolute (ha)	3,775	2,349	6,124
	Relative (%)	62	38	100
1978 population	Absolute (no pers)	340,000	506,000	846,000
	Relative (%)	40	60	100
1995 residential area	Absolute (ha)	7,130	5,020	12,150
	Relative (%)	59	41	100
1995 population	Absolute (no pers)	540,000	1,260,000	1,800,000
	Relative (%)	30	70	100

The housing situation in the Tanzanian capital Dar es Salaam at present extremely reflects the current situation of financial, technical and administrative constraints that the national and local governments have to face. In this situation the few social and infra structural services like housing, education, health services, roads and communication networks, water, electricity and sanitation facilities, are stretched to a limit. The relative peacefulness of Dar es Salaam attracts migrants from the urban and rural hinterland. The result of the accelerated urban growth has been a host of urban development ills such as spontaneous settlements, deteriorating infrastructure, environmental degradation, and overcrowding. Seventy percent of the population is housed in unplanned settlements and they account for 64 percent of the housing stock. (SDP1995). The growth and magnitude of the spontaneous settlements in Dar es Salaam is indicated in the table 2.1. It is estimated that 40% of the households in Dar es Salaam has to cope with overcrowding, which is in particular the case for households living in the squatter areas.(CHS 1995)

2.3 Housing: adequacy and affordability

The Tanzanian housing problem actually is not a question of quantity but rather one of standard. This refers to the adequacy of the house to meet the basic functional requirements in terms of the appropriateness of the size of the house to provide for enough living space per person. It also refers to the availability of basic services and a level of technical quality; in terms of meeting the basic functional and technical requirements with regard to materialization, building construction details, strength and durability. The last requirements should guarantee safety and security for the inhabitants for a period of at least 25 years. The current housing situation -which becomes more and more visible in the squatter settlements- shows a lack of houses which can meet these standards.

The supply of houses is insufficient. In most cases the houses are of in-adequate standard due to the ongoing decrease in income resulting in an aggregate poverty. It is obvious that the ability to pay of a household is one of the critical elements for the housing circumstances. For the determination of the affordability of housing one needs to have an insight in the household income and expenditures. An exact determination of household income and expenditures of the lower income households is hard to become. Households are not only reluctant to divulge such information, they sometimes actually do not know it, particularly when it comes from a variety of sources and is irregular as is the case for the large majority of the lower-income earners. In this study we have relied on secondary sources to get insight in what a household can afford on housing.

The average monthly household expenditures in Dar es Salaam were Tsh 9,408(Tsh 1991), while for Tanzania the figure is Tsh 5,130. The average annual income per household in 1991 was Tsh 64,378, the ratio for the whole country is 1.05. For rural Tanzania this ratio was 0.97 and for urban Tanzania 1.31 (Fereira, World Bank 1993, p1). The minimum wage in the formal sector in the last few years shows an increase of income, although the monthly expenditures also have risen. The conclusion can be made that the 25 to 30 percent figure of a household income that is generally assumed to be acceptable to spend on housing, appears to be too high for the lowest-income households, which implies that the percentage of income those households can afford should be taken at most as 10 percent. The minimum cost of a house of approximately 50 m2 was estimated to be Tsh 1.5 million (1993) which is equivalent to US$ 3,750,-, excluding land and services. In Dar es Salaam house price to income ratio is 5.0. (Materu 1993), which makes the repayments on such a unit unaffordable for the majority of households, even when long term financing should have been available.

2.4 Housing needs

When the attention is turned to the actual need for housing in terms of quantity the following can be said.[1] Calculations of the actual housing stock in Tanzania are difficult to obtain and fall beyond the scope of this research project. Estimates made by experts of various institutes and organizations in and outside Tanzania like for instance the Center of Housing Studies in Dar es Salaam and the World Bank reports on urban housing surveys rendered the basic data. The descriptions and figures (if any) given in the various publications indicate a tremendous need for decent housing facilities. However it should also be kept in mind that these needs are seldom transformed to a real market demand due to the unfavorable socio-economic situation of a high percentage of the Tanzanian population. The total need for houses was 21,550 in 1991. (see table 2.2) The supply of housing units in urban Tanzania was indicated to be below 20% of the requirements (Kyessi et al 1995). Thus the actual annual supply of houses will be 4,310.

It is estimated that Tanzania faces a cumulating need for houses so that by the year 2000 9,745,700 urban dwellers will be in need of 2,370,404 units of which 75% represents new households without any existing housing facility.

The figures in the table in the appendix indicate the housing deficit classified for the different income groups, taking into account that about 60% of the urban population belong to the lower income group. For the rural areas a deficit of 1,760,000 housing units is expected by the year 2000 (based on figures from the population census 1978 and Hoek-Smit 1990)

Table 2.2 : Estimated annual housing needs in Dar es Salaam
Source: Treffers/TUE 1996 pp 14, based on data from Hoek-Smit 1991, CHS 1995

Annual housing need resulting from	Nr of needed houses per year
Population growth	13,500
Number of inhabitable houses	4,350
Elimination of overcrowding	3,700
Total housing need	21,550

2.5 Housing delivery system

The urban housing market in Tanzania is rather distorted. The house prices are very high relative to the average income level. Rents are kept low by heavy subsidizing and the application of the 1984 Rent restriction Act. This Act allows just a maximum rent of 14% of the market costs of construction of the dwelling. Rent to income ratio in Dar Es Salaam is 0.03, which is only 3% of the annual income of the household. (Materu 1993). The house price appreciation is quite high as well and accounts for 36% in Dar Es Salaam and slightly lower in other urban areas.

The current housing delivery system in Tanzania can be sub-divided in a public- and a private housing sector.

[1] The actual need for houses refers to the nominal lack of houses including the houses in-adequate for habitation. Calculations of the current deficit of housing units are generally made by extracting the estimated stock of more or less up-to-standard dwellings from the estimated number of households. In Tanzania the housing need resulting from the present situation of overcrowding also has been taken into account in the calculations.

Public sector housing in Tanzania offers predominantly housing units for rent through the Government, the National Housing Corporation (NHC) and the Registrar of Buildings (RoB). Other parastatals like the Tanzanian railroads, educational institutes, hospitals and banks are other public sector house owners renting out their houses. The total stock of units is rather small. Most of the housing units were built already some decades ago and are poorly maintained. Public sector rents in particular are highly controlled by the Rent Restriction Act (1984) and rents are determined by the Rent Tribunal. (Hoek-Smit, WB 1990). The rent controls applied to the rental housing stock, do not permit any maintenance, due to the low level of rents. Government investment in housing projects have been reduced to practically zero, due to the unfavorable national socio-economic situation. In the past site- and services programs have been implemented by the Tanzanian government to alleviate the housing problems in the country during the seventies, with the intention to at least provide surveyed plots with basic infrastructure to the lower income households. Although these sites and services projects did not meet the objectives for the target groups, and were not sufficient to serve all households, they still contributed to an increased and qualitatively better urban housing stock. (see appendix II-2) The fact that the formal supply of houses is far below the actual quantitative need makes that people seek ways to find proper housing themselves.

The *private sector of the housing delivery system* is the predominant supplier of housing units in the country. In Dar es Salaam 27% of all households is living in their own private sector house and 57% of the totality of households in Dar es Salaam is a house renter in the private sector. (Hoek-Smit 1991)
Ninety percent of the investments in urban housing appears to be done by *private individuals* in Tanzania and 75% in Dar es Salaam. This includes formal and informal investments. The last predominantly take place in the so-called unplanned areas and account for nearly 70% of the total housing stock of Dar es Salaam (even more in other urban areas). (Hoek-Smit 1991) But not all construction in the planned areas appears to take place in the formal sector. Literature indicates that house owners themselves generally plan and manage the construction process and hire fundi (craftsmen). Drawings are nearly not made by officially registered architects and construction engineers. House owners and their fundi generally just make a rough sketch of the planned building. Even where the few building permits are obtained, the building construction often is not carried out in compliance with the approved plan. On the other hand one can also find formal housing in the unplanned areas, since surveyed plots are difficult to obtain. In this case house owners engage a private surveyor to survey their plot and subsequently apply for a title over the plot. (Mwaiselage in Tegelears/TUE 1995)

The low performance level of the Tanzanian housing delivery system contributed to the less favorable situation on the housing market, which is characterized by an alarming shortage of housing units affecting the lower income households most in urban areas and in particular in Dar Es Salaam.

2.6 Housing financing system

Long term financing and mortgage systems are practically non-existing in Tanzania.
Government housing finance systems were developed to enhance the affordability for both rental and owner occupied housing. Next a housing allowance system and a rent control system exist. The housing finance system appeared to be rather ineffective in reaching the targets, only 4% of the resident owner households was enabled to finance their house with a mortgage administered by the government financing system. The Tanzania Housing Bank – that was established in 1972- has been the only formal source of finance. (Hoek-Smit 1991 p7) This institution however has gone bankrupt in 1995.

All income groups appear to finance the construction of houses largely from non-conventional and informal sources, like finances from extended families, loans from employers, cooperative savings and credit societies. Due to the present high rate of inflation and unfavorable economic situation in the country households and developers tend to seek short term financing from a variety of sources. This implies among others that households have developed their own saving system in the form of buying building materials whenever they have the means for it. The actual workings of the informal and unconventional financing systems in terms of mechanisms, institutions, size, interest rates, etc. are not known except from the result of this situation which is reflected in the numerous uncompleted buildings and the incremental construction processes lasting years.

2.7 Housing policies and regulations

At national level housing policies are presently under the responsibility of the Ministry of Lands, Housing and Urban Development (MLHUD). This has not always been the case. In the past also the Ministry of Regional Administration and Local Government (MRALG) had the responsibilities for housing in the country. The implementation of the national housing programs in real practice were carried out by parastatal organizations, such as the National Housing Corporation (NHC), the Tanzania Housing Bank (THB), the National Engineering and Design Corporation (NEDC), which do not necessarily report to the Director of Housing or the Ministry. Other departments or Ministries may have had the responsibilities.

The government has followed various strategies in the past to cope with the housing problems. During the sixties a policy of slum clearance was followed, however the former squatters could not afford the new houses. Next came the policies of squatter upgrading and site-and-services programs stimulated by the World Bank. However none of these have been successful (Mosha 1988, Mwapilinda 1992).

Only recently the government has started formulating a comprehensive housing policy. National policies on urbanization, rural development, housing and the construction industry[2] as have been formulated in the latest National development Plans are summarized in appendix II-2)

In 1993 a special program on sustainable city development has been started in Dar es Salaam with the first objective to formulate a new Strategic Urban Development Plan (SUDP). Housing is just one of the integrated elements in this program. A problem that might be encountered during the execution of this program is the existing structure of policy making, coordinating and implementation in the country.

The *building regulations* that are currently in force were issued for the first time in 1930 during the British colonial period. Some of them have been amended but a large part of the regulations are acknowledged to be outdated. In 1985 the Tanzania Building Regulations 1985 (TBR 1985) have been prepared by the Building Research Unit (BRU). Together with the local Government Act 1982 it was supposed to replace the existing building regulations which were contained in the Township (Building) Rules. These regulations also included simple guidelines for the design and construction of buildings under the Tanzanian circumstances and were to be applied for the construction of all new buildings of the height up-to eight floors. The District and Urban Councils are responsible for setting and enforcing the overall housing regulations. Only recently the formulation and up-dating of building

[2] derived from the President's office. "The rolling plan and forward budget for Tanzania for the period 1994/95 - 1996/97" (1994) and the Ministry of Works "National Construction Industry Development Strategy" (1991).

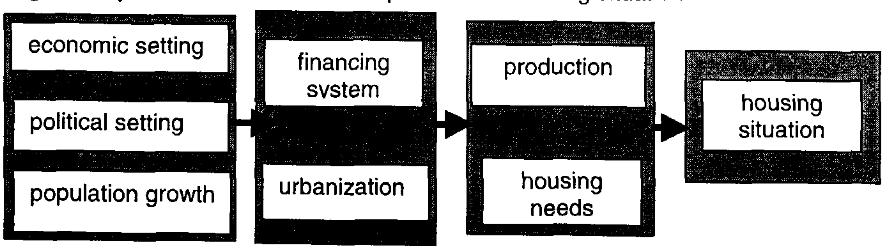
standards and regulations -which are appropriate to cater for the present level of requirements for living conditions and shelter- has been undertaken by the Tanzanian Bureau of Standards (TBS), the Ministry of Works, the National Construction Council (NCC) and the Building Research Unit (BRU). It is admitted that coordination and control of proper application of the regulations and standards is lacking. (NCC, 1995) At the very moment the 1985 regulations are still in force. The basic requirements as mentioned in the appendix are applicable for houses (see appendix II-2 and TBR 1985 p 26-67). These regulations concern the plot and exterior building design -which should be in compliance with urban plans- the dwelling itself, the individual rooms (living rooms, bedrooms, kitchens or combined cooking and dining rooms, sanitary facilities, storing facilities) their location and size (height), the openings and communication elements (doors, windows, stairs) the safety regulations (structural safety, stability and durability, safety with regard to fire and accidents) and the regulations on hygiene, sanitation and indoor climate (thermal and acoustical comfort, air quality and lighting, water and moisture prevention).

2.8 Conclusions

Like in many other countries in Tanzania one has to deal with *a human settlements problem*, which has a tremendous magnitude. (housing need = 21.550 houses/year)

In the urban areas of the country one has to face a situation of many un-employed people, inhabitants who live in absolute or relative poverty, *lack of basic facilities such as housing* and a far from favorable development prospect. In particular for those belonging to the lower income households the housing problems are most acute. The enormous population growth and the un-favorable economic position of a high percentage of the population in Dar es Salaam are major factors that result in a *housing need* that requires an adequate supply of houses and infra structural services. (see fig 2.1)

fig 2.1 Major factors that have an impact on the housing situation



The housing delivery system in Tanzania is dominated by the private sector (90% in Tanzania; 75% in DSM). The small and informal construction sector has an active role in here though not sufficient to bridge the *tremendous gap between the supply and the demand of adequate housing* for the lower income households. The estimated deficit of decent housing facilities is rather extensive, while the housing supply is estimated to be even less than 20% of this demand.(Kyessi 1995) Housing supply = 20% x 21.550 = 4310)

This may be one of the major reasons to mark housing construction with a high priority in the governmental policy plans.

Policy interventions have not been very successful so far, although the government has followed several policies and strategies in the past to cope with the housing problem.

The government also has not been able in making financing for housing available. The country has to face a number of related problem areas like unemployment, low income levels, unequal income distribution, in-sufficient supply of social services like infrastructure, including water and electricity, education and health. These have a severe impact on the housing deficit.

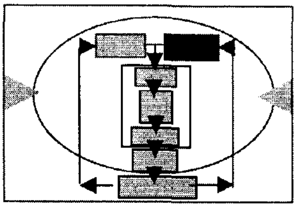
One of the most difficult problems to overcome will be the decrease of the costs of housing construction, in order to increase the affordability of decent housing for all income groups in the country. In the recent governmental plans it was indicated that the development of new materials and building construction technologies and systems is to be promoted by organizations such as the National Construction Council in Dar Es Salaam with the objective to achieve better *technological and socio-economic* results.

In the following chapters the results of the investigations on the status of technological capabilities, the technologies utilized in construction projects and the performance of the sector of dwelling construction for the lower income households in the urban areas of Dar es Salaam will be described. These data are expected to indicate the impact of the major factors – the status of the technological capabilities and the technologies utilized in construction projects- on the achievement of the desired *technological and socio-economic* targets.

Chapter 3

Technological Capabilities in the sector of dwelling construction for lower income households in urban Tanzania

Part III



3.1 Introduction

The four components of the complex of technological capabilities -(1) the technology stock, (2) the human resources stock, (3) the natural resources stock, (4) the technology infrastructure were investigated by the execution of literature studies and through interviews with local experts in the construction industry and in the building materials industry. The results of these studies are described in this chapter.

3.2 The technology stock

The *assessment of the status of the technology stock* has taken place by investigation of the available range of technologies in the dwelling construction sector. The range includes the (a) product technologies and (b) process technologies that can be committed to the production processes in the dwelling construction sector. This status is assumed to reflect the available capabilities to realize the construction projects efficiently and effectively. It also implicitly reflects the capabilities to locally develop or acquire from abroad more advanced technologies.

It was not easy to get exact figures on the total existing technology stock in the Tanzanian dwelling construction industry. The majority of data for this study is derived from different sources such as the Household Budget Survey 1991-1992 commissioned by the World Bank, the Urban Housing Survey 1990 by Hoek-Smit, publications by the Building Research Unit (BRU), National Construction Council (NCC), University of Dar es Salaam and data from the National Bureau of Statistics in Tanzania.

3.2.1 Construction product technology stock

The indicators used for the determination of the *construction product technology stock for houses* for the lower income households in urban Tanzania were the *availability, the type and the quality aspects* of the building components and building materials that constitute the *construction product technology system* for the houses. The construction product technology systems are classified in traditional, conventional and modern systems. The tables in the appendix II-3 give an overview of the available *product technology* systems in the country. Also an overview of the different types of houses that are built with the product technology systems in Mainland Tanzania is given in Appendix II-3.

Box 3.1 Type of houses in Mainland Tanzania

The houses that are built throughout the country still are predominantly the traditional ones. Over time there has been a move away from different types of traditionally built (round) houses to concentrating on angular or rectangular types, when new houses were built. (Edvarsen & Hegdal 1972).
At present a mixture of different types of houses can be found in the various areas in Tanzania. Still the most common type is the traditional rectangular house with a hipped roof and entrance door on the long side (40 %).
The houses that are built in urban Dar es Salaam belong in the majority of cases to the type of the un-extended (modern urban) Swahili house (78,5%). Other types are the extended Swahili houses (7,14%) and the traditional houses (14,29%). The last two have a rectangular shape; in 75% of the cases a hip and gable roof; 15% has a curved roof and 10% a flat roof. The rectangular form offers the possibility to make extensions to the houses without many engineering problems. The size of the houses in Tanzania is relatively small with an average of 23m2. In the urban areas of Dar es Salaam the size of the dwellings is in general rather large: on average more than 100 m2. The government rented houses are generally smaller than the private sector dwellings. The number of habitable rooms is in the majority of cases 4-5 rooms per house (excluding kitchen). The average number of bedrooms is 2.5 per dwelling.

a. Type and availability of construction systems.

The ***construction product technology systems*** for the houses for the lower income households have undergone a process of change in Tanzania. Enhanced by processes of modernization and changing culture and lifestyle in urban areas, the originally applied traditional mud (-and-poles) systems are substituted by building with solid mud walls and conventional technologies burnt bricks sand-cement blocks, corrugated iron roofing sheets, aluminum, sawn timber and timber components. The degree of change differs from one region to the other and appears to be highest in the urban areas of Dar es Salaam. The changes have taken place more or less at the same pace as the life style changed from rural towards urban by taking over the habits from abroad.

In urban areas the conventional technologies (80%)are applied more often than the traditional technology systems (20%). The conventional systems include (a)improved foundation systems (b) cement and sand-cement masonry systems, (c) the burnt bricks masonry system (d) the use of sawn timber and trusses for the roofing structure covered with light weight metal sheets. (see tables in appendix II-3)

In conclusion can be said that throughout Tanzania only the traditional (88%) and conventional (12%) class of construction product technology systems are available for the lower income households.

b. Quality aspects of the construction systems

The majority of the technologies that are available and in use for the construction of the houses is considered to be non-durable and implies a life-span of less than 6 years for 38% of the housing stock in Tanzania and a *life-span* between 6 and 10 years for 48% of the stock. Only 14% of the stock has a life-span of more than 20 years. Wrong engineering during the application of the construction systems in the country were mentioned to be the major cause. The lack of *proper site preparations* for example unnecessarily causes erosion of the plot, land slides and flooding of at least the ground floor. A *positive feature* of the traditional systems is their suitability to the climatological conditions in the country (for example the high insulation value of the roofs). More over these systems are easy to repair and renew.

Most of the traditionally used materials are locally available at low cost relative to the income of the households. See also appendix II-3 for an overview of the major *construction product technology systems.*

c. Ease of production on the construction site

The systems practically all are rather labor intensive with a high *production complexity.*
The houses are composed of many different elements of which a large part is even produced on site (cement aggregate blocks, timber roofing structure). (see box 3.3)

d. Affordability

It was hard to acquire reliable information on *prices and price trends* of the various technologies applied for the construction of the housing stock since most of the houses are built in the informal sector. An attempt was made to compare *the costs* of the different construction systems. The basis for the comparison was a house of 50 m2 with a basic un-extended Swahili type lay-out, that complies with the technical requirements and building regulations for a family house. This means that the foundation is properly carried out with a footing, the ground floor is finished with cement screed and all the walls are plastered, the roofing structure is a simple trusses structure, the roof finishing is made with corrugated iron sheets and windows and door frames are of sawn timber.

Box 3.2 Building materials constituting construction systems

The building materials for the traditional dwelling construction systems are mainly raw materials and intermediate products. Most of the materials used for the main structure of the houses - like soil, grasses, palm leaves, timber poles and other organic materials- are obtained locally within the village or nearby to it. Improved durability of the materials is obtained by further stabilization of these with cement or other binders - like lime and gypsum- or by burning the clay soil into bricks. However the last materials still are rarely applied *in rural areas.* Cement is *locally available and used to a little* extent in rural areas for reasons of costs and the low availability due to transport constraints. Metal roofing sheets are imported and being applied more often both in rural and in urban areas. Most materials are produced on site. The small scale and informal sector plays an important role in the extraction and production of the materials. Off-site produced building materials are the sawn timber for the roof structure, doors, windows and casements, corrugated iron sheets for the roof finishing. No evidence was found on other off-site produced building components with the exception of the ready made timber and metal doors, windows and casements, although no exact data were readily available. The costs of the roofing sheets form a slight constraining factor for its application. The import content of the materials in dwelling construction is 30%.(NCC 1995)

The average costs for a house of 50m2 built with the cheapest construction system(mud-and-poles) then is estimated to be Tsh 480,000 (US$ 800 in 1995). Still the walls in this house are *not plastered* and the roof finishing is still carried out with grass, which decreases the durability of the house. When the walls are finished with plaster and the roof finishing is with corrugated iron sheets, the total costs will be Tsh 700,000 (US$ 1200 in 1995). The houses carried out in the most expensive construction system (sand-cement blocks masonry) will cost Tsh 925,000 (US$ 1600 in 1995). The soil blocks, soil walls and mud-and poles systems are the cheapest alternatives for all regions. For Dar es Salaam the difference between the 'mud and poles' system compared to the cement/ aggregate blocks masonry system in terms of costs is only 5 % of the total building costs. When a calculation is made with an interest rate of 20% and a loan on annuity basis for 15 years then the official annual repayment for a house of US$ 1200.- will be US$256.- Even when the calculation is made with an interest rate of 10% then the official annual repayment is still US$ 157,-. The conclusion is that even the houses built with the cheapest construction systems are officially un-affordable for the majority of the Tanzanian population given the GDP per capita that was US$ 126 in 1991 and US$ 102.- in 1995.

3.2.2 Construction process technologies

The characteristics of the stock of *construction process technologies* are derived from several sources. (NBAQSBC 1995/1996, BRU/WR68/Mpuya, 1990; Anders, 1992, interviews with NCC, 1995, Field studies TUE :Wouters, Tegelaers, Dankers , 1995, Rijkenberg 1996)

The availability of **tools and equipment** in the sector is rather limited. Only the large scale contractors possess a number of more advanced equipment and machines. 80% of the capital stock in the construction industry is owned by the contractors in class I and class 2. The contractors involved in dwelling construction projects only own 2% of the total capital stock. These conclusions could be drawn by using the data of the National Board of Architects, Quantity Surveyors and Building Contractors (NBAQSBC see also appendix II-6)). The classification of the building contractors in this Board is based on the possession of equipment and machines. The majority of the tools and equipment is imported. This also becomes evident at a higher level of aggregation in the output figures of the capital goods industries and the trade figures. The construction units involved in the dwelling construction for the lower income households have nearly no access to these due to limited availability of capital. The projects are predominantly carried out with hand tools. (see appendix II-3) Only occasionally powered tools are hired for the work on the site. Also transport equipment to transport building materials to the project sites is only scarcely available.

The composition of the **labor force involved in the execution of the construction** tasks differs as shown in Appendix II. The construction projects are in most cases built with *hired craftsmen in the informal sector.* The labor force per project includes on average 40% *skilled labor and 60% unskilled* (family helpers). The skilled labor force has gained their experience on the job by frequent participation in the building construction projects. Of these 40% skilled labor force only 65% is literate.

Written **information and documentation** is in building construction processes generally *not available* or it is given by *verbal* instructions by parents and relatives only. No computerized documentation is used or available. Information is mainly used in the construction projects carried out in conventional construction systems (10% of all projects).
Technical specifications for the projects are practically not used, cost control and progress control is documented in 30% of the projects. No documentation on materials and equipment is available. Regarding the retrievability can be said that the utilized information is available in written form. The process of dwelling construction starts with an idea of the future house owner, who "draws" a rough sketch, selects the materials and informs a craftsman who is considered to know how to convert the ideas into a house. The application of non-traditional materials -which increasingly takes place in urban areas- requires proper application of construction methods. The information on the newer technologies is in principle available in the country in institutes like the Building Research Unit (BRU). But there is a lack of diffusion of the available information and knowledge on possible application and improvements of the construction systems to those who are involved in the dwelling construction projects.

The **construction process organization** in the dwelling construction projects for the lower income households is mainly private (90%) and takes place on ad hoc basis. Project management in general in Tanzania is in the hands of different persons who are not necessarily participating in the actual execution of the construction tasks. The construction units are more or less *specialized* in principle in residential buildings for lower income households. Most of the units operate without a realistic form of *planning or development strategy.* The rate of *regulation and control* is neglectable; the organizations are nearly completely deregulated as they operate on *informal* basis. No efforts are spent on modernization, nor on R&D. External relations of the construction team belong mainly to the informal sector contacts.

3.3 The human resources stock

The indicators used for *the assessment of the human resources stock* are 1.the population figures, 2. the age structure, 3. the educational profile, 4. the employment profile 5. the skill profile in terms of labor force employed as researchers, teachers, managers/engineers, specialized technicians, crafts persons (skilled), laborers (semi-skilled & unskilled).
The status of the human resources stock is supposed to indicate the (a) *actual and the potential availability* of human resources relevant for the sector and (b) the *nature* in terms of social and educational background. The data for this component of the technological capabilities are derived from the Statistical Abstracts of several years, from the National Bureau of Statistics (NBS) in Tanzania and the UNESCO (1995) and WB (1995) statistics.

Labor force that can be employed in building construction is in *abundance available* in Tanzania, but the level of skills and knowledge leaves much to desire.

Tanzanian *population* structure is similar to that of the majority of developing countries. The population is about 30 million. Its growth of 2.8% per annum is one of the highest in Africa. Some 51% of the total population is economically active - in particular in the agricultural sector (84%)-.And 69% of the labor force of persons aged 10 years and above is employed.

Only 1% of the total population is officially employed in the construction industry. Tanzania has to face a high rate of *unemployment in urban areas (44%) due to* urbanization caused by migration from rural areas. The deficits, in the creation of employment and the production of the public and private sector, are partly taken care for by the informal sector. The formal statistics indicate that 9% of the employment is in the informal sector. In reality this figure might be higher.

The *social status* of the majority of the labor force in Tanzania is reflected in a large percentage of the population that belong to the so-called low income households.

The *occupational status* of most labor force (84%) in the construction industry is that of a *craftsman or technician.* In the informal sector this percentage is even higher might even be 100%. Some 16% of the labor force in the construction industry is employed as professional or project manager.

The Tanzanian population is relatively *young*. A large percentage of population is below 15 years of age. This means in one hand an increased need for houses and other social services in future. On the other hand the current percentage of population below 15 years of age also offer an opportunity of valuable human resources whenever the education system is appropriate to meet the future demand in the production sectors of the country. But the country has to deal with a pressure on social services like the education system in the country. This has a negative impact on the quantity and quality of labor force for construction in the country.

Primary *education* increased in quantitative sense, but its quality decreased due to a lack of qualified teachers, instruction materials and schools. During the past decades *literacy rate* increased from 46% in 1978 to 76% in 1993 (both figures based on people aged 15 years and older UNESCO 1995). For the employed population counts that only 64% is able to read and write. In judging these figures it should be noticed that the absolute population also increased from 17 to 26.7 million during the same period. Tanzania is among the two countries with the lowest *secondary enrollment* ratio in the world: 4.7 % in 1990, against 2.7% in 1970. due to policies to limit the entrance to secondary education to avoid producing more students than could be absorbed by the public sector (World Bank 1995). The *tertiary enrollment* ratio (1986-88) was only 0.3% (1991 est). The availability of third level institutions and teaching staff is limited.

The major *source of training* for the project managers / entrepreneurs in the sub-sector of dwelling construction for the lower income households currently still is the informal sector (91%), where the people are trained "on-the-job" (34%) or in a kind of apprentice system (57%) (TIS 1993, Tegelaers 1995, Treffers 1996). Only a small percentage (9%) is formally trained, in 2% of the cases by government training, 3% in private enterprises, 4% in training institutes. Throughout Tanzania 75% has not received a formal form of skill training. The figures do not differ much from those in other African countries.

Regarding the available *R&D staff in the country* no comprehensive data were found. For an optimal selection, application and further development of technologies in the sector qualified staff is needed involved in R&D and consultancy. An overview of the available R&D statistics in Tanzania, Costa Rica and the Netherlands is given in appendix II-3. The R&D institutes are in majority 100% staffed by Tanzanian nationals. A selection of R&D institutes was investigated by Mwala and Sheya in 1990. Their findings did not indicate much change in the relatively small number of R&D staff in the country. The R&D activities are predominantly carried out by government institutes under direct responsibility of the various Ministries. Relevant for the construction industry is staff carrying out research under the Ministry of Works, Ministry of Science technology and Higher Education and the Ministry of Land and Urban Development. Some 84 persons were in 1990 employed as R&D staff in these institutes, which was only some 14% of the total R&D staff in the country according to the investigations in selected institutes (Mwala & Sheya 1990) Most of the persons were employed by NCC (20) , BRU (17) and the ARDHI (17). These numbers have most probably decreased after the liberalization policies were introduced.

Consultants have a determining voice in many decisions for projects in case they are consulted and thus have a major influence on the performance of contractors. A study on the local consultants indicated that their performance leaves much to desire due to lack of experience, limited capacity and capabilities. (Msita 1993). The share of the local consultants in project preparation, design and supervision is limited to some 24% of all projects compared to foreign consultants who are responsible for 69% of all work. while the rest of the work is carried out in joint ventures between local and foreign consultants. (Msita 1993).

Problems due to a lack of skills and knowledge and training needs were expressed by many contractors involved in the dwelling construction projects for the lower income households. This implies a necessity for the improvement of the current education system.

Human resources development in the construction sector seems to be very much needed. Following the investigations in this research project 91% of the labor force needs training of technical skills and 3% needed literacy training. Remarkable was that none of the contractors put forward a need for training in managerial skills, whereas the lack of these appeared to form a major bottleneck for the construction process. A reason for this might have been that the project management, progress control, quality control (if any takes place), selection of materials, equipment and labor, generally is in the hands of the owner of the house in this sector of the construction industry.

3.4 The natural resources stock

The status of the natural resources stock relevant for the sector is supposed to indicate (a)the availability of exploited natural resources relevant for and applicable in the production processes in the sector, (b) the capabilities to exploit these natural resources judiciously. The *indicators* used for the assessment of the natural resources for the construction industry are the *type, quantity and quality of the available natural resources* for the major inputs in a construction process (land, water, energy, forest, metallic and non-metallic mineral resources.

The importance of the stock of certain natural resources as basic element for the construction industry in Tanzania is derived from the need for building materials. This on its turn is derived from the demand for building and construction for the other sectors of the economy. In this context the importance of the stock of natural resources can be considered as a direct function of the performance in the before mentioned sectors of the economy. Despite the recognition of the immense importance and significance of the stock of natural resources to the performance of the construction industry and in fact to the all over economic and social development of countries, for the purpose of this study just a simplified overview is given rather than a comprehensive and thoroughly investigated documentation of the actual status. A comprehensive documentation of the status of natural resources requires data from more in-depth studies. These data were not readily available. Therefore secondary sources were used like literature complemented with personal interviews with a number of local experts.

The share of the value of building materials in gross construction output averages 60%. By value some 70% of the principal building materials that are used are purchased from Tanzanian producers and 30% is imported. But the import content of the locally produced materials is rather high. For example 57% of the costs of the locally produced cement is composed of imported components, while for metal products the import content is even more than 90%. (Kisanga, Aida U 1990)

The availability of *land* is of basic importance to the construction industry. Land use in Tanzania indicates the abundant availability of land for construction. (see appendix II)

Natural resources in Tanzania include a variety of metallic and non-metallic mineral resources, agro-based resources and forestry resources. (Kimambo 1984, see also appendix II) Natural resources especially relevant for the construction industry, include clay, gypsum, limestone, pozzolanic materials[1], vermiculites[2], lateritic soils[3] and stones like marbles, basalts, granites etc. (see appendix II). Especially lime can be of great importance for the Tanzanian construction industry. Current production is however inadequate and primitive. This is endorsed by a study by the National Construction Council (NCC 1992) among 43 responding local building material producers, which revealed the shortage of local raw materials to be the major constraint for their production .

Kimambo (1984) listed several problems faced by the Tanzanian mining industry in the beginning of the 1980s. These include constraints such as a lack of financial resources, a lack of skilled high and middle management, a lack of transport facilities, a very small internal

1 Pozzolanic materials are materials which contain a considerable amount of silicates and aluminates. Those materials do not posses any binding characteristics of themselves, but, in combination with lime and water they can act as a binder.

2 Vermiculite is a mineral which resembles mica and is used for similar purposes A building materials, produced by heating of the mineral, has the same name and is used for isolation purposes.(Mica is a glass like material with a metal shine. This material can easily be split and resist high temperatures.)

3 Lateritic soils are soils containing iron and aluminum, which came into existence by chemical weathering of certain stones in tropical areas.

market and a long distance to the main world mineral markets. No data on current mining developments were available at the time study was executed. Several indicators could be used to express the mining developments over the years (like the annual production per mineral type, number of new mines opened each year, demand for versus supply of minerals etc.). No data on these indicators were found though. Therefore the increase in mining GDP using constant prices is used here to get a first impression. The statistics show that after a decline during the eighties, mining GDP increased during the early nineties which points at (a slight) improvement. (NBS 1994)

A major natural resource in Tanzania are the forests and woodlands. These constitute 47% of the total land area. Approximately 30% of the total forest area is reserved by the government for, among other things, the production of timber, which is also used by the construction industry. Currently, the share of the construction industry in total wood use is only 2.2%. The local wood industry at present can fulfill the demand for wood in the construction sector in quantitative sense, but hardly in qualitative sense. (Van Iwaarden, TUE/1996). Since natural regeneration is slow and reforestation is rare, the area under forest and the country's wood resources decrease. Especially around settlements, fuelwood consumption leads to serious deforestation.

A by far neglected and even banned natural resource which is in abundance available in the country and which can be used for construction purposes is bamboo. Bamboo is a light weight, environmental sustainable and rather cheap material. Bamboo building construction components and elements have proven to possess a number of advantageous physique-technical features. The bamboo grows in many parts of the country except on the dry highlands. The majority of bamboo is to be found in the Southern highlands, in the coastal zones and near the border with Burundi. The annual harvest from the existing bamboo forests can be some 10 billion tonnes. (Dankers TUE/1995) The utilization and enhancement of cultivated bamboo forests can have a preventive impact on some of the current environmental issues in Tanzania like soil degradation, deforestation and desertification. An overview of the state of art of the major natural resources in Tanzania compared to Costa Rica and other countries is given in appendix II.

3.5 The sectoral technology infrastructure (actor network)

The *assessment of the status of the technology network* (technology infrastructure) serves the purpose of getting information on the complex- and the outcome of interactions between the technology utilizing organizations and firms of the construction technology sub-system and the other technology supporting, promoting agents and groups. *Indicators* used are the: (1) nature of activity of the technology supporting and promoting agents and groups, (2) policies, objectives and strategies (3) source and availability of capital, (4) relative frequency and kind of relations with the construction companies. For the investigation of the sectoral technology infrastructure secondary sources were used to determine the characteristics of the major actors of the technology infrastructure for the sub-sector of dwelling construction in urban Tanzania. The following conclusions can be made.

Overall the Tanzanian operating environment imposes many bottlenecks on the dwelling construction processes in general. The existence of these bottlenecks contributes to the comparatively low level performance of the construction units in the execution of the construction projects.

The *linkages within the actor network* of the sub-sector of dwelling construction are apparently rather weak. Communications and relations of the major actors with the construction units which carry out the dwelling construction projects for lower income

households are practically non-existing and materials and equipment are generally bought in the informal sector as well.
Moreover the *performance of the various actors in the network* themselves leaves much to desire The most important causes were mentioned to be a lack of capital, skills, experience, equipment and management, which is reflected in the performance of the construction units. (Maro 1991, see also appendix II-3 on the actor network).

3.6. Conclusions

The stock ***of technologies*** that is available and utilized in housing construction in Tanzania can be ranked in the lower class of technological advancement. The majority of construction systems belong to the traditional class (88%). Next to these are the concrete blocks masonry systems that belong to the conventional class. (12%). No further local technological advancements are found. The quality of the applied construction systems is poor for at least 38% of the systems. The production complexity on the construction sites is high. The affordability of the houses is low. The construction systems with a reasonable quality formally fall beyond the reach of the potential users due to the higher costs and import content of the technologies. Only the large scale (foreign) construction companies have access to the modern technologies but these are not involved in the dwelling construction activities for the lower income households.

This is also reflected in the level of advancement of the *process technologies* on the construction sites. The *process technologies* belong to the traditional type of transformation technologies. These are mainly in use by small scale or informal sector contractors, who have a limited access to funds and credit facilities, in-adequate investment, a low level of managerial skills, without any formal external relations. This consists of the combination of simple tools, low-skilled labor, practically no formal information and an ad -hoc *organizational framework*

The present status of the stock of human resources employed in the construction industry indicates an in-sufficient quantity and quality of the needed technological capabilities for production, investment and innovation activities. The sector is relatively labor-intensive. The need for skilled and unskilled laborers, as well as highly qualified technicians and managers is large (25% more labor force required). The dwelling construction sector shows a large part of the labor force, employed in the informal sector as technician or craftsmen. The knowledge and skill level leaves much to desire The sector's performance highly depends on the country's educational system.

The ***potential status of the stock of human resources*** that can be employed in the construction industry is promising The Tanzanian *population is relatively young* This offers an opportunity of valuable human resources provided that education and training is given

Only in case of an appropriate education system the local construction capacity can improve quantitatively, but, more important, also qualitatively. Compared to the construction GDP as % of total GDP and to the construction labor force as percentage of the total labor force the apparent potential in terms of Human Resources in the R&D institutes for technology development and innovate efforts seems to be reasonable. It thus can be expected that the R&D Human resources could form an enhancing factor for the improvement of the construction performance in the country, provided that this potential is fully exploited and when the technology infrastructure is adequate in this sector.

The ***present status of the natural resources stock in Tanzania*** has a considerable potential to provide for the necessary inputs that are required by the construction industry. The

exploitation of these are limited though. This reflects a lack of technology investment and production capabilities in the mining industry. The land area in Tanzania is rather extended although only a small part really is in use by its population. To safeguard a sustainable land use pattern it should be best to formulate appropriate land use development plans.
The exploitation of the natural resources by the mining industry to supply for the input in the construction industry is rather limited, given the high import content in the majority of building materials. An important forestry product which is by large neglected and even banned for the construction industry is bamboo. It was indicated that Tanzania has an abundance of this resource which can be used for construction purposes like in other countries.

The present status of the *technology infrastructure* of the dwelling construction industry is weak and reflects a lack of technology assimilation and diffusion capabilities. This situation is due to bottlenecks imposed by the functioning and features of the actors in the infra structural network itself as well as bottlenecks with regard to the communication and relations between the actors and the construction units which are building houses for the lower income households in particular.

fig 3.1 TCAP status

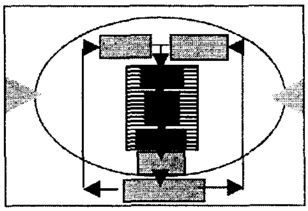
	Tstock	HRstock	NRstock	Tinfrastr
■STCAP	2,1	2,9	1,8	2,1

The present status of exploited technological capabilities in the dwelling construction sector is relatively low. (See figure 3.1, whereby 0<STCAP<10)
The potential technological capabilities -such as embodied in the *actually* available natural resources stock- is not fully exploited. The same applies to the actually available human resources.

Technological capability building by development and further exploitation of these two components may contribute to an increase of the technological capabilities for the construction industry in the country.

Chapter 4

The technology status in dwelling construction projects



4.1 Introduction

The status of the technological capabilities for the dwelling construction sector in urban Tanzania was assumed to have an impact on the status of the technologies in the dwelling construction projects. The results of the Technology Mapping Studies on the Technology Status in the dwelling construction projects for and by lower income households in the urban areas of Dar es Salaam are presented in this section. The data collection took place during field studies in the period from 1992-1996.
The *research units* in this part of the studies were the dwelling construction projects in the urban areas of Dar es Salaam.

The *population of the studies* included those dwelling construction projects that are located in the urban areas of Dar Es Salaam where the construction activities were either on-going or have taken place to build dwellings for the lower income households. Within these areas a number of dwelling construction projects were selected and investigated. It was impossible to identify the entire population of dwelling construction projects that were executed for (and by) the lower income households within the time-span of 1989 until 1998. This was due to the fact that most of the projects were not officially registered and even built on illegal sites. Moreover most of the projects were built by the type of (petty-)contractors who are also not registered. This implied that the total population is not known, which made standard sampling impossible.

First area sampling took place to determine areas where construction projects had been carried out for (and by) the lower income households within the time-span of 1990 up to 1996. The Dar es Salaam region has 40 districts. Thirty districts remained after taking into account the ease of accessibility and the criterion that the areas should be known as common residential areas. This implied that the center district of Dar es Salaam was excluded. The assumption was made that possible differences between the areas could be noticed when the number and the dispersal of the selected areas is as large as possible. This resulted in the selection of *14 areas all over Dar Es Salaam* where dwelling construction projects were carried out. The selection was checked with experts (from the National Construction Council (NCC), the

Ministry of Lands Housing and Urban Development (MLHUD), the University of Dar es Salaam ARDHI institute, the Building Research Unit BRU) and own observations of construction activities that happened to take place in the different -fast expanding- areas of Dar Es Salaam by visiting these sites.

In the selected areas further sampling was necessary due to time limitations. Some prerequisites were taken into account for the selection of the projects. The projects should have had similar features with regard to: (a) the target group of the dwelling construction project which should be the lower income household, (b) the execution of the construction project in the private sector, (c) the basic features of the dwelling. The first criterion implied that the lowest income households were excluded.

The sample finally included *forty two dwelling construction projects in the selected areas, in each area three.* The sites were selected by 'the first opportunity' and by taking into account the above mentioned criteria. The selections were cross checked with experts. The remark should be made that a dwelling construction project for the lower income households in Dar Es Salaam usually includes the construction of one single storey dwelling only.
A number of *methods for data collection* were applied during this part of the research, since it was not always possible to collect all necessary data by means of one method. Moreover it was necessary to cross-check the reliability of the found data. The data of the own field studies were to be compared with data which were collected from several publications. The data collection methods included literature studies, un-structured and structured interviews, expert opinions, non-participant observations and visits to construction sites and building materials industries. (see Appendix II-4) *Data analyses* and interpretations took place as described before. The results of the technology mapping studies on the technology status in the construction projects are described in the following sections.

4.2 Construction project setting

The location of the construction projects in the urban areas in Dar es Salaam is as follows: 1. Temeke, 2. Vingunguti, 3. Buguruni, 4. Mabibo, 5. Tandika, 6. Changombe, 7. Tabata, 8. Sinsa, 9. Ubungo, 10. Kiwalani, 11. Mbezi, 12. Gongo la Mboto. 13. Mzimbasi, 14. Mbagala.

The *location of the plots* determines its size and value. 'Up-country bush' plots are of little value in contrast to plots in the major urbanized centers and densely population areas. The last can be rather expensive and generally are smaller than the rural plots, due to the nearby availability of physical infrastructure and the accessibility to services like markets, schools, health centers etc. The location of the construction project sites show the similar features of the geography and climate of the tropical coastal area of Tanzania, with high temperatures and a high relative humidity. The mean annual temperature is 26°C, and the average humidity is 96 % in the morning and 67 % in the afternoon.

The *climatic factors* require particular considerations for the design of the houses to meet the terms of physique technical durability and comfortableness for its inhabitants. This means for example that as much as possible natural cross ventilation should be applied by making use of the winds to bring maximum comfort to people both indoors and outdoors. The climate enhances that many activities of the households are carried out outside de house. Moreover the climatological features influence the construction project performance.

The various *land forms and soiltypes* that can be distinguished in region of Dar es Salaam is given in appendix II-4.2. The types of soil that can be found in Dar Es Salaam are sand, gravel and sandy silts, clay bound sands and limestone with iron on a layer of sandstone or limestone. The soil is generally red with layers of sandy soils. The size of the top layer varies according to the particular location. Generally speaking can be said that the soil in Dar Es Salaam is "sandy with a moderate good drainage". Sand for building construction and for bricks is abundantly available' in particular in the 'Mbande depot' in the southern part of Dar Es Salaam. (Babu, 1965: 2-3, Kimambo, 1988: 109, Koeppel: 12 and Kimambo, 1988: 103; SIDA-BRU Techn. guideline no 4, 1990) .

The *land-use pattern* in the Dar Es Salaam region has to a large extent been shaped by these geographical and physical conditions. Consequently simple foundations in this area are sufficient though it is recommended to construct these with footings in trenches of 400mm width at a minimum depth of 400mm below groundlevel.

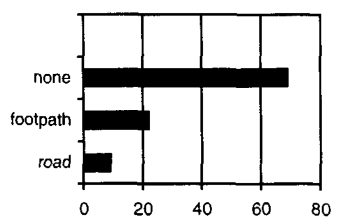
The *groundwater level* in Dar Es Salaam is assumed to be the same as the static water level (swl) in a bore-hole and is on average 12m. Since the water normally starts flowing towards the well as soon as the pumping is started the pressure head at the well is lowered, the lower so-called dynamic water level is on average 26 meter. The groundwater level may rise during the rainy season. A too high groundwater level requires particular engineering details for the foundation and floor construction. (Drilling unit of the Hydrological Section of Maji 1994). No data were found on the quality of the groundwater.

Earthquakes in the coastal area occur only very rarely and are actually unknown. The risk level of earthquake loads - vibrations and oscillations in the structure- is more or less neglectable. No evidence of earthquakes is encountered during the field studies.

Wind forces in general do not cause any severe threat to the population and their houses. The average annual wind speed in the country is at most 4.8 m/s (Dodoma region). In Dar es Salaam the average wind-speed is 3.1 m/s (Wit, B.de/TUE, 1996).

The major *infrastructure* in Dar es Salaam exists of four main exit roads giving access to the city, all are tarmac roads, like the majority of the main roads in the city. The maintenance has lacked resulting in a bad condition of these roads. In residential areas the roads are unsurfaced, of fair quality as long as the rainy season has not damaged them recently. This situation has a major impact on the site construction performance.

fig 4.1 Site accessibility (%)



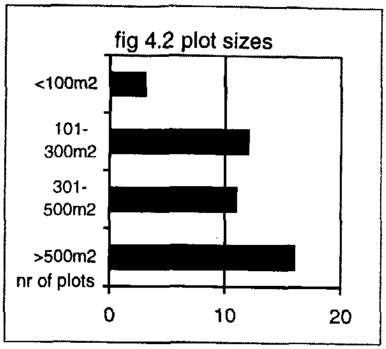
The *accessibility of the sites* in the investigated areas is rather bad. Only approximately 10% of the plots is accessible by road and for even some 70% of the plots counts that these are not connected to any road or footpath, which is in a situation of emergency - like fire or flooding - rather troublesome.

Also the basic requirements for *access paths* to the dwelling sites as recommended in the Building Research Unit technical reports are not met. These refer to the construction of the paths (a) with slopes to the sides of the path and (b) with a firm and hard surface to keep the paths dry and not sticky during rains, and to avoid severe maintenance.

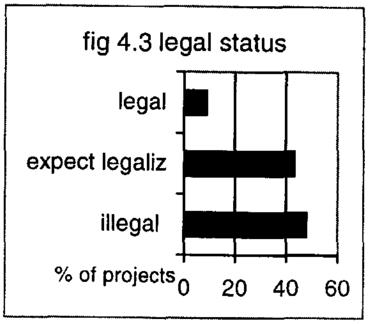
Water and electricity on the building sites in Dar es Salaam is only sparsely available.

The quality of urban infrastructure is extremely low and the extensions have not kept pace with the urban growth. The quality of rural infrastructure is even worse. The plots are rather expensive in Dar Es Salaam and are generally smaller than the rural plots.

The basic requirements for the dwelling plots that are described in the Tanzanian Building Regulations of 1985 (TBR 1985) refer to the size of the plots which should be *sufficient* with access roads for users and also for emergency vehicles. This means that the land use for the building should be not more than 60% of the plot. (TBR1985 p 26-67).

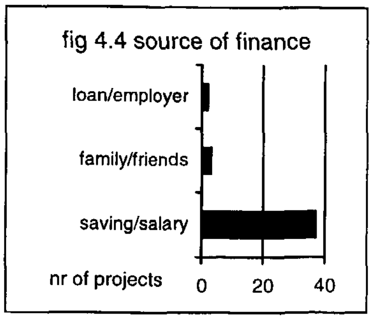


The *plot sizes* of the investigated dwelling construction projects for the lower income households in Dar es Salaam are generally larger than the prescribed plot sizes. 65% of the plots are larger than the officially planned and surveyed plots. Only 7% of the plots is smaller than 100m2. The smaller plot sizes appear to be *unsuitable for using pit-latrines as sewerage system*. These require larger plots and might endanger the subsistence farming, which often is carried out on the plots. The relatively larger sized plots in the unplanned areas have the advantage of flexibility of land-use and give an opportunity for extension of the houses over time. In some 28% of the cases the land-use for the dwelling is less than 20%. In most of the cases - 53%- between 20 to 50 % of the plot is used for the house. But in 19% of the investigated cases the land-use for the building on the plot exceeds the recommended 60% of the plot-size.



A *legal status* to build and live on the plots has been obtained by only 4 households. (9%, n=42) Some 18 households mentioned to expect to receive the legalization of their house ownership on short term, by indicating that they simply have to apply and pay for it with the Dar es Salaam City Council. The rest of the interviewed households did not expect a legalization on short term. These opposite ideas reflect the fact that the local government seemingly has not (yet) expressed any clear ideas on how to cope with the situation of squatter areas all over the city, in particular with those areas where people have built their houses on hazard land like the Msimbazi Valley.

The *size* of the investigated dwelling construction projects for the lower income households in Dar Es Salaam involved in all cases the construction of one single storey house (n=42). No mass construction projects were encountered.



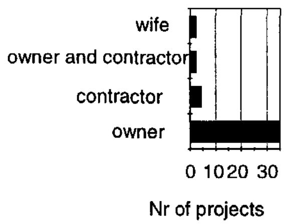
The *period of construction* of the houses has been different, ranging from less than one year ago (8 houses) up to two houses that were built in the beginning of the nineties. (n=42)

Source of finances for the execution of the construction projects came in all cases from the household (n=42). The households pay for the construction of the houses, by using mainly their *savings or their salary as source of funds*. (37 cases), three households borrowed money from friends or family and two other could obtain a loan (from their employer).

The amount of *money to be spent on the building construction* was determined by the household in negotiation with the contractor and depends on the type of work required from the contractor. When the materials are bought by the households themselves the contract was based upon an estimate made by the contractor of the man hours and labor input required to finish the total project. The calculation generally was made by taking into account the size and complexity of the job, as well as the location of the site, since this last aspect might complicate the construction process for example due to the difficult accessibility of the site or soils with particular requirements for the foundation. An advantage of an agreement on the financing of the construction project in this way is that the agreed price will seldom influence the qualitative output of the job.
The contractor was usually *paid in installments during the execution of the work.* In 2 cases the fundi was paid beforehand and in 4 cases afterwards (n=42) .Lack of funds and delayed payments, due to the fact that households could not manage to get enough money were a cause of time overruns in the project execution.

The *project management* was in most cases in the hands of the future owner (81% n=42), who organizes the building process and was also directly involved in the construction activities. He was assisted by unpaid relatives and/or hired fundi (craftsmen). A contractor was seldom hired for the execution of the total project - only in 10 % of the cases, since it is a common wisdom that this increases the costs with 50% to 100%. Women carried out the project management in 4% (n=42) of the dwelling construction projects.

fig 4.5 project management



The *involvement of the various participants* in the investigated building construction projects for and by the lower income households in the urban areas of Dar Es Salaam is indicated in an overview in Appendix II-4.

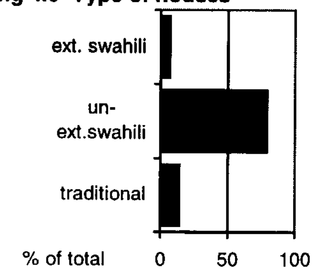
The *conclusion* with regard to the project setting of the dwelling construction projects for and by the lower income households in urban areas of Dar es Salaam is that the above mentioned characteristics of the setting in which the dwelling construction projects take place include promoting and constraining factors. These are expected to have an impact on the construction project performance.

In the following section the results of the investigations of the product technological features of the site construction output are described.

4.3 Product technological features of the output

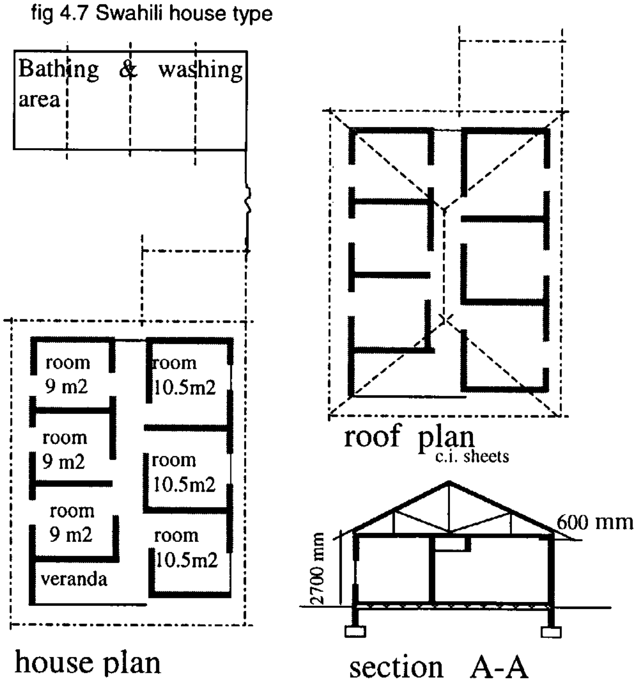
The *type* of the investigated houses -constructed for and by the lower income households- is mainly the single storey building of the (modern) un-extended Swahili type (78.5%); other types are the extended Swahili houses (7,14%) and the traditional houses (14,29%). (Field studies TUE 1995-1996 n=42).

fig 4.6 Type of houses



The *Swahili houses* are an urban type of houses, with a rectangular shape and a gable or hipped roof. Their design is thought to be derived from the original Zaramo houses of the country with the difference that the Swahili houses were adapted over time to accommodate a more Arabic and a more urban pattern of life. The main structure of the Zaramo houses is made of mangrove poles dug into the ground and tied with horizontal sticks. This structure is either plastered with mud-plaster (stabilized with cement or lime) or thatched with grass. The roof structure is made of grass thatch on a pole structure. The floor is a continuation of the site. The verandah can be raised a little. (Nnkynya, 1984).

fig 4.7 Swahili house type



With regard to the *geometric properties* the following can be concluded. The *shape of the investigated houses* is in all cases rectangular with a gable or hipped roof in most cases - hipped (50%), gable (25%) - Other roof shapes flat (10%).

The *layout* of the Swahili houses is in principle the same as that of the traditional rectangular Zaramo houses.

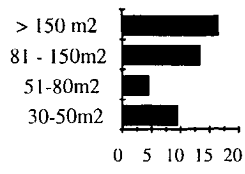
The *house sizes* are fairly large and have a mean dimension of 120 m2.Some 22% of the houses is smaller than 50 m2, 9% has a size of 50 - 80 m2, some 38% of the houses has even a size of more than 150 m2.

The *average number of rooms* in the largest percentage of the investigated houses is two to four rooms. Some 7% of the houses that are of the extended Swahili type, have more than seven rooms.

The percentage of houses that is occupied by one household only is 65% in the investigated areas of this research project. This is higher than the percentage mentioned in literature but might be due to the sample in this research project. In three percent of the cases the house was occupied by the owner- household with 7 tenants.

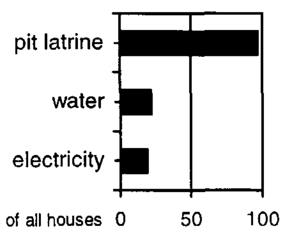
Functionality of the houses in the investigated areas in terms of the found average for the available *floor space per household* is only 17m2 which is very low compared to the minimum required floor space (45m2)
Multiple usability of the dwelling is possible thanks to the relative large sizes of the plots. On average some 25% of the plot is used for the dwelling. Most of the households use their plots for farming (87%) next to having their house on the plot. Given the low income of the households the relative large size of the plots offering the possibility of farming for own consumption is of great advantage. Only few of the households in the investigated areas use the house for carrying out their job or for commercial activities.(small business 10%; shops 3%)

fig 4.8 Size of the houses



The situation with regard to the *facilities on the plot* is rather poor. Only a small percentage of the households have direct access to water (21.5%) on the plot. The same is the case for electricity (16%) and most of them even draw these off from houses in the neighboring areas.
Cooking and preparing the food takes place inside the house (74%) for most households despite the relative small size of the houses in terms of m2/per person.
Bathing facilities and washing of clothes on the other hand takes in the majority of cases place outside the house (81%).
Toilet facilities are in most of the houses available in the form of a pit latrine. In a number of cases however the plot size is actually too small to be provided with this type of toilet facility. Some 3% of the houses have no toilet at all.

fig 4.9 facilities on plot

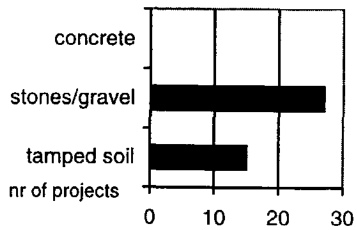


With regard to the *materialization and applied construction systems* the following can be seen.
Site preparations took place in only a limited number of cases in the investigated areas the construction of the houses. The houses were directly built on the site ground. The excavation of the top soil is only carried out in 40% of the cases, leveling has taken place in 90% of the cases and only a small percentage of households has constructed a drainage system for their own use (10%), while this is a bare necessity in particular in the rainy season.
The *type of foundations* is in compliance with the construction system of the main structure in the investigated areas. The foundations for the mud-and-pole structures (14%) existed of the mangrove poles which are dug into the excavation of some 300-400 x 300-400 mm, filled with either gravel or stones in -most often- a mud mortar. But mud mortar is actually not preferred, since it reduces the friction between the stones. The houses constructed in the sand/cement blocks masonry system generally had a foundation of sand/cement blocks masonry in an excavated trench (86%).
The foundations of the houses in the investigated areas were not all meeting the basic requirements. The depth and the width of the trenches did not always comply with the recommended measurements of at least 300-400 x 300-400 mm depth and width.

In more than 50% of the cases no footings were observed and the width (in 60% of the cases) of the foundations was less than 300mm. In 5% of the cases the foundation depth was less than 300mm. Moreover the line of the foundation trenches in a number of cases (15%) was not really straight.

A large percentage of the *floors* are not constructed as required. The major *floor construction materials* used are stones and gravel (64%) and in 36% of the cases the existing soil has been tamped. In none of the cases in the floor construction the application of damp proof foils could be noticed to prevent the humid from the soil underneath to damage the floor. In only some 57% of the investigated projects the *floor level* is at least 150mm above the outside ground level, to prevent the penetration of rainwater into the house during the rainy season. The *floor* in nearly a quarter of the investigated projects (24%) has no hard and smooth surface, which is easy to clean.

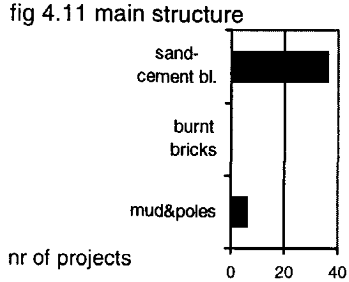
fig 4.10 groundfloor materials



A relative small part o the houses (14%, n=42) is still constructed in the *traditional mud-and-poles construction system*, by making use of the available materials of the direct environment. The walls constructed with the mud-and-poles construction system (14%) are considered of *non-permanent nature* which does not comply with the basic requirements for exterior wall constructions. This means that the walls cannot withstand all applied loads without harmful deformations. They are not always properly bonded together, not durable and require on-going maintenance and repair, since they are also not rain-proof and no precautions have been seen in order to prevent water and vapor to raise from the ground through the walls.

The *main structure* of the majority of houses in the investigated areas is carried out with a masonry system with the *cement aggregate blocks* as basic material (86%, n=42). The sand-cement block walls are in principle considered to be of durable and permanent nature. The compressive strength of walls built with the soil cement blocks is 0.3 N/mm2, which implies that the single storey houses of the investigated projects comply with the limits to *withstand their own weight.* Moreover the sand-cement ratio applied for the production of the blocks has been found to be on average lower than 1:10. (the minimum ratio for exterior walls is recommended to be 1:14 ; Mortiary & Therkildsen, BRU, 1973). This means that the blocks will *not easily be washed out by rains.* On the other hand the lower ratio does not improve the block quality significantly and can thus be seen as a waste of capital. Also the *quality of the masonry* leaves much to desire with regard to the way the walls are bonded together. Whenever reinforcement is used the *bars are not placed correctly* in 24% of the cases. No particular precautions are found to be made to prevent water and vapor to raise from the ground through the walls. This enhances the destruction of the house by humid and the creation of discomfort and danger for health and hazard.

fig 4.11 main structure



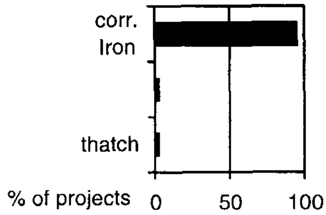
Other construction systems are unknown or rarely applied in the urban areas of Dar Es Salaam due to the unavailability of the basic materials for those systems in this area.

The *wall-finishing* was in 88% of the cases with a sand-cement plaster. In the rest of the cases no finishing was applied. In none of the cases the walls have been coated with materials like white wash, or any other light colored coating in order to be reflective and have a low thermal storage capacity.

All *roofs* in the investigated area are carried out with slopes as gabled or hipped roofs to ensure a quicker run off of rainwater. The *roofing structure* in all projects was composed of non treated timber rafters and purlins. No calculations are made to determine the precise construction engineering details for the roofing structure. This apparently implies often a waste of material since the structure was found to be over-dimensioned. The number and size of these materials are in the majority of cases (70%) determined by the craftsmen and in 23% of the cases upon the client's order.

Roof finishings are in most cases carried out with corrugated iron roofing sheets in the investigated projects. These roofs are in principle rain and water proof, of light weight material and reflective. The *insulation value* of this roofing material leaves much to desire. The more since it is most often applied without any ceiling or other form of insulation which makes the in-side of the house unbearably hot. Moreover the c.i. sheets have to be purchased at relatively high cost prices in contrary to the thatch. An advantage of the application of newer materials like the c.i roofing sheets is that the life time of the houses can be extended provided that proper roofing construction details are applied to the houses.

fig 4.12 Roofing materials (%)



The *roof attachments* to the main structure in a large majority of the houses are made of iron strips (36%) screwed or nailed to the wall plate. The roofs are in a majority of the cases (54%) *not wind proof* and not properly anchored to the walls to prevent the roof or parts of it to be torn off by the wind. This implies that often stones are put on the roof to prevent it to be blown away by the wind. The roofs also cannot sustain a point load of 100 kg so that persons can walk on the roof for maintenance. The *roof overhang* complies in only some 12% of the cases with the standard requirements of at least 500 - 600 mm to keep rainwater away from the walls and contribute to the shading of the walls in order to prevent the rainwater to destroy the walls and the sun to penetrate the rooms. The function of a roof overhang is in most cases well known (86%). Other reasons which were mentioned for the size of the roof overhang were the client's order (3%), decorative function (3%), shading (3%), or not known in 5% of the cases.

The used *ventilation openings* are concrete blocks with holes. In 5% of the cases these blocks only had a decorative function. The number and position of the ventilation openings is in most of the cases determined by the craftsman (59%), the client 33% or even not available in the rest of the cases. All *casements, windows and doors* in the investigated areas were made out of timber. Only in one case the *size and location of the windows* in the walls are based upon the general requirements for light and ventilation. The size and the location of the windows is usual a multiple of 1 foot (300mm). The size of the windows is generally determined by the craftsman (70%) based upon the function of the room and upon the client's order (23%), in the rest of the occasions the actual function of the windows is not taken into account. The attachment of the casements to the walls is in general carried out by fixation of the horns into the walls and application of nails or iron rods for further fixation.

With regard to the *physique technical properties of the houses* can be concluded that in particular the durability of the houses against climatological and biological influences leaves much to desire. Moreover many technical details applied during the realization of the houses do not meet the requirements which reflects the lack of proper skills (know-how) and knowledge (know-why). Examples are the wrong or bad fixation of the roof structure to the main structure, the low quality of masonry, the wrong sizes of the foundations, etc. (see appendix II)

The site- *production complexity* becomes visible in the time needed to build a house, which is on average more than 6 months. The houses are produced as simple units to customers orders composed of many different products, components and elements. Moreover the majority of building materials, components and elements are produced on-site. But as the informal building construction processes of houses for the lower income households in Tanzania should be seen as *incremental processes*. The major constraining factor for minimization of the construction time is mentioned to be the availability of capital to be invested to purchase the materials.

The average *minimum costs of a house* of 50 m2 built with the sand cement blocks masonry system following the basic requirements was approximately Tsh 800.000 (US$ 1280 in 1995). House-owners were rather reluctant to mention the actual costs of their house or did not know these, since they did not keep records of it. We made an attempt to estimate these costs cross-checked with local experts. The costs of the presently built houses - with a number of deficiencies- are estimated to be between Tsh 400.000 (mud&poles system US$ 640 in 1995) and Tsh 650.000 (sand cement blocks masonry US$ 1040 in 1995).

The *overall conclusion* is that the present product technological quality of the construction output leaves much to desire. Also in terms of quantity of constructed houses per year the same conclusion can be drawn. The last is based on data stated by the CHS which indicates a dwelling construction output of only 20% of the actually required number of houses. (Kyessi, CHS, 1995)

4.4 Material inputs

The features of the *major material inputs* that are used during the building construction of the houses for and by the lower income households in Dar es Salaam are described below.

Construction sand is bought in 66% (n=42) of the cases. In 85% (n=42) of the cases the sand was transported by truck. Materials like sand and soil are also often directly dug out of the construction site.

Timber products for the roofing construction is locally available -although the quality of these is rather low- and are also imported.

Un-treated timber poles (mangrove hardwood) are the only poles used in the Dar es Salaam area and are available in various trade sizes. The windows, doors and casements are produced by carpenters, who generally have their own workshop, from where the casements are transported to the construction site.

Cement is a commonly used material. The material has to be bought in the shops and the buyer has to transport it.

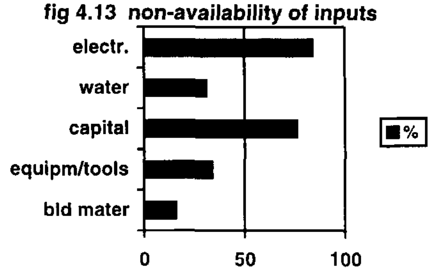
Sand-cement blocks are predominantly produced on-site by making use of molds or presses, of a mixture of sand and clay stabilized with cement. Other stabilizers are also possible like for example lime, but this is seldom used since it is nearly not available or too expensive for the owner of the house.

Lime and gypsum are hardly or not used in the dwelling construction for the lower income households due to the costs and scarce availability.

Roofing sheets are locally produced but the import content is rather high since the production relies on the imports of semi manufactured metal products. The same is applicable for nails, screws and bolts. Pipe fittings have to be imported.

The non-*availability of the materials* on site was mentioned by 17% of the contractors/house owners. In 21% of the cases the house owner did not buy enough of the required building materials like for example cement.
Water has been available in 69% of the cases (n= 42). When water is available on site, this means that there is either running water or a near by located well.
Electricity was only available in 16% of the cases. In other cases a generator was hired when needed, which made the use of powered equipment possible in 71% of the cases. The availability of electricity should be read as the wires are rather close to the building site.

fig 4.13 non-availability of inputs



The *quality of the building materials* was mentioned to be poor in 21 % of the cases (n=42), although the contractors and house owners could not indicate the particularities in terms of strengths and durability. Building materials that were produced on site -like the concrete blocks- have a *poor quality.* The addition of stabilizers like cement for the production of sand cement blocks increases the strength and durability of the blocks in particular to withstand the climatic influences, which makes plastering even unnecessary and reduces the need for maintenance. The life span of the blocks is often longer than of the house they are used for. This enhances the re-use of the blocks that was found in 5% of the cases. An important prerequisite for the quality of the blocks is the utilization of the right mixture of cement and aggregates as well as the proper curing procedure and time. This should take place in a shadowed place to avoid cracking of the blocks and last at least 9 days. These aspects are not always taken into account.

The *import content* of the inputs in the building construction projects is relatively high and concerns predominantly the part of intermediate products which are needed for the local production of the building materials such as the corrugated iron roofing sheets.

In 80% of the cases the building construction inputs and materials are acquired from informal sector organizations. In 13% of the cases the materials are bought from the formal sector. This counts for example for the iron roofing sheets. In the rest of the cases one could not precisely indicate where the materials came from. None of the contractors directly imported the materials, which is sometimes the case in projects that are carried out by the higher class contractors.

The *costs* of the building materials have been increasing over time. This is caused by the relatively high rate of inflation in the country during the past few years. (NCC 1995)

4.5 Process technologies

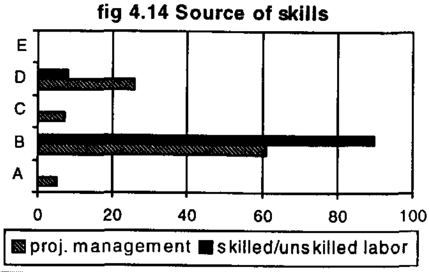
The ***technoware*** *component* in the construction process consists of *simple hand tools*, with which most of the construction activities are carried. Only in the case of concrete mixing and pouring a concrete mixer and sometimes a generator is hired for a couple of days only. This was the case in 71% of the projects (n=42).
Few contractors sometimes use high temperatures in the form of welding, but only when the project and the size of the project requires it. Electricity is used by more contractors, but only for certain tasks like concrete mixing. High voltages are not used. The equipment that consumes the electricity is in most cases hired equipment.
The *working capital* of the majority of contractors is on average Tsh 30,400 (US$ 49 in 1995), which represent mainly the value of the available equipment and tools.

Investments in tools and equipment are very low. The average value of the equipment that was purchased in the last 12 months was Tsh 3,300 (US$ 5.3 in 1995).

Maintenance of tools and equipment practically does not take place.

The ***humanware*** *component* -size and nature of the labor force involved in the construction projects has the following features. The construction processes are still rather labor intensive. This is even enhanced by the fact that most of the building materials or building components are produced on site and practically no prefabricated are applied.
Project management is in 81% of the cases taken care for by the owner of the house himself, in 4% of the cases it is housewife who takes the responsibility for the management of the construction project. In none of the projects a permanent project manager has been involved. On average in 70% of the cases (n=42) a master fungi has been working as general *foreman* on permanent basis in the total construction project. The number of *permanent skilled labor force* is on average 3 per project, while on average 2 laborers work in each project on temporary basis. The total labor force per project is on average 4.6 persons.
With regard to the *availability of the labor force* none of the house owners and contractors has mentioned to have troubles in finding the know how and skills he needs. There seem to be enough skilled workers. Problems occur, when a fundi is less capable than he pretends to be. In this case the contractor just did not hire the right person, who will definitely be available somewhere.

fig 4.14 Source of skills



A = self-taught;
B = apprentice in small scale enterprises
C = apprentice in large scale enterprises
D = vocational training; E=,other

Many of the general foremen (95%) and skilled labor force (93%) have been involved in more than two construction projects before. This co-incites with the age of most of the construction unit. This means that they have a certain *experience level* in dwelling construction projects. The project managers are less experienced. Only 16% of these have some experience in former projects. This low experience level is not surprising since in most cases the house owner acts as project manager for the first and possibly for the last time.
The *level of education* is not very high for the total labor force. No substantial differences occur among employees with respect to formal education and training.
The project manager in only 53% of the projects has completed primary school, 40% has not completed their primary school education, while 2% has finished a university program. Most

foremen have completed the primary school (90%). None has completed the secondary school. Most of the skilled labor force has completed primary school (96%). Two laborers (family helpers) had even finished secondary school. Almost 90% learnt in a small scale enterprises 8 persons attended vocational schooling and 12 persons mentioned that they had no training at all. All apprentices completed primary education.

The *source of building construction skills* has been for the foremen and project managers in 26% an apprentice ship in a small scale construction enterprise, 3% in a large scale construction enterprise and 11% has followed vocational training. The skilled labor force has acquired their skills during apprentice ships in small scale enterprises in 93% of the cases and in 7% of the cases the labor force followed vocational training. Two of the fundi -contractors mentioned *self taught* as source of skills. But it is difficult to draw a line between learning in an enterprise and self taught. In general a learning-by-doing process takes place when boys start as a kibarua (unskilled worker). After quite some years they are regarded as fundis unskilled craftsmen. Since no actual training or lessons take place in this process, one could thus regard this process as self taught. Two contractors went to Muslim school. This implies that they do not have the same educational level as the contractors who finished primary school, as the main concern in Muslim school is the reading of the Koran. In most cases those pupils are not even able to write and read proper Kiswahili. This might thus have its impact on the ability to read instructions, keep records etc.

A *lack of knowledge and skills* among the labor force was mentioned as a problem in 12% of the projects. This has much to do with the use of relative new materials like cement and the c.i. roofing sheets for which the process technologies are not commonly known and the information and guidelines for appropriate application are not direct available.

Infoware in the form of written information is hardly used in the investigated dwelling construction projects for and by the lower income households not to speak of the use of computerized documentation and information systems. A number of fundi-contractors use written building contracts, very few use working schedules (4%) or operating instructions (9% n=42). However, this last figure will probably be slightly higher, since drawings were not always taken into account. No other written information is used. Payments to workers are recorded by more than half of the contractors. Other aspects are recorded in less cases.. Materials databases are only available in 26% of the cases. No equipment databases are used.

The basic characteristics of the ***orgaware*** *component* in the construction projects are the following. The projects are executed with the involvement of *small construction units* (fundi) in the construction process are of the *type of traditional tradesmen and fundi* in the informal sector. All are of *Tanzanian origin.* Some 93% of these informally operating construction units indicated to prefer to be legalized as a formal sector contractor, although 7% of the fundi do not mind to stay working in the informal sector.

The *configuration* characteristics are investigated by looking at the organizational structure of the construction project and the number of direct and indirect labor force. Next to this the wage structure is taken into consideration.

The major part (93%) of the fundi-contractors operates as a master with laborers in their organizations. A small number has also some apprentices. The number of permanent labor force that operates with the master fundi is on average 2,7. Temporary labor force -on average 1.6 per project- is employed on ad hoc basis for specific activities like for instance concrete pouring. The average number of apprentices per project is rather small (0.13

The average wage for a male skilled construction worker is 2100 Tshs (US$ 3.4 in 1995) per day. The average wage for a male casual worker is 1035 Tshs per day.

(NCC 1995) No contractor has determined wages for skilled female workers, since they are not hired. The female unskilled worker earned 500 Tshs a day, although she was employed on a permanent basis. In this particular case no distinction was made between casual workers and unskilled but permanent workers.

The *financial means* for the project operations are in 97% of the cases provided by the client. The average working capital per construction unit in 1995 has been on average between Tsh 40,000 and Tsh 59,000.(The construction units work in majority on ambulant basis and have no fixed workshop.

The mean number of working hours per week is on average 54, which is relative high. This is caused by a small group of contractors who work more than 60 hours per week. The mode thus provides a better indication for the average number of working hours per week. No other economic activities of the informal building contractors are found. Most fundi-contractors do not have other jobs as a result of the large number of working hours during daytime in the informal building sector. It is however not clear to what extent contractors really do participate in agriculture and livestock keeping as it is quite common for many households to have at least a certain number of chicken.

All construction units show the same characteristics regarding the degree of *centralization*. This becomes clear by the fact that problems and complaints in general are discussed and decisions are taken when consensus on a particular issue has been reached.

The degree of *formalization* in terms of the level of utilized information and documentation (infoware) showed that many activities are hardly carried out without any form of formalization or written information on operations and expected and realized role performance. A number (10%) of fundi-contractors use written building contracts.

Regulation and control mechanisms are negligible. Only progress administration and control are carried out in 28% of the cases, while the financial matters and costs in the project are documented in 54% of the cases. This has much to do with the payment of the project, which generally take place after completion of a certain job. This aspect was also investigated by measuring the level of bureaucratization in terms of overhead like the time spent on administrative activities that is on average less than one hour. Part of the administrative activities consists of discussion and negotiating with the client.

Standardization was investigated by looking at the existence of procedures for employment selection, job acquisition, technology development, quality control, safety precautions. Hardly any form of standardization is seen in the employee selection procedures. Selection of project foremen, fundi-contractors takes place by personal recommendation in 95% of the cases, supplemented with interviews by house owners/superiors. The selection of the labor force takes in 87% of the cases place by personal recommendation, in 7% of the cases supplemented with interviews and in 64% of the cases also practice testing on the job takes place.

Job acquisition takes place on ad hoc basis by personal recommendation in all of the investigated cases.

None of the fundi-contractors carries out any form of technology development or *R&D activities* on standardized or regular basis. Neither is any form applied of standardized (a) *quality control* of materials and finished products, (b) safety precautions on site.

The construction units are mainly *specialized* and have *experience* in the execution of residential building projects. Only one of the interviewed fundi-contractors has been involved

in the construction of a small commercial building in the formal sector. They all are not specialized in a particular trade of work and mention to be able to carry out all activities in the total construction process.
The level of experience is measured by investigating the age of the construction unit. It appeared that the level of experience of the fundi-contractors in the execution of projects is reasonable. A large part of the units already exist a long period of time, 96% of the units exist already longer than 5 years (6-20 years). Some 21% even exist already more than 20 years being occupied with building construction activities in the area of Dar es Salaam.

Regarding their *business orientation* the contractors put forward that their major objectives are growth and expansion of their business. However this is without a realistic form of planning or strategy. A minor part (5%) mentioned to prefer to start another type of business like for instance in the trade sector. No technology development initiatives are taken, neither any form R&D. Most of the contractors have expressed the desire to move towards the formal sector. A major reason for this is the fact that they expect to get more jobs by being registered and thus known to a larger community. The rest plans to stay unregistered.

The *external relations* of the construction units are limited due to the fact that they operate in the informal circuit. The number of *clients* per year is on average 3.7 per construction unit. All contractors notice an increase in demand. This is an affirmation of the information as provided in many reports in which is stated that the demand for residential buildings will keep on increasing.
The contractors mentioned to encounter *competition* from other informal *construction units.* Contacts with governmental organizations, institutes and organizations working in the field of R&D and education or labor and branch organizations do not take place or not on formal basis. The purchase of 80% of the building materials and 100% of the simple tools takes place in the informal sector. Those involved in the execution of the dwelling construction projects for and by the lower income households have no relationship with the actors of the network of the formal construction industry in Tanzania. (see appendix II)

4.6 Conclusions

The conclusions on the results of the mapping studies on the technology status in the dwelling construction projects are given below.

The product technological status of the constructed houses in the investigated dwelling construction projects for the lower income households in urban Tanzania does not meet the basic standards for houses in Tanzania (Building regulations BRU).

The availability of facilities like water (21.5%), electricity (16%) and sanitation in and around the dwelling is poor. The accessibility of the dwellings is bad.

The majority of the houses is built with the sand-cement masonry system (86%). This can be classified as *conventional system,* although the system is for most Tanzanian lower income households a less known, new and urban system. The technical details applied to the various building elements show a number of deficiencies most probably caused by a lack of knowledge and skills. Other houses are still built with the traditional mud-and-poles system.

Positive is the design and lay-out of the houses that suit the present life style of the urban population. The majority of houses (78.5%) is of the un-extended swahili type, with a rectangular shape and a hipped and gable roof. The majority of houses (30%) has two to four rooms. The houses are fairly large (38% has even a size of more than 150 m2) and offer room for more than one family. The houses in general have a multi-functionality. The dwelling offers the opportunity to use the house for additional purposes such as farming and shop-keeping.

Another positive point is the apparent affordability of the houses for the lower income households. At the same time can be concluded that this is to the disadvantage of the quality in terms of durability of the houses. Properly built houses by right application of the technical details and materials cost more than the presently built ones.

Major constraints in the dwelling construction projects are the production complexity and the lack of materials. A major cause is that most building materials are produced on site with a minimum of equipment. These factors are found to have a negative impact on the quality and the duration of the construction project. Moreover the investigated dwelling construction projects all concern the construction of one single house, no mass construction projects were encountered. This also has a negative impact on the duration of the projects.

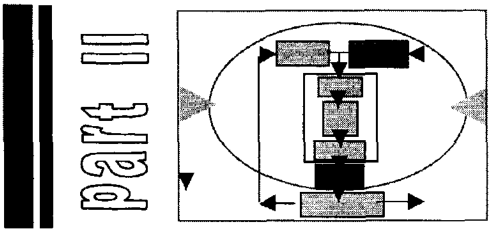
The major building materials used for dwelling construction for the lower income households in urban areas of Dar es Salaam are sand, aggregates, soil, cement, water, timber and corrugated iron roofing sheets. Grasses and other traditional local materials are used in decreasing percentages. Major constraints for the performance of the dwelling construction sector are the non-availability, the low quality and high costs of the building materials. The import content of the materials is rather high (30% on average).

The *status of the process technologies* used in the investigated dwelling construction projects obviously is not sufficient to carry out the construction activities in which skills and knowledge, information on the application of the conventional urban construction systems like the sand-cement masonry system is needed. They can be classified as *traditional.*
The majority of the building elements of the houses are constructed with simple hand tools only. Investments in tools and equipment are very low.
The house owner, his relatives and friends form a large part of the labor force on site.
The availability of the needed labor forms no problem. The project management is in the hands of low experienced labor force. The hired labor has been involved in construction projects and gained on this way experience. The level of skills and education in contrary is not very high of the total labor force on site. The major source of skills is an apprentice-ship in small scale enterprises as un-skilled laborer.
The construction projects are carried out with little or *no information or documentation* other than verbal instructions given by the house owners.
The organizational framework of the construction projects is of the informal ad hoc type, with involvement of fundi/ small scale contractors. The contractors have less than 10 employees, 60% of these are permanently employed, 40% is employed on temporary basis in the project. These are often the relatives and friends of the house owner.
The organizations have a high degree of centralization, little or no formalization, regulation and control of the activities. The business is oriented at expansion without a realistic form of planning, no technology development efforts, R&D or specific form of job acquisition.
The external relations of the organizations are limited to other informal sector organizations.

The present technology status is assumed to have an impact on the technological production performance in the dwelling construction sector for the lower income households. In the next chapter this *technological production performance* is described.

Chapter 5

The technological production performance of the dwelling construction projects



5.1 Introduction

In the foregoing chapter conclusions were drawn on the status of the technologies used in the dwelling construction sector in urban Tanzania. This technology status is assumed to be reflected in the technological production performance of the dwelling construction projects. Herewith the views are followed that the *Technological construction project performance* (TPP) depends on the technology efficiency (Tefficy) and technology effectivity (Teffect) of the construction project. (part I chapter 3) The technology efficiency and technology effectivity of the investigated dwelling construction projects for and by the lower income households in urban areas of Dar es Salaam will be described in the next sections .

5.2 Technology effectivity of the investigated dwelling construction projects

Technological effectivity of construction projects refers to the rate to which the desired product technological characteristics of the houses are achieved -both qualitatively and quantitatively. The technology effectivity of the investigated dwelling construction projects - in terms of quality- is assessed by bench marking the found data on the product technological characteristics of the houses against the basic requirements as set in the Tanzanian Building Regulations (TBR). The benchmark for effectivity -in terms of quantity- is the number of houses that are needed. The major question thus is whether the required targets of the construction output - both quantitatively and qualitatively- are being reached in reality.

In terms of *functionality* the output of the investigated dwelling construction projects meets for 55.5% the basic requirements of adequacy for an average lower income household. With regard to the *physique technological* features of the various building components the scores are indicated in the table in the appendix II. The conclusion can be made that the output of the investigated dwelling construction projects meets for 64 % the basic product technological requirements described in the Tanzanian Building Regulations (TBR 1985).

Thus the score of the product technological features of the output of the investigated dwelling construction projects is 0.64.
The quantity of the output though leaves much to desire and covers only at most 20% of the annual housing needs. (Kyessi CHS,1995) In other words the overall score of the technological effectivity of the dwelling investigated dwelling construction projects is

$$T_{effect} = f(\text{Produtec, Q}) = 0.64 \times 0.20 = 0.12 \quad (0 < \text{Teffect} < 1)$$

5.3 The technological efficiency of the investigated dwelling construction projects

Technological efficiency of construction projects refers to the ratio of actually utilized versus the theoretically possible utilization of means and procedures for the transformation of inputs into desired outputs. Improvement of the technology efficiency on site has been enhanced by improved product and process technologies.
The best practice process technology is determined by the product technological specification of the desired production output of the transformation processes. Hereby is assumed, that a higher production output in terms of quantity and quality is directly related to an increasing order of more developed and better attuned components of process technology applied in a rationalized, systematized, standardized mechanized and automated manner in production processes.
But the nature of the inputs also has an impact on the technology efficiency in the construction processes. Standardization and off-site industrial production of building components and building elements - like complete parts of a wall structure, roofing structure, etc- has proven to have a positive impact on the construction project performance on-site.

The characteristics of the process technology components *-technoware, humanware, infoware and orgaware-* were examined for the determination of the technology efficiency of the dwelling construction projects. A scale between 0 and 10 was used to determine the average scores. (See appendix II)
The results of the technology mapping studies indicate that the process technologies are characterized by a: (a) rather low level of utilization of advanced *equipment and tools*, (b) low level of *training and education* of the labor force, (c) very limited availability and quality of *information and documentation* on site, (d) highly centralized *organization structure*, (e) type of configuration, (f) low level of formalization and standardization, (g) low level of planning and control, (h) limited external relations beyond the informal sector operations.
Positive and promoting factors are (a) the availability of labor force and (b) the relatively low entrance barrier, (c) the flexibility of the small scale and informal sector during the execution of the construction projects (no tight time schedules with high penalties)

> The conclusion is that the status of the process technologies applied during the execution of the construction projects scores rather low with a score of *2.61* (0<Stprocestec<10 see appendix II for scoring tables)

The scores for the *inputs of building materials and components* in the construction projects are also rather low. Again a scoring range between 0 and 10 was used to come to conclusions with regard to the nature, the availability and the quality of the materials input in the construction projects.

The *nature* of the materials input in the construction projects scores in total 2.2. Most inputs are raw materials or semi-manufactured products which still have to be transformed to building materials and components on site. This enhances the possibility of failures in construction details, which ultimately has a negative influence on the quality of the construction output. Moreover the time consumption of the on-site construction process is also negatively influenced by the nature and preparation of the materials input. Higher scores can be reached by application of more prefab components and elements.
In 55% of the projects was mentioned that the *availability* of the inputs (building materials, water and electricity) formed a major constraint. The score for the availability of the inputs on a scale between 0-10 is then 4.5. The average *quality* of the inputs is mentioned to be poor in 21% of the projects; reasonable in 74% of the projects in particular for the imported products and in 5% of the projects no problems regarding the materials inputs were mentioned. The quality score for the inputs is then 5.5 (on a scale between 0-10). The small scale and informal sector plays an important role in the extraction and production of the materials. The import content of the materials in construction projects is 30%. This becomes evident in the costs of building materials that have increased to a large extent over the past years in Tanzania. (See appendix II) The total score for the material inputs then comes down at

$$I_{inp}=f\ (N_m,A_m,Q_m) = \frac{2.2 + 4.5 + 5.5}{3} = 4.06$$

Thus following the starting point that technology efficiency is a function of inputs and process technologies the conclusion can be made that the technology efficiency score as result of the following calculation ends up at a score of

$$\text{Technology efficiency} = f\ Inputs\ x(T,H,I,O) = 4.06\ x\ 2.61 = 10.6$$

In an optimal situation this score could be 100. This means that the technology efficiency in the dwelling construction projects in urban Tanzania is rather low.

5.4 The technological production performance of the investigated dwelling construction projects in urban Tanzania

The technological production performance of production systems is considered to be a function of the technology effectivity and the technology efficiency.

The technological production performance of the investigated dwelling construction projects in urban Tanzania thus results from the following calculation as

$$TPP = Teffect\ x\ Tefficy = I\ x\ (THIO)\ x\ O = 4.06x\ 2.61\ x\ 0.12 = 1.27$$

The range for the technology effectivity score is $0 < Teffect < 1$ and that for the technology efficiency is $0 < Tefficy < 100$. This means that the technological production score range is $0 < TPP < 10$.
The technological production performance of the investigated dwelling construction projects is thus on the very low side.

5.5 Conclusions

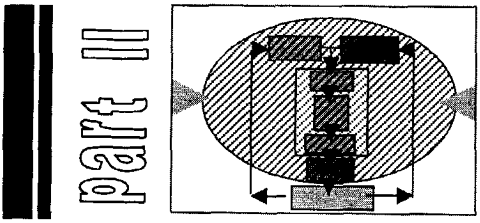
It is possible to determine the causes of the technological production performance by means of the applied methodology.

The *material inputs* show a low availability, a low quality (high costs and a high import content) and include in majority raw materials, that require transformation processes on site. The *process technologies* used in the construction projects are not in compliance with the actually needed components for an efficient construction process. The presently applied technologies include simple low cost hand tools and very few equipment. At the same time a labor force is involved with a low level of education and skills. There is a lack of information and documentation on site and a non-standardized construction process that is executed on ad-hoc basis by informal sector organizations. The product technological features of the construction output show a low level of product technological quality and a low quantity of output.

The dwelling construction projects that were investigated in the urban areas of Dar es Salaam in Tanzania form a part of the activities in the construction industry in the country. In the next chapter the findings of technology mapping studies in the investigated dwelling construction projects are placed within the context of the general performance of the construction industry in Tanzania. The purpose of this is to determine the factors of the particular characteristics of the *sectoral setting of the dwelling construction projects* that might have an impact on the found technological production performance.

Chapter 6

The construction industry in Tanzania



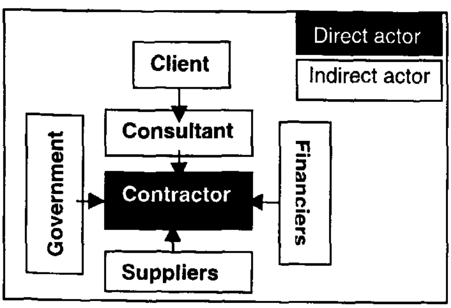
6.1 Introduction

In the foregoing section conclusions were drawn on the technological production performance in the dwelling construction sector in urban Tanzania. In this chapter the results of the studies on the sectoral technology setting of the dwelling construction sector in Tanzania are described. The objective of these studies was to get more insight in

a. the structure of collaborating actors in the dwelling construction industry
b. the contribution of the dwelling construction sector to the overall performance of the construction industry in Tanzania.
c. the national policies and regulations for the construction industry that is expected to have an impact on the performance of the dwelling construction industry.

This is considered necessary to determine the priorities in technology management and policy making for the construction industry. For this purpose the available data of the official statistics (NBS 1991/93) and several publications on the Tanzanian construction industry were used.

Fig 6.1 Actors in the formal construction industry

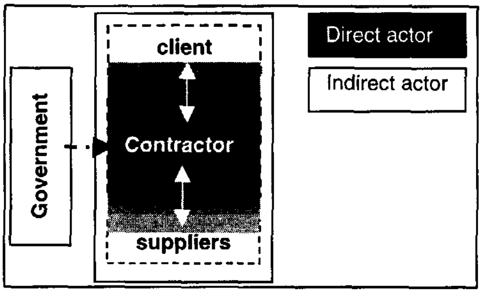


6.2 Actors in the Tanzanian construction industry

A key position in the actual realization of buildings on site is taken by both the formal and informal construction units in Tanzania. Next to these several *other actors* are involved to a more or lesser extent in the activities within the construction industry.
In a simplified model the figure 6.1 shows the direct and indirect actors within the *formal construction industry.*

The next figure depicts this for the *informal* *construction industry*. In the last case consultants do not play a significant role in the construction process. This is due to the fact that unless the client can afford it, there usually is no intermediary between him and the contractor (Mwaiselage, 1991). Also financiers are not involved in the informal construction process. The client pays the construction costs from his own savings or borrows the money of friends or family. So the client acts as a financier as well. The role of the government is also slightly different in the informal construction industry as compared to that in the formal construction industry simply because all activities of this sector take place in the informal sphere.

Fig 6.2 Actors in the informal construction industry



The existence of a notable number of firms operating in the informal sector is one of the major characteristics of an economy in a developing country. The importance of the informal sector in the development of a country has been recognized by governments as well as by non-governmental and parastatal organizations. Despite some disadvantages put forward on the existence of an informal sector in a country the advantages outweigh them. This is enhanced by the fact that the socio-economic situation of a large percentage of the population force people to find their ways through the informal sector. This is also the case for the informal construction sector in Tanzania that seems to offer opportunities for the lower income population. Dwelling construction projects for them are mainly carried out in *the private informal construction sector* in close collaboration with the future house owners themselves. (See appendix II) The power of the informal sector operations in Tanzania and Dar es Salaam can be felt in every day life: in the way people do their shopping at markets and with street vendors. The informal construction sector thus can be considered as an inextractable part of the construction industry in Tanzania although this becomes not always clear in the official statistics.

An *overview of the different types of contractors* in Tanzania is given in appendix II. For this purpose the data from the registration system of the National Board of Architects, Quantity Surveyors & Building Contractors (NBAQS&BC).[1] was used. In the NBAQS&BC registration system contractors are classified in seven classes. The classification is based on the average level of the contract sum of the projects executed by a contractor and the major characteristics of the construction unit. Companies of Tanzania-Asian origin are dominant in the higher classes of the system (class I-IV). Foreign companies are especially dominant in class I: they represent only 4% of the total of registered contractors but 40.9% of the total number of contractors registered in class I in 1990. The total number of contractors operating in Tanzania has decreased since the beginning of the nineties (1143 in 1990 versus 1070 in 1995). This decrease was especially noticeable in the middle and lower classes (class II, V and VI). The percentage of foreign contractors in class I decreased to 36% (16 on a total of 45) (NBAQS&BC, 1995). Only in class VII, comprising small scale formal contractors, a growth was experienced over this period (8.6%). This is not surprising when considering the less strict entry requirements for the lower classes. The figures in appendix II show for the

[1] Since 1974 the building contractors in Tanzania who are constructing for public purposes have to be registered with the National Board of Architects, Quantity Surveyors & Building Contractors (NBAQS&BC). The road contractors are separately registered with the Ministry of Works (MOW).

period after 1986 a relatively fluctuating and decreasing growth trend of the lower classes, compared to the higher classes. This might indicate that the economic changes affected the lower classes in particular and thus might have had an impact on the informal sector contractors who are working in the dwelling construction projects for the lower income households as well.

The *major characteristics of the contractors* in Tanzania are discussed in short in the following. (See also appendix II)

The *public sector* has been given a crucial role by the government from the late sixties on, including a role in the construction industry. The role of the public sector as a contractor however is and always has been rather limited, despite the government's intentions in the past. The public construction activities fall far behind those of the private sector, even before the economic reforms towards liberalization in the late eighties.

The local private sector contractors in Tanzania represent 94% of the registered contractors. Most of them have their basis in Dar es Salaam. The performance of the local private sector contractors is rather low. The government acknowledges a current *lack of contracting capacity* among local contractors - in particular for civil works- in her policy documents. The low capacities of the local contractors in the construction industry and the resulting low performance in this sector were indicated by the facts that projects of local contractors frequently suffer from time overruns and, consequently, also cost overruns (The President's Office, 1993).

Foreign contractors are most of all dominant on large and technically complex projects, which usually are civil work projects (Ministry of Works, 1991). This is due to two reasons: (1) a lack of capacity and expertise among local contractors; (2) conditions of bilateral donors concerning the use of a contractor from their country of origin. No evidence has been found in literature of recent foreign contractor involvement in dwelling construction for the lower income households.

The above described three categories of contractors (public sector-, the local and foreign contractors) have practically no activities in the field of dwelling construction projects for the lower income households.

The *small-scale and informal sector contractors* are foremost concerned with the construction of houses. According to a combined report of the Planning Commission and the Ministry of Labor and Youth Development (1991) the informal construction industry at that time comprised some 116,500 enterprises. Of these around 9% could be found in Dar es Salaam, 16% in other urban areas and 75% in rural areas. Most registered building contractors are located in Dar es Salaam (1995: 576 out of a total of 1070).

The small-scale and informal contractors operate in three different systems (Mwaiselage, 1991): *1. a contractor who moves with his gang, (2).a contractor who is hired for a certain skill, (3).a contractor for specialized jobs like concrete pouring*

In actual practice this division is not static, but rather dynamic. This means that almost every informal small scale contractor operates in each of the three systems, according to the type of job acquired. At present most informal contractors seem to operate under the first system >(a contractor who moves with a gang'). It is thus assumed that the informal small scale contractors constitute a more or less homogeneous group, with the same characteristics and the same problems and needs.

An experienced informal contractor may even undertake jobs categorized for class VI-VII of the formal sector. Most lower graded small scale contractors in the formal sector also operate in this way, when they are not able to obtain jobs on the formal market. In that case, they are actually operating in the informal building sector, while being registered in the formal sector.

Since the informal small scale contractors operate in a flexible way, adapting the construction process to the spending power of the client they can be viewed as a good option for clients with limited financial resources. At the same time literature indicates that the jobs that are carried out within the informal sector are not very sophisticated when it comes to managerial and technical skills. The use of equipment other than rather simple tools is limited; equipment is mostly hired when needed (e.g. concrete mixer, terrazzo grinder etc.). The speed of construction depends on the clients resources. The traditional process of undertaking, their labor intensive nature and flexibility in the formal agreements is in its own way a managerial skill that is working reasonably well within the informal sector. However, especially when informal contractors have to provide more than labor only, their lack of managerial skills becomes evident. In many cases contractors are confronted with so-called opportunity costs: for instance by wrong planning and cost decisions the contractor may construct in a way which is not the most efficient one, wasting part of his profit. In case the payments by the client do not cover the contractor's costs, this proves to have severe consequences: many buildings remain unfinished for quite some time or even forever. (Mwaiselage, 1991).

The performance of the *other actors* in the actor network of the construction industry (educational institutes, R&D organizations, building materials and equipment producers and suppliers, documentation centers, etc.) and their inter-relationship has a clear impact on the performance of the contractors. A diversity of professional and specialized organizations can be involved in the construction process. The bottlenecks in their performance were found to have a negative impact on the project execution by the contractors. (Maro 1991) The informal sector of the construction industry has very few formal contacts with the various actors operating in the formal sector.

6.3 The socio-economic performance of the construction industry

In this research the available official statistical data were used to describe the socio-economic performance of the construction industry in Tanzania. The remark should be made that even those who have been executing a survey on the construction industry in Tanzania underpinned that the reliability of the data could not be assured for 100% since representative sample taking has been extreme difficult. The major constraint was to get a total and comprehensive list of all operating construction units. (NBS/WB 1995). The data of the official statistics on the construction industry were therefore considered rather careful and critical.

Another point is that the official statistics on the construction industry in Tanzania mainly represented the figures of the public construction sector, resulting in too low performance figures for the whole sector. (Komba 1988). The reason for this is that people who have been collecting data for the National Accounts Report have had access only to the data for government and parastatal activities. No comprehensive data from the private sector have been taken into account during the past decades except from a handful of large-scale construction enterprises (Aero 1992). This resulted in the exclusion of data from small scale and informal sector construction activities.

In 1995 the Bureau of Statistics, in cooperation with the World Bank, made an attempt to cover the construction industry in a statistical way which is to be more accurate than it was at the moment the field studies for this research took place. But also in this World Bank commissioned survey the small construction units with less than 5 employees were excluded. In the following description the data on the economic performance of the small scale and informal sector were included.

The construction industry's contribution to total GDP for the period 1983-1993 is as follows. After the economic reforms of the last decade total GDP has experienced a steady growth. The statistical data on construction GDP reveal a fluctuating movement in the growth rate of construction GDP, from a negative growth of 41% in 1982/83 to a positive growth of almost 70% in the year 1989/90. (see appendix II-6)

But the *contribution of the construction industry to total GDP growth* seems to be limited during this entire period, and sometimes even negative. Remarkable is that no structural link can be seen between the current growth of the Tanzanian economy and the share of the construction industry in this growth. On the contrary, whereas the economy shows a structural growth, the construction industry seems to be very unstable. This might be attributed to the exclusion of small-scale and informal construction activities from official figures. These activities fulfil a considerable part of the demand for construction that irrevocably results from the overall economic growth. When the results of the 1991 survey on the informal sector in Tanzania are taken into account one may see that the data suggest that the contribution of the informal sector to national output is considerable. The official national statistics show that construction GDP was Tsh 14416 million (1991 current prices; US$ 66 million). The total estimated annual gross output for the informal construction sector was estimated at T.Sh 14577 million. (US$ 66.5 million). This is more than 100% of the official GDP, which indicates that the informal sector contributes even more to GDP than the formal sector does. It was also estimated that the value added generated by the informal construction sector accounts for some 75% of the formal construction sectors value added. (TIS 1991). This is far more than the ratio VA and Gross Output as estimated by the WB commissioned survey in 1995, which was indicated to be 29,8%. (See also Appendix II-6)

The construction industry's contribution to Gross Fixed Capital Formation (GFCF) is in any country considerable in the sense that it is the construction industry that brings about the built environment. In Tanzania however investments in buildings seem to form a minor part of the total GFCF following the official statistics. The share of buildings in GFC has even decreased since 1983, while the share of other civil works (land improvement, road, water and other works) increased during the same period. This growth could be attributed to the Integrated Roads Project, which started during the early nineties. Over time the percentage of buildings in GFC has been low (8% to 15%) compared to investments in equipment and works. But when the informal sector production output is also included in the calculations - by taking the estimated average annual gross output of the informal construction industry that was T.Sh 125128 Million (US$ 57 million TIS 1991) and add this to the GFC share of buildings in 1990 (T.Sh 20423 Million = US$ 92 million) - then the share of buildings in total GFC in 1990 rises from some 10% to 42%. This figure is more in line with the statements put forward by Moavenzadeh who even mentioned percentages of 40% to 70 % in most developing countries. (Moavenzadeh MIT/UNCHS 1987).

The technological qualitative features of the buildings established by the informal sector may be considered for a large part (50-80%) as semi-permanent and temporary with a life time of not longer than 5 years. Based upon a calculation of the value of the output of the informal dwelling construction sector the conclusion can be made that a capital investment of on average 3 billion Tsh on annual basis can be considered to be wasted within a period of 5 years. Thus the current way of building construction by the informal sector construction activities can be seen as real capital destruction over (a relatively short period of) time.

Despite the fact that the figures used for the calculations were not completely accurate the *importance of proper dwelling construction* for and by the lower income households in the country might have been indicated.

Box 6.1 GFCF by dwelling construction in the informal sector

The average number of dwellings that is constructed on annual basis in and by the informal sector is 4500 (Kyessi 1995). The mean costs of a (semi-) permanent dwelling are between 400.000 to 1 million Tsh (US$ 640 – US$ 1600 NCC /MLHUD 1995). When a careful calculation is made with a number of 4500 dwellings each of 800,000 Tsh costs, then one ends up with a total of 3600 million Tsh that can be added to the GFCF on annual basis.

The construction industry 's contribution to national employment in Tanzania based on the officially published statistics appears to be rather limited and is only some 0.8% of total formal employment.(NBS 1993). The total number of employed people in the construction industry of Tanzania in 1991/92 is said to have been some 91,649. This is very low compared to some other developing countries where the percentage is between 2 and 9 percent of total national employment, with a heavy clustering around 4 to 5 percent (Habitat, 1984). (see appendix II). The preliminary data -that result from the 1994/95 WB survey of private sector construction enterprises in Tanzania- differ from the fore mentioned data. These reveal that the average number of employees per establishment in the construction industry was 70 compared to 18 in the transport and storage industry and 14 in the restaurant and hotel trade. A conclusion of the 1994 survey is that an additional construction establishment is most likely to provide more employment than for instance a trade or transport establishment. (Bureau of Statistics, 1996).

But again in the 1994 survey not all informal construction activities have been included. In 1991 employment in the informal construction industry was indicated to be approximately 160,000 people. Of these on average 18,530 people were involved in the house building trade. 123,000 people were involved in masonry and the remaining in other construction activities.(TIS 1991) In 1986 Mwaiselage already put forward the expectation that the total number of people employed in the construction industry (formal and informal) will exceed the 200,000 landmark by the year 2000 (Mwaiselage, 1986). When the formal and informal sector data of 1991 are combined one may see that this landmark has been exceeded already. This indicates that the *informal construction industry is one of the non-negligible employers in the country.*

Forward and backward linkages of the construction industry are generally considerable in any country. The current growth of the population implies an annual increase of the demand for residential buildings. Next to this can be stated that the growth of productivity in other production sectors of the Tanzanian economy will definitely require the supply of buildings and infra structural works. This means that the contribution of the construction industry -be it by the formal or the informal sector- to the economy could grow as well. This is despite the fact that the official statistics do not show an increased production output of the construction industry in line with the general pattern of growth following the overall economic growth in countries.

The *backward linkages of the construction industry* with other industries are generally quite strong and in fact represent a value which in most cases exceeds the value added by the construction industry itself (Habitat, 1984). The data in appendix II reveal that in the case of intermediate consumption the largest part of expenditure takes place for the purpose of dwelling construction other buildings and construction services (74%). Fuel (10%), cement

(9%), subcontracting (8%) and reinforced steel (5%) are the items for which most expenditures occur (next to the items >other building materials' and >other expenses') Most expenditures on the products and services for construction take place at large-sized companies (59%). Expenditures made at small-sized companies (5-9 employees) only account for 1% of total expenditure. These figures point again at the operations by the informal sector. The part of the construction industry that operates in the informal sector tends to purchase its materials informally as well. (Tegelears/TUE 1995) This complies with the findings in this research project on the practically non-existence of relations between the dwelling construction sector for the lower income households and the formal sector organizations and enterprises.

6.4 National policies and regulations

Over time the government has formulated various policy plans on the development of the construction industry. The targets of most plans were never met. This is partly due to external factors, such as increasing costs for imported building materials and tools. On the other hand many strategies were formulated in such a vague form, that it became extremely difficult to translate them into effective measures. A representative example for this way of formulating strategies is the objective of "increasing the level of technology". It is not stated what this technology should look like, which level would be appropriate and how to increase the current level.

In 1991 the government of Tanzania formulated its first comprehensive policy plan and strategies for the construction industry. In this policy document, the government formulated the following overall development objective (Ministry of Works 1995): '*to develop an efficient and effective, self-sustaining construction industry that is capable of meeting the diverse needs for construction, rehabilitation and maintenance of all building and civil works.*' Further more has been indicated that the existing construction capacity has to be exploited and expanded to the fullest. At the same time, the development and creation of new capacities is encouraged. In the national context the sector was considered to contribute to the country's economy and self-sufficiency. (Ministry of Works 1995) No data were found in these documents on the targets in technological terms. For example no indication is found of the actually existing construction capacity in the country and the quantitative targets for its expansion. This information is needed for an adequate implementation of the policy plans.

Reports on the government policies showed that in previous years priority was given to road works. As the problem of lack of shelter is increasing to quite an alarming extent these days, it might be preferable to direct more attention to that part of the construction sector which produces shelter and especially to those actors who are involved in the processes of residential building construction. It is taken into account though that the actual implementation of the measurements highly depends on the availability of financial resources. In case of a limited availability of financial resources it will be necessary to attach priorities to the policies in a careful and balanced way. In most previous plans this was not done explicitly. The above is taken into account for the formulation of the recommendations for the technology policies in this research.

6.5 Conclusions

The *small scale and informal sector* take the bulk of the construction activities for their account and are foremost concerned with the construction of houses. (90% in the country and 75% in Dar Es Salaam). This sector offers a good opportunity for the population with limited resources to provide for the needed houses. They operate flexible and are able to adapt the construction process to the purchasing power of the clients. The *performance of the small scale and informal sector contractors* is characterized by a *traditional way of realization of the houses* by using the process technologies that are *in-sufficient* for the increased application of urban modern construction materials. The results are reflected in wrong construction details, wrong planning and waste of profits. The *production output is qualitatively and quantitatively poor* due to a lack of managerial and technical skills, lack of capital, tools and equipment.

These internal bottlenecks within the institutions, organizations and enterprises themselves have a severe impact on the performance of the actors in the actor network of the dwelling construction industry. The lack of interactions between the actors in the construction industry is due to this performance as well.(Maro 1991)

With regard to the *socio-economic performance of the construction industry* can be seen that the official statistical data reveal no structural relation between economic growth and the rather *fluctuating growth rate* of construction. This might be attributed to the exclusion of the small scale and informal sector construction activities from the official statistics. The *contribution of construction to total GDP* is limited even after the addition of the gross output of the informal sector that gives a doubling of the total value of output of the sector. The *contribution of the construction sector to GFCF* in the country even nearly triples when the informal sector is taken into account. However due to the poor *quality of the output* of the small scale and informal construction sector one can even speak of real capital destruction up to a level of some 4 billion Tsh per year (1995!) Total formal *labor force* in construction is limited but the informal construction industry is one of the non-negligible employers in the country. *Forward linkages* of the construction industry seemingly are established through the small scale and informal sector as well. This counts in particular for the demand for shelter for households. Also the *backward linkages* of at least 50% of the construction activities are fulfilled by the informal sector.

National policies and regulations have practically no impact on dwelling construction for lower income households due to the fact that the majority of the activities take place informally. The potential of the contribution of the dwelling construction industry to national development is considerable provided that construction takes place on an improved and more durable technological performance basis.

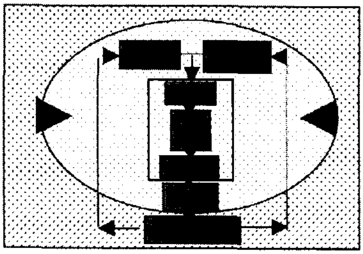
The government has acknowledged the importance of the construction industry; however, the targets that were set in the past for the development of the sector have never been met. The national policy plans and strategies regarding construction were vague. The urgent need for decent shelter in the country has no priority but certainly calls for attention. Adequate measures to be taken in order to reach the targets of the national development plans should be focussed on an increased quality and quantity of output of construction at lower costs. This means that the activities of the informally operating construction sector should receive attention in order to improve its performance.

An improved production performance in the informal sector could already be achieved through the diffusion of existing information on technology, such as on the application of innovative construction systems, that could involve a simplification and improvement of the construction processes on site. Enabling and stimulation of technology developments and their diffusion in the construction industry should thus be on the political agenda. This should be based on the results of investigations of the actual state of art of the technological capabilities and the status of technologies in the construction projects vis-a-vis the actual needs for construction output.

Chapter 7

The national technology setting of the construction industry in Tanzania

part III



7.1 Introduction

In this chapter attention is given to the national technology setting in which the dwelling construction projects are carried out. The Technological Capabilities and Technologies in production processes are seen as essential factors that determine the technological production performance and the achievement of socio-economic development goals. At the same time they must be seen as an *integral part of the national technology setting* in which the production processes take place. An assessment of the national technology setting could give an explanation of the factors in this setting that have an impact on the technological production performance in the construction industry. The results of such an assessment should point at the opportunities and constraints in the national setting for an optimization of the technological capabilities and the technology status in the sector.

The characteristics of the national setting are determined by the socio-economic and geographic-physical system of the country. These are divided in seven broad categories that are considered relevant for the construction industry. Quantitative data on several partial indicators of these categories generally is available. The interpretation of the data takes place by taking into account a number of non-quantifiable (explanatory) variables such as the historic backgrounds and the nature of the policies in the country.

7.2 Geographic setting: location and climate

Patterns of community life, building construction, building material utilization and the design, shape and layout of the houses reflect the large variation in natural environment and climatological conditions in Tanzania. The extreme humidity and heavy rainfall during the rainy seasons -in particular in the coastal region in which Dar Es Salaam is located- have their impact on the design, planning and execution of building construction projects and may form a constraint to the construction project performance. (See appendix II)

7.3 Historic backgrounds

The patterns of community life, building construction, building material utilization and the design, shape and layout of the houses also reflect the historic roots in the country. History has left its marks on various other aspects of the Tanzanian social system as well like for instance the national administration system, the legal system production structure and basic infra-structural system. The country was originally populated by the Bantu people, but was colonized by Germans in 1890 and after the First World War by the British until 1961. (For further details see appendix II)

7.4 Political setting

The particular policy setting in the county has an impact on the policies that are formulated for construction. The *political orientation* in the country since independence was originally based on the 'Declaration of Arusha' (1967) focussed on following the path of 'self-reliance' and 'socialism' towards national development.

The *effects of these policies* have been a high increase in population, an increased rate of urbanization, hardly any economic development and an increasing foreign debt. This situation led in the mid-eighties to *political changes* of the development orientation from import substitution towards liberalization of the economy. Also the one-party system changed into a multiparty system. Despite some positive effects of economic reforms the country still suffers from a rather deplorable economic situation, which make the implementation of the policies troublesome.

Tanzanian *legal system* is based on English common law. For the construction industry this means that still a number of regulations are taken over from the British.
Politically Tanzania is a relatively stable country. This stimulates international collaboration in several programs amongst which housing programs. As a result of the rather *peaceful and stable situation* in the country Tanzania had and still has to deal with an influx of many refugees from the neighboring countries that are in war. This puts some pressure at the housing situation and thus on the construction performance in the country. (See appendix II)

7.5 Economic setting

The construction industry is vulnerable to the economic performance in a country. The figures in appendix II show that the Tanzanian economy is far from flourishing. Tanzania is one of the poorest countries in the world in terms of GDP per capita (US$ 110 in 1990 against a world average of US$4200). Economic growth in 1991-94 has featured an improvement of industrial production and a substantial increase in output of minerals, led by gold. Recent banking reforms have helped increase private sector growth and investment. Nevertheless the Tanzanian economy still faces many economic problems despite the recent increase in growth. The *inflation* (23.5%) is still on the high side. (RPFB 1994/95-1996/97. 1994.) To limit the inflation, *interest rates* were increased. The higher rates attract foreign investors in Tanzania. On the other hand, borrowing money becomes more and more expensive, which can be a severe constraint for the expansion of economic activities, including construction activities.

The *balance of payment* continues to remain under strain. The import still mainly consists of manufactured goods. Primary commodities form the largest part of the export. The economic liberalization policies increased the trade possibilities for the private sector and have further enhanced the existing pattern of imports, despite the fact that the large variety of agricultural products and the abundance of natural resources offer possibilities for a further agro-related industrialization. More (building) materials and products became available on the local market, at the same time imports also became more expensive. The *exchange rates* increased sharply in 1986, after the introduction of more realistic exchange rates.

The economic dependence on *foreign aid* has been enormous in the last decades despite the national policy of 'self-reliance'. With the increasing tendency amongst donors to limit the development assistance and/or to tighten the conditions of the aid, this dependency is even larger than merely expressed by the official figures.

The economic situation in the country becomes evident in the limited purchasing power of a large part its inhabitants. Nearly no financial resources are available for substantial allocations to the social services sector such as education, health and housing. This situation has not been enhancing for investments in the construction industry.

7.6 Education and health setting

The Tanzanian construction sector is a relatively labour-intensive industry that puts pressure on the level of skills and knowledge as well as on the health situation of its labour force. For these aspects the contruction industry has to rely on on the country's education and health system.

The Tanzanian *education system* proved to be qualitatively and quantitatively unsatisfactory soon after Independence. Tanzania experienced a major increase in its literacy rate from 46% in 1978 to 76% in 1993 thanks to this focus on *primary education.* (both figures based on people aged 15 years and older in Dorgan 1995, Euromonitor.1994, Ferreira 1995) Despite this the output of the education system obviously is not sufficient and not tailor-made to meet the demand in the construction industry (See also appendix II)

The fact that the Tanzanian system of social services like the education and health system has to suffer from the diminishing resources in the country is expected to have an impact on the health situation of the construction labour force although it was not investigated in this research project.

Box 7.1 On education in Tanzania

The Tanzanian education system could not meet the demand in particular for highly skilled people, that came into existence with the disappearance of many expatriates Under British rule only one locally educated African engineer was available. At the early seventies 180 locally trained African engineers were available. As a consequence of this, hardly any Africans were to be found at higher positions at that time. In view of the political ideas of that time: 'educational self-reliance' most policy attention was given to the provision of primary education for everybody. Public expenditures on education in Tanzania increased from 4.4% of GNP in 1980 to 5% of GNP in 1990. Primary education took the largest part of the public funds although it still is not sufficient. (UNESCO, Statistical Yearbook 1995).

Although statistics indicate an increased literacy in the country from 1978 to 1993 these figures it should be noticed that the absolute population even increased from 17 to 26.7 million during the same period. But, while primary education increased in quantitative sense, its quality decreased due to a lack of qualified teachers, instruction materials and schools. The government has long rationed the enrollment in *secondary education.* This was done to avoid producing more students than could be absorbed by the public sector. The result of this rationing policy has been the fact that currently Tanzania is among the two countries with the lowest secondary enrolment ratio in the world: 4.7 % in 1990 against 2.7% in 1970. (WB, 1995) *Tertiary education* is only reserved for a few. The availability of third level institutions is very limited. During the period 1986-88 the tertiary enrolment ratio was 0.3%.

7.7 Land and natural resources

The availability of land and natural resources is of high importance for the construction industry. The landarea in Tanzania is rather extended although only a small part really is in use by its population. Due to bureaucratic procedures, the land delivery system in the county leaves much to desire. Tanzania has a considerable potential to provide for the necessary natural resources, which are required by the construction industry. (See appendix II) But the construction industry has to rely to a large extent to imports of these. A survey by the National Construction Council in Tanzania that included 43 responding local building material producers, revealed that the shortage of local raw materials is the major constraint for their production performance (NCC 1992).

7.8 Infrastructure

Production in a country with such a large landarea requires an infrastructural system that makes in principle the economic relevant parts of the country easily accessible. This counts in particular for the construction industry that carries out project activities that are location bound. The *physical infrastructure* in Tanzania (the road-, railway and waterway network) is obviously far from supportive for the Tanzanian economy.

Box 7.2 On the physical infrastructure in Tanzania

Considering the fact that Tanzania by far covers the biggest land area compared to its neighboring countries, the availability of infra-structural facilities per 1,000 square kilometer land area appears to be limited. Large parts of the country are not accessible by one of the major roads and/or railways. The road network is concentrated on linking the coastal area, and especially Dar es Salaam with other parts of the country. Until recently this road network was in a very poor state. Improvements have taken place in recent years, but they are still not sufficient. In the early nineties only 3,700 km of the network was bituminized (NDC Tanzania 1994). Problems experienced by the rail system include inadequate maintenance and a lack of rolling stock.(NDC Tanzania 1994). The two sea harbors in Dar es Salaam and Tanga are of major importance to Tanzanian economy and the neighboring landlocked countries. The national electricity company TANESCO supplies electricity. The electrical grid connects in particular the main towns. Many rural areas are not connected yet. At the beginning of the nineties the situation with respect to electricity supply deteriorated, leading to rationing. This rationing affected industrial production in the country.

7.9 Population and urbanization

The demographic characteristics of the country determines the pattern of human settlement development and the size, nature and quality of the demand for houses, that should be met by the output of the construction industry.

The population of Tanzania is about 30 million, and consists of people with various ethnic backgrounds mostly numerous black African groups, that live rather peacefully together. None of them constitutes more than 10% of the total population. The ethnic background determines the lifestyle and thus the requirements for the houses.

The *age structure* is characterized by a high percentage (>40%) of population below the age of 15. The population with age of 65+ is relatively small. The old age dependency is minimal compared to the child dependency.[1] (HBS 1991/1992) This has an impact on the households' affordability to acquire a decent house. Moreover a large percentage of younger people in a nation puts quite some pressure on future land-and housing provision, and might form a stimulating factor to migration and urbanization. This was underpinned by the 1991 population census by which was indicated that the rate of migration is faster among people between15 and 24 years of age.

The majority of the Tanzanian workforce is employed in the informal sector *Employment* statistics of Dar es Salaam show a larger than average urban work force employed in the city's

[1] The dependency ratio: the ratio of persons aged 0-14 and 65+ divided by the number of persons aged 15-64.

formal sector (some 25 percent in 1988), which is one of the major attractions for migrants. The informal sector though is very important in providing daily services to the city residents under the current economic circumstances.

The level of *household income* is unequally distributed in Tanzania. In 1991 about 50 percent of the Tanzanian people was classified as poor, living below the poverty line of Tsh. 46,173 (= US$ 149.2/yr). Some 36 % could even be classified as very poor, living below the absolute poverty line of Tsh 31,000 (= US$ 100.2/yr). This income situation becomes evident in the housing situation of a large part of the Tanzanian population.(Fereira 1995)

Tanzania has many *large families.* More than 50% of the households have more than 6 persons (Fereira 1995). Most large families can be found among the lowest income population of which two third are households with more than 5 members and in rural areas. The average *household size* in Mainland Tanzania is 5.91, 6.2 for rural households and 7.1 for the poorest quintile of the population. The household size appears to decline over time. The average size of the households in Dar es Salaam is 4.76 persons. The *number of households* in Dar es Salaam was estimated to be 345.000 households in 1990. The growth rate is approximately 4.8% per year. At the time of the field studies in 1994 the number of households in the urban area of Dar es Salaam should have been increased to approximately 415.000 households. This implied at the same time an increased demand for houses.

The *households are composed* with more than 3 adults. for 55% of all Tanzanian households This type of extended families occurs most among the lowest income population (72.4 % of all lowest income households, Fereira, 1995) The household composition in Dar Es Salaam is slightly different from that in the rest of the country. Here the highest percentages of households belong to the type of 2 adults with 1-4 children. (See Appendix II). These household characteristics have an important impact on the basic requirements for a house.
Tanzanian population still is predominantly rural (75%). The highest percentage of urban population (89%) can be found in the Dar Es Salaam region. Some 6% of the total population of Mainland Tanzania live in the Urban Area of Dar es Salaam. The population in the large cities is expected to be growing more rapidly than that of the urban population as a whole.(see appendix II) The primate city still is Dar es Salaam, despite attempts to re-distribute the population. It was expected that the population in Dar es Salaam will rise from 2.5 million people to 9.7 million people by the year 2000. (CHS 1995).

Box 7.3 Backgrounds of urbanization in Tanzania

Human settlement development and urbanization was slow during the colonial days. Many urban areas were established during the colonial era as centers of trade and administration. Urban planning was [illegible] the interests of colonial regime and based on German and British regulations and laws. After independence (1961-1965) urbanization patterns were still based on designs of the Germans or British. With the attainment of independence in the early sixties urbanization increased at unpredictable rates. The growth of the primarily urban-based industries and services attracted many migrants from rural areas.
The *population density is* on average 30 persons per square km. In the Dar es Salaam area population density is highest of Tanzania. The *rural character of Tanzanian population* becomes clear through the fact that some 84% of the households still derives its income from agricultural activities in the country. Even in urban areas 43% of the households have activities in agriculture. (Mwapilinda 1992) The residents survive as part-time farmers and part-time wage laborers or small-scale entrepreneurs. Probably no family is able to survive without farming as a source of (additional) income. Such a conclusion has direct implications for the affordability of the population to acquire a decent housing.

The urbanization pattern resulted in an extreme growth of unplanned areas at a rate higher than general urban growth. Many un-acceptable social conditions for many households in the cities become a drain on the country's financial and physical resources. The local governments responsible for their provision and maintenance have to deal with this situation under financial, technical and administrative constraints. The result has been a host of spontaneous settlements, deteriorating and lacking infrastructure and basic facilities, environmental degradation, overcrowding, high unemployment, a poor condition of most houses. The deficits, in the creation of employment and the production of the public and private sector, are partly taken care for by the informal sector. Only few households are connected to water (22%), sewerage (6%), electricity (37%) and telephone (25%) At present 70 % of the population is housed in unplanned settlements and they account for 64 percent of the housing stock. (CHS 1995)

7.10 Conclusions

Existing urban structures, housing patterns and planning, design and execution of building construction projects are influenced by the particularities of the geographic setting of the different regions in Tanzania. Also the Tanzanian historic backgrounds have their impacts. The political and economic setting -in all its dimensions- have a predominant impact on the socio-economic situation in the country. Tanzania suffers from a deplorable *economic situation* despite reforms in the recent years. This makes the implementation of development programs troublesome, since financial resources are tremendously limited for substantial improvements. This becomes visible in the housing situation and the performance of production sectors such as the construction industry

Tanzania has an abundance of *land* and a considerable potential to provide for the necessary *natural resources* that are required in the construction industry. But the exploitation of these is rather limited, which forms a constraining factor for the construction project performance.

The in-sufficient availability of *infrastructural facilities* forms a constraint to the construction industry which and require an easy accessibility of at least the economic relevant parts of the country since its project activities are location bound

The large percentage of *young people in Tanzania* puts quite some pressure on future land- and housing provision and might form a stimulating factor to migration and urbanization. The relatively low *household income level,* large household size and high dependency rate have an impact on the affordability and basic requirements of the housing facilities.

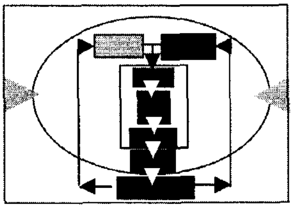
Although Tanzanian population is mainly rural at present Tanzania is one of the most rapidly urbanizing countries in Africa. Cities are overcrowded, un-employment is high, most houses are in a poor condition and the levels of infrastructure and basic facilities are low. This becomes visible in the housing situation of particularly the lower income households in Dar es Salaam, still the primate city, despite attempts to re-distribute the population.

The *national development status* of the country is generally used as indicator for many of the above mentioned features of the national setting. This is held responsible for the public and private capabilities to invest in various areas of the social system, like education, health, housing, infrastructure, production and technology development. The *development status* of Tanzania -ranked by using official ranking indicators- is on the low side compared to other countries in the region and also compared to the entire group of low-income countries. (Low-income countries: 1993 GNP / capita < 695 US$; World Bank 1993) Among all countries (174) over the world Tanzania is ranked at the 144th position of the Human Development Index (HDI) ranking in 1993. The situation has not changed very much until now. (See appendix II)

Chapter 8

Synthesis and discussion of the results of the Technology Mapping Studies in Tanzania

part III



8.1 Introduction

The Technology Mapping studies have resulted in data-sets with which the existing gap between the present and the desired *best practice technological production performance* in the construction industry can be determined. This best practice *technological production performance* is expected to optimally meet the need for houses for the lower income households

The particular *societal problem area* that was addressed in this study is *the housing problem*. The *housing problem* results from a number of interrelated factors in the country. (see Ch II-2). Housing supply largely depends on the production output of the construction industry. The *construction industry* has the challenging task to contribute to the alleviation of the housing problems for the lower income households

In a situation of a need for specific (lower income) housing facilities that exceeds the supply the construction companies are urged to improve their production performance and lower the costs of construction to better suit the market. In other words an increased and improved production performance of the dwelling construction industry should contribute to solve the housing problems. Following the theoretic viewpoints adhered in this research project an improved production performance largely depends on the status of technologies in the construction processes and the technological capabilities in the dwelling construction industry.

An improvement of the technology status in the construction projects implies a more effective production output and a more efficient use of the material inputs and process technologies in the construction projects. This expresses itself in lower cost of production and a higher quality of output. Such improvements may contribute to a supply of more adequate houses, a better affordability of the houses for the households and to an increased profit margin for the involved contractor. Moreover if the contractor is able to realize the construction process on site more efficiently this may contribute to strengthening his position on the construction market.

Insight in the strengths and weaknesses of the technology status in the construction projects indicates the possibilities for technology management interventions to improve the technological production performance in the construction projects.

But the construction projects are not carried out in a vacuum and consequently in every respect the technological production performance on the project sites depends on external factors of higher levels in the project environment. Not all of the existing problems and constraints of the external environment can be solved by the households and the contractors involved in the projects themselves. For some of the aspects the households and the contractors have to rely on the factors and actors at the sector and national level.

At sector level it might be necessary to improve the *technological capabilities* (the status of the totality of national resources that can be committed to the production processes in the construction projects). This means that improvements might be needed in the stock of technologies, the stock of human resources and the stock of natural resources. It might be necessary to improve the performance of a number of actors in the *actor network* of the construction industry like the supplying enterprises, organizations and institutes. It might also be necessary to strengthen the relationship between the actors where these are weak or even non-existent. The links between the actors in the network should provide a long term improvement of the operating environment for the execution of construction projects.

At *national level* the government should be aware of the actual status of technological capabilities and technological production performance in the sector. Moreover the government should be willing (and able) to alleviate any existing negative impacts of the national technology setting and create an enabling environment for the execution of the construction projects with a high technological production performance.

A synthesis of the technology mapping results is discussed in the following sections. Based on this conclusions are drawn on the possibilities to devise technology management and technology policies in such order that these lead to improvement of the technological production performance in the dwelling construction sector.

8.2 The strength and weaknesses of the technological capabilities in the sector

The results of the studies on the sub-sectoral technological capabilities showed a number of strengths and weaknesses of these that form a promoting or constraining factor to support the project level construction activities.(appendix II-8) The major strengths and weaknesses are discussed below.

The *stock of construction systems* with particular *product technological attributes that can be* applied in the dwelling construction projects reflects a rather modest level of advancement. It has a dualistic character: (1) traditional systems and materials that are in majority applied in rural areas and (2) the conventional ones that are applied in the urban areas. No evidence is found of more advanced construction systems (see chapter 3)

Tanzania knows a range of *different traditional construction systems.* The mud-and-poles construction system was the major type of construction system in Tanzania until around 1987. The urban lifestyle has changed the requirements for adequate housing. Over time the mud-and-poles construction system has been substituted gradually in urban areas by the *conventional* cement-aggregate block masonry system. The basic understanding of the realization of the houses with these construction systems is too often lacking. Other more *advanced systems* like prefab timber or concrete wall panel systems are only in negligible numbers available the country. Often these systems were completely imported and applied by foreign contractors and financed by foreign investments in housing projects. No exact figures were found on these in this research project.

The *quality* of the available systems depends on the way in which the materials are processed. Houses constructed with properly manufactured sand-cement blocks, properly executed masonry on a proper foundation adapted to the soil type and with the application of the right construction engineering details for the other elements - like floors, roofs and openenings- and their interconnection, might have a lifespan of at least forty years.(BRU: Moriarty and Therkildsen 1973). The houses constructed with the traditional construction systems need on-going repair and maintenance at least every five years (CHS 1995).

The *complexity* of the available construction systems -with many different materials and components of which a majority even is produced on site- forms a real burden to efficiency and effectivity which is reflected in the long time needed to finish the house and the relatively low quality of output. The investment costs of the houses that are built with the traditional construction systems are lower than of the houses built with the conventional construction systems.

> The *stock of process technologies* shows a number of weaknesses in all technology components: (1) lack of equipment and tools, (2) lack of manpower in terms of both technical skills and management skills (3) lack of proper information and documentation, (4) a lack of a proper organizational framework.

These weaknesses are reflected in the fact that the Tanzanian construction industry still has to rely predominantly on labor intensive construction with a low quantity and quality of output. and consequently a lower level of quality of the construction output then required.. The concrete blocks masonry construction system that is increasingly applied requires more knowledge and skills than the mud-and-poles system. First the blocks should be processed in the right way to arrive at the right -and uniform- quality. Next the mortar for the masonry should be prepared in the right mixture and the masonry it self requires also the necessary skills to achieve a strong and durable structure. These requirements for skills and knowledge are not met.

A major *cause* of the weakness of the stock of process technologies is that development in both the capital goods industry - for the supply of equipment and tools- as well as the building materials industry in the country has only made little or no progress at all. The results are imports and high costs of equipment tools and materials, and a low affordability for most contractors and house owners involved in the dwelling construction projects. The necessary information and documentation component is seldom available for dwelling construction. Most dwelling construction projects are carried out in the informal sector.

> The *stock of human resources* is reasonable in quantitative sense in the country but it shows at present severe deficiencies with regard to the level of education skills and knowledge of the manpower on the project sites.

This concerns both the manpower needed for project management, the foremen as well as the labor force on the project sites. The human resources stock in the country has a high potential to provide for the necessary labor force in the construction industry, given the demographic features of Tanzania with a large percentage of the population below 15 years of age and the relatively low entrance barrier in the construction industry. But the education system and training opportunities should be adequately developed to serve the needs for labor in the sector. Only the large scale and foreign contractors give the opportunity for in-house training of their labor force, through learning-by-doing. (Rijkenberg/TUE 1996). Those involved in the dwelling construction projects for the lower income households have no access to the available information and documentation on building construction available at organizations such as the Building Research Unit (BRU).

The *stock of natural resources* has a rather high potential in the country.

The present situation however is disappointing in all aspects -land, mineral and non-mineral resources, forestry and agricultural resources- to provide for the required raw materials for both building materials production and the construction projects.

Practically no investment has taken place during the last decade in the development of the mining industry except from the gold mining sector. The same applies to the development of the local building materials industries while these should be beneficial for the construction industry and is also promoted by the national government.

> The present *technology infrastructure* of the dwelling construction industry for the lower income households is characterized by a rather weak network of actors, which on their turn deal with internal performance bottlenecks.(see appendix II-3)

The weaknesses of the technology infrastructure are due to the weak inter-linkages between the actors as well as to the performance of the actors themselves. This counts for practically *all indirect actors in the building construction* projects like the equipment and building materials suppliers, the R&D institutes, the information and documentation centres, governmental agencies. An important example is that despite a reasonable amount of information on proper dwelling construction is available in the country this seemingly does not find its way to the project sites. The major bottleneck is formed by imperfect diffusion of these due to the weak linkages between the actors in building construction. Information and documentation on the opportunities for further exploitation is available at the existing R&D, information and documentation centers.

8.3 Technological strengths and weaknesses at construction project level.

The technological capabilities were expected to be reflected in the results of the technology mapping studies on the strength and weaknesses of the project level factors that determine the construction project performance.(see appendix II-8)

> The *technological effectivity* of the dwelling construction industry in terms of *quantity of output* (annually constructed houses) is only 20% of the actual need for adequate and affordable houses in urban Dar es Salaam. .(Kyessi 1995)

In this research project no exact figures could be traced to validate this statement. What could be investigated was the rate of overcrowding of the houses. This reflects the deficit in the housing delivery system. Literature indicates that overcrowding has become a common experience in the houses in urban areas. The various settlements were reported to show an eminent overcrowding of the houses reflected in rooms that are often occupied by more than 3 people while the international standard indicates an occupancy of 2 people per room of 10 square meters. (Hoek-Smit 1990). Only 14% of the households occupy the house alone. (CHS 1995 p40, Hoek-Smit 1990 p 11). On average in half of all privately owned houses two households share one dwelling in Dar es Salaam.

In this research project was found that the basic requirements regarding the *average number of rooms* in the traditional houses (two rooms), the *lay out* of the houses and the *dimensions of the rooms* -formulated in the TBR1985 p 26-67 - are in general met. This is in compliance with literature. (Hoek-Smit, World Bank, 1990; Nnkynya, 1984) But the number of persons that live in the house ranges from three to even thirty persons. The mean figure of occupancy of the investigated houses was 5 persons, which is a different figure than mentioned in other reports. This might be due to the sample in this research.

> The *product technological qualities* of the output of the dwelling construction projects leave much to desire in more than 60% of the cases.

The product technological characteristics of the constructed houses show many deficiencies regarding the basic requirements for these as formulated in the Tanzanian Building Regulations (1985). These refer to the strengths and durability against climatological mechanical and biological forces, like storms, rains and humidity, material loads, fungus and termites. The finding is that not enough technological precautions are taken to protect the buildings against these forces. During the site preparations and the construction of the foundations- the necessary preparatory activities are carried out in a wrong way or not at all. The deficient product technological quality of the dwelling construction output can be attributed to the fact that increasingly newer construction systems (sand-cement blocks masonry systems) are being applied in urban Dar es Salaam thereby substituting the traditional (mud-and-poles) systems.. This takes place without enough skills and knowledge on these technologies. But also the traditional construction systems do not meet the basic requirements of durability and need ongoing repair and maintenance, which might be attributed to the same reasons.

> The *costs* of properly constructed houses are still to high for the lower income households.

Properly constructed houses cost on average at least Tsh800.000 (1995). The house price to income ratio is 5.0, which makes repayments un-affordable for an average (low) income household.(Materu 1995) The finding about the costs of the houses refers to the socio-economic situation of the house owners and their in-ability to make more investments that make the buildings last for a longer period of time. The data on the status of the utilized process technologies in the construction projects and those on the socio-economic situation of the house owners could endorse the above made assumptions.

The studies on the *technological efficiency* of the construction projects revealed the strengths and weaknesses of the utilized process technology components and material inputs. These were assumed to have an impact at the product technological qualities of the houses.

> The houses are built with limited simple hand tools and equipment only. The strength of the use of this type of technoware is the low level of capital intensity that enhances the affordability of the houses for the common man. On the other hand the use of the simple tools and equipment (and the lack of proper tools) gives no guarantee for a reasonable standard quality of the houses. But this characteristic of the utilized technoware should be seen in combination with the other process technology components.

The major *reason* for the found Technoware status in the construction projects, is the *high price of tools*, whether they are bought or hired. This was mentioned by 28 contractors (n=42) in this study. Literature and the results of this study reveal that most contractors generally use a large part of their financial means to buy tools. (Mwaiselage 1991) The high prices can partly be attributed to the *limited local production* of tools and capital goods and the need *to import* them. The data from the studies on the performance of the actor network (one of the components of *the technological capabilities in the sector*) have endorsed this assumption.

> One of the major weaknesses of the present process technologies is the lower level of *skills and knowledge* among the project management and the labor force than is required for the execution of the construction project with the newer construction systems like the sand-cement masonry system. (see appendix II-8)

Most of the house owners and also the fundi-contractors are not in detail familiar with the technical requirements for the newer construction systems like the sand-cement blocks masonry system. This is noticeable in the site engineering performance and it is reflected in the defaults in the engineering details, the production complexity and non-standardized, low quality of the house. In contrary to the research findings the *lack of knowledge* is not really felt to be too alarming by the contractors, fundis and laborers themselves. Anyhow the findings in this research project comply with a number of publications in which was indicated that the lack of knowledge is considerable especially regarding the newer construction systems, not only among the fundis, but also among the more established small contractors. (UNCHS.HS/03/05/E 1985, Mwaiselage 1991, NCC 1995)

Literature suggests that the lack of proper information and technical knowledge among the house owners, contractors and fundis results in Tanzania -alike in many other developing countries- in the *selection and application of relatively new materials* like cement and construction systems. What can be seen is a contradictory situation of a long history of traditional construction from locally available materials and a rich stock of recent construction- related R&D results which are not or not properly put into practice. (See box 8.1 in appendix II-8)

The *reasons* for this situation could be found in the data from this research on the status of the components of the *technological capabilities* in the sector: the technology stock, the human resources and the technology infrastructure. The last component is hold responsible for a proper diffusion of technologies. This apparently does not take place.

> The current technological production performance is enhanced by the lack of *information and documentation* on the project site.

The characteristics that were found regarding the *information and documentation* component of the process technologies in the construction projects were underpinned by various publications. (Moavenzadeh 1987, UNCHS 1985))

There is no availability of specifications of the product technological features of the house. Thus the terms of reference for adequacy and affordability of the houses are not precisely known and thus not specified either. This should have taken place first and next a selection should have been made of the construction method (materials and system) that offers the best opportunities to match the specifications. The final determination of the method depends on the availability and costs of the materials and systems. Thus the selection should be based on an overview of the range of construction product technologies which can be used for dwelling construction. For a precise specification the households and contractors should have or gain detailed information on the available range of construction product technologies before they start building on site. This does not take place.

Also the advantages of the use of a record keeping for improved planning and control of the future activities and the benefit of this to eliminate future mishaps are not known. The *reason* for this is that contractors, fundi, laborers and house owners are *preoccupied with the building construction activities* only. These require efforts to such an extent that no time seem to be left to bother about keeping records of their efforts. The found data on the status of the infoware component of the utilized process technologies in the construction projects point at deficiencies in the *technology infrastructure* in the construction industry. Apparently nearly *no technology diffusion* takes place to the project sites. This can be attributed to a *weak or even non-existing relation* between R&D institutes, educational institutes, information and documentation centers (the technology creative system) and the work-floor, which is endorsed by the data on the organizational framework of the dwelling construction projects.

> The *organizational framework* within which the construction projects are carried out is that of the small scale and informal sector organizations that show a lack of managerial skills and knowledge for proper construction project management.

The projects are executed on *ad-hoc basis* by house owners themselves with the involvement of the small scale and informal operating construction units. Literature underpinned the findings in this research project on the lack of modern management practices in the small and informal construction sector. The result of the *lack of managerial skills* is reflected in needless delays in the construction projects. This implies a risk of suddenly increasing material prices and other unexpected events that influence the final costs and thus the profits for the contractors.

Also the *lack of ability to accurately calculate the price* of a project in advance has an impact on the profits. Contractors appear to be unconscious with regard to these aspects and tend to neglect possible delays. Since *records of the construction processes are kept on very limited scale* no insight can be gained on the major causes of the low performance level. The problem is even worse. The majority of dwelling construction projects in urban Dar es Salaam is managed by the house owners themselves. They generally have no experience. This clearly has an impact on the technological production performance of the projects. They have to deal with a rather complex production process to realize their house. They make use of many different building materials, parts and components and various different actors are involved during the different stages of the construction process from initiative, design and engineering, tendering, purchase of materials, to building construction on site. Moreover the construction processes take place without much information or forms of documentation on site.

Literature suggests that the lack of management, planning and control techniques can be attributed to the *low entrance barrier* to the construction business, which results in problems with the entrepreneurial skills among the contractors. Most starting contractors are not more than little experienced fundis or general foremen who decide to start for themselves. Others even have no experience at all in the construction sector. A severe lack of experience is reported among most small scale contractors in estimating, planning and project management, in understanding contract documents and in job acquisition. (Mwaiselage 1991). This suggestion points at an *in-adequate regulatory and education and information system* in the country that secures the level of managerial skills and knowledge for proper construction project management.

> Major weaknesses regarding the material inputs in the construction projects are the *shortage of materials on site*, the *wrong type* and the defaults in *quality of the materials and the costs of the materials.*

This finding complies with those in many other publications. Materials alone constitute at least 60 % of the total construction costs It is thus not surprising that problems with respect to material supply have a rather large negative impact on the construction project performance. (NCC 1994).

The low *quality* of the building materials can be attributed to the processing of the majority of building materials that takes place on a traditional way: Many building materials -like the sand-cement blocks- are produced on site. Quality standards are highly neglected or not known. Except from a small number of cases in which prefab windows and doors were applied no further evidence is found of ready made building components.

The assumption is that problem of *on-time availability* and *wrong material selection* can be attributed to a limited knowledge and insight of the person who is selecting the materials and the construction system. This selection and purchase in a large number of dwelling construction projects takes place by the house owner himself. No contracts -or simplified bills of quantities- are used to make explicit which materials are required from the parties involved in the projects. The assumption is endorsed by the findings of this research on the level of knowledge and skills of the project manager and the labor force in the project.

The problem regarding the *high import content* of the inputs and therefor the higher *costs* in the projects is considered to be caused to a great extent by the use of the -to Tanzania newer- conventional construction systems with more modern imported materials. The strength of the utilization of traditional material inputs -which is the nearby locally availability of low cost building materials- has been swept away by its substitution by newer systems. Literature endorses that the costs of the building materials have been increasing tremendously due to the high import content and the rate of inflation.(NCC 1995) This is one of the reasons for the widening gap between demand for and supply of several major construction materials.

Literature indicates that the availability of the right materials on the project site also depends on *external causes* that cannot be solved by those who are directly involved in the construction projects. The problems have much to do with the *purchasing power* of the client, the *production performance* of the building materials industry and the available *transport facilities* in the country.

Literature also pointed at the *policy system and the allocation of public resources* that could be blamed, although the problems regarding the construction materials have the utmost attention of the Tanzanian authorities (NCC 1995). The objective to promote the local building materials industries can be found in almost every current policy paper. Despite this new and modern materials are still imported, at least the raw materials and intermediate products to produce these. In previous years few parastatals were responsible for the distribution of the materials. They heavily controlled allocations to contractors with priority to well-advanced and major government projects (Mwaiselage 1991). Only for foreign-based contractors, within the bounds of foreign-financed projects imports of building materials and equipment were possible. The trade liberalization in 1991 changed the situation to a certain extent, but informal small scale contractors still have no access to foreign currency to arrange own imports. A further promotion of more traditional, locally available materials is in the urban areas out of fashion (NCC 1995).

Furthermore the suggestion is made that the *diffusion of information* on the use of locally available materials does not take place although it is available.
A more extended use of locally available materials though processed in different modern ways could very well solve the problems that are also related to lack of skills. Tanzania seems to have the opportunity to produce the "new" building materials and components based on locally available natural resources such as gypsum, pozzuolana, industrial and agricultural wastes e.g. sawdust, fly ash etc.
The use of bamboo for building materials for example seems promising. (Egmond, Gaillard & Janssen 1996) Projects in Costa Rica have shown the usability of bamboo as a building material. Bamboo resources in Tanzania seem to be sufficient for employing them in the building construction sector. The Tanzanian Building Research Unit (BRU) performed much

research in the field of the use of local materials. The documents however in which the results are stated are not widely spread. Most contractors have no idea what source of information the BRU could mean to them. The BRU could be the institution, in cooperation with the NCC, to promote the use of local materials by means of the distribution of pamphlets, in which the advantages of local materials in the sense of lower costs and better availability are explained.

A performance promoting factor of *the current project setting* in which the construction processes take place in Tanzania is the realization of the construction projects in the informal and small scale sector.

The informal construction sector operates more flexible and at lower costs than the larger scale enterprises in the formal sector. The project execution is not tied to rigid contracts; it is carried out at low capital intensity and at low labor costs too, due to the participation of less skilled labor force and family helpers.

A constraint is formed by the fact that the *houses are built illegally* in squatter areas with a lack of basic infrastructure, which implies a bad accessibility of the plots and a low level of available facilities. Moreover the houses are built upon initiative of a single house owner who takes the role of project manager in many cases and hires a fundi-contractor for the project execution or for part of the project.

The initiative to build a house, all preparations and the project management is in the hands of un-experienced and unskilled persons, often the house owners. The facts that houses are built illegally and upon initiative of individual house owners as single unit construction project means that *no advantage can be taken of the economies of scale* which can be achieved by building a number of houses at a time in mass construction projects. When houses are built in mass construction projects still house owners could have a say in the ultimate realization of the house. At the same time the acquisition of proper information and documentation, purchase of materials and the total project management can be shared with others. Such a project organization can be established by forming a group of potential house owners whereby the advantages of informal building construction could be maintained. The last could be possible by involvement of the house owners and family helpers for instance during the finishing of the houses since this stage of the construction process generally does not require high level process technologies and is not tied to rigid time schedules.

The *lack of financial means* among the house owners and contractors involved in the dwelling construction projects forms a real bottleneck in the project setting.

This results in a delay in the construction process and laborers who leave the project sites when they are not paid in time. The findings in this research -that are also endorsed by literature- indicate that the majority of the house-owners and contractors has no cash working capital or access to credits and opportunities to solve this problem themselves do not really exist. Hired contractors fully depend on the payments of their clients and carry the risk of not being paid in time or not at all. The house-owners face a limited income and often employment in the informal sector only. (see appendix II-8)

8.4 The promoting and constraining factors of the sectoral technology setting

The local contracting capacity in the country is reflected in the overall socio-economic performance of the construction industry, that is low in terms of it's contribution to GDP and to GFCF even after inclusion of the performance data of the informal sector.

The local private sector contractors in Tanzania represent 94% of the formally registered contractors of which a majority is based in Dar es Salaam. The *small scale and informal sector* take a large share of the dwelling construction activities for their account: 90% of the construction of houses in the country and 75% in Dar Es Salaam. (Part II chapter 6). The government indicated the *reasons* for the low performance and acknowledges a current *lack of contracting capacity* (a lack of managerial and technical skills, lack of capital, tools and equipment) among local contractors - in particular for civil works- in her policy documents. The projects of local contractors frequently suffer from time overruns and, consequently, also cost overruns (The President's Office, 1993).

> Investment in small scale and informal sector construction can be seen as an opportunity for employment, income generation and skill upgrading. Despite this the investment in construction is low.

The formal *labor force* in construction is limited but the informal construction industry is one of the non-negligible employers in the country. Investments in formal construction are limited which is reflected in the limited employment figures. On the other hand due to the application of labor intensive technologies and the relatively low entrance barrier in the small scale and informal sector the employment and income generation opportunities are considerable.

> The local contractor's knowledge of the traditional product technology specifications regarding the household's requirements for housing, shape, functional division and number of rooms can be regarded as an advantage for an adequate specification of the needed houses.

On the other hand the *traditional way of realization of the houses* appeared to be *in-sufficient* for the increased application of urban modern construction materials. It takes place by the application of traditional methods of building construction (the process technologies, procedures, equipment, manpower and information) known and within the reach of the small scale and informal sector, but it results in wrong construction details, wrong planning and wasting the profits. Due to the poor *quality of the output* of the small scale and informal construction sector one can even speak of real capital destruction up to a level of some 4 billion Tsh per year (1995)

> The local contractors have nearly no access to or contacts with the local and international sources of technology, .in contrast to the foreign and large scale contractors

Large scale and foreign contractors are most of all dominant on large and technically complex projects, that usually involve civil work projects (Ministry of Works, 1991). The majority of the projects is financed by foreign donors who determine the conditions concerning the selection of a contractor who complies with the requirements for capacity and expertise (often from their country of origin) and the application of (advanced) construction systems. Once selected they have easy access to international sources of technology (information and expertise, to advanced equipment and imported building materials). The spill-over effects to the local construction industry is limited. It most probably only concerns the learning-effects on the local labor force. In this research project no attention was given to this aspect since no evidence was found on the involvement of the class of large scale and foreign contractors in the dwelling construction projects for the lower income households.

> The opportunities of the construction industry to contribute to socio-economic development are not optimally used although this is acknowledged by the government.

Enabling and stimulation of investment in dwelling construction and improvement of the present dwelling construction activities carried out by the local contractors contributes to the alleviation of the housing problem and has the potential for employment, income generation and skill up-grading. This will enhance a better and more durable contribution of the construction industry to national development.

8.5 The promoting and constraining factors of the national technology setting

The predominant constraining factor of the national setting for the improvement of technology capabilities, the technology development and utilization in the production processes and the technological production performance in all sectors of economic activity is the economic situation, which does not allow any sizeable investment in technology development. (appendix II-8)

The *high inflation, decreasing exchange rates, high quantity of imports* of building materials implies an increase of the building construction costs, which makes the dwelling construction un-affordable for the lower income households.

The *un-equal income distribution* and high un-employment rate hampers the abilities to save. Moreover high *interest rates* blocks the road to financial means for dwelling construction. *Governmental budget overruns* and the un-favorable *foreign debt* situation hampers the opportunities to provide for sufficient social services such as education, health care and housing through an adequate financing system for housing. The current *production structure* in the country with a high dependence on agriculture and a relatively low rate of industrialization -largely limited to the production of consumer goods- implies a lack of capital goods which are needed for production in other sectors such as the building materials and construction industry.

A constraint- that results from the problematic economic situation- is the present education situation which has a particular impact on technology capability building in terms of development of human resources skills and knowledge

The illiteracy rate in Tanzania is relatively high and the enrollment figures in secondary and tertiary education levels are disappointing. This is reflected in the lack of skills and knowledge on the construction sites.

The current structure of policy making, regulation, coordination and control of the implementation of the policy plans needs improvement.

The relative political stability in the country as well as the recently adopted liberal political orientation form promoting factors for the attraction of foreign investments for example for the production of capital goods and building materials.

But the national policies are formulated rather vague which hampers the implementation of an adequate strategy to alleviate the numerous problems in the country. Moreover the regulatory and legislative environment is not promoting for optimization of the technological production performance in dwelling construction projects. One has to deal with rigid procurement procedures for land and rather bureaucratic public organizations that form a constraint to efficiency in the construction industry.

An advantage for the construction industry in the country is the availability of land, though the land delivery system shows numerous deficiencies.

The limited spatial distribution of urban and industrial centers over the country where production processes take place create distribution problems, transport snags and high rates of urbanization.

The development *of infra-structural facilities* is not moving in line with an increase of production of building construction materials and a continued increase of demand for housing and dwelling construction.(NCC 1994).

The current physical infrastructure forms a real constraint to the construction industry, since building construction is location bound and the accessibility of building materials is harmed by a bad status of the transport and communication system. The problem of enormous delays in the harbor is another aspect of the infra structural problem. The present import regulations that now result in an extremely slow handling of goods in the harbor should be revised. This would also mean a ban to corruption. The provision of facilities like electricity, water and sanitation is problematic and harms the quality of the houses.

Although it sounds contradictory the international setting of Tanzania as a rather peaceful and politically stable country forms a problem due to the influx of many refugees from neighboring countries in war.

This puts quite some pressure at the provision of social services like housing in a country that actually is not able to cope with number of severe national socio-economic problems.

8.6 Conclusions

The synthesis of the findings of the technology mapping studies seems to endorse the theoretic starting points in this research project.

The factors, that indicate the opportunities, problems and constraints for the solution of the present housing problem in urban Tanzania, can brought back into *clusters*. These clusters form the concepts that were theoretically assumed to be the major determinants for the technological production performance in any sector: *the technological capabilities* in the sector under investigation, the *technology status in the production units* and the *national setting* in which the production takes place.

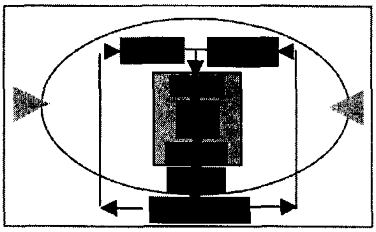
The major factors of the national setting that have an impact on the technological capabilities in the dwelling construction sector and on the needs for affordable and adequate houses were found to be (1) the politic-economic setting, (2) the geographic setting and (3) the demographic setting. The technological capabilities in relation with the need for adequate and affordable houses determine the quantity and quality specification of the houses, that should be built. This determines the selection of the construction systems, material inputs and the process technologies (equipment and tools, labor force, information and organizational framework) to be utilized for the processing of the construction systems on site.

Any deficiencies in the technological capabilities are found to be directly reflected in the technology status in the construction projects. This on its turn has an impact on the technological production performance and the extent to which the housing need can be met. These elements are embedded in a national setting that should be supportive to the production performance in the sector.

Chapter 9

Implications of the Technology Mapping results for Technology Management in the dwelling construction industry in urban Tanzania

part III



9.1 Introduction

The implications for technology management at project- and sector level and for the national policies resulting from the technology mapping studies are discussed in the next sections. The objective is to indicate the areas for management interventions that should be made to improve the technological production performance in the dwelling construction industry for the lower income households in the urban areas of Dar es Salaam.

The theoretic starting points in this research project indicate that the achievement of a strong international *competitiveness,* which at the same time safeguards sustainable development, depends on the status of technologies in use in production. The status of the used technologies is determined by the technological capabilities. (part I chapter 2)

Technological capability building offers obviously a gateway to sustainable development. Up-grading of the technology capabilities leads towards an improved technological production performance. An increased level of technology capabilities comes in fact down at an increased availability and quality of the totality of the national resources that can be dedicated to the construction industry. The set of information on the current status of technological capabilities and the technologies in production revealed the opportunities problems and constraints for improvements in the dwelling construction industry. This should facilitate the determination of the interventions by technology management and technology policies.

9.2 Implications for sector level Technology Management

The results of the technology mapping studies regarding the technology capabilities in the construction industry in Tanzania indicated the strengths and weaknesses of the components of technological capabilities. These lead to the focal points for technology management at sector level to achieve an increased level of technology capabilities. These are summarized in table 9.1.

Table 9.1Focal points for sectoral technological capability building

Technology stock	Human resources	Natural resources	Technology Infrastructure
>construction systems (low cost, prefab, lightweight, easy transport, easy handling on site)	> skills and knowledge labor force >mobilization of human resources – employment	>sustainable exploitation for building materials production	>performance of actors >interrelationship between actors

Thus the present technological production performance in the dwelling construction sector requires the improvement of the utilization and development of the existing technology capabilities. By an *increased advancement of the product and process technologies, mobilization of the pool of human resources*, sustainable *exploitation of the natural resources* and *extension of the stock of technologies* for building construction through a *strong technology infrastructure.*

The studies indicated that the potential strength of the Tanzanian technological capabilities can be found in the stock of natural resources. At the same time the present level of exploitation of these is minimal, although the government has been stimulating mining activities (particular regarding gold mining) during the last years. The impacts of these have become visible in the first place in the development of the physical infrastructure in Tanzania. The western part of the country that was practically unreachable until a few years ago at this moment has an airport and a water supply distribution network. Further developments are the establishment of education and health centers. The mining activities also have a spill-over effect to other local economic activities. Another potential strength of the technological capabilities is the pool of human resources provided that education and training opportunities are available.

***Recommendation 1** The available stock of natural resources and the pool of local human resources should be utilized more efficiently and effectively to increase the availability of the necessary inputs in the construction projects: building materials, tools and equipment, labor force.*

The implementation of this recommendation is not easy. It has to face a number of constraints that fall beyond the scope of the construction industry such as *such as the lack of capital goods, skilled labor, management frames, financial means, regulatory measures and legislation.* An improved exploitation of the stock of natural resources and human resources requires at the same time:

a. a proper preparation, investigation and negotiation of the *opportunities* to start the exploitation of the natural resources for the production of building materials, tools and equipment
b. the local and international search for and development of appropriate and sustainable construction systems, prefab building materials, components and building elements which are (1)produced with locally available raw materials, (2) low cost, (3) easy to transport and handle on site with limited knowledge and skills
c. the acquisition of the presently non-available means for the exploitation of the natural resources for the production of local building materials, tools and equipment such as skilled manpower, capital goods, management frames, financial means.

A scenario that can be followed to implement the recommendation for the sustainable exploitation of the available natural and human resources that are needed in the building construction projects is to strive after joint ventures with foreign organizations under equitable terms and conditions. Through this channel the lacking process technologies to start the exploitation of the natural resources for the local production for the building materials, equipment and tools can be transferred from abroad on *temporary* basis.

Training of the local management and labor force and the sustainable exploitation of the local natural resources should be a primary condition for the joint ventures. Thus negotiation of a *knowledge and skills agreement* concerning the production processes and the proper application of the production outputs on the dwelling construction sites is important. The information, guidelines and short training programs given by the building material and equipment producers and suppliers to the purchasers (contractors, labor force and individual investors in building construction projects) will contribute to mobilize and develop the pool of human resources.

In this way the local manpower can be trained and given an improved access to the needed information, knowledge and skills for building materials and equipment production and dwelling construction.

The benefit of such an activity is twofold: (1) the suppliers attract a number of purchasers for their products, (2) the clients gain knowledge and skills on the utilization and application of the products on the building sites. Employment and income for the local population then can be secured, which increases the affordability to acquire a decent house.

Through working in this way a number of targets can be reached in an integrated manner. : (a) *human resources building*; (b) *proper exploitation of natural resources* for the benefit of the building materials, equipment and tools and the construction industry; (c) the *development of the technology stock* through the extension of the range of available construction systems, materials and equipment. In other words a scenario as proposed above contributes to technological capability building.

A sustainable technological capability building requires the existence of a strong technology infrastructure. This includes

a. the accessibility of the available information on adequate and affordable dwelling design and engineering. The documentation and information on this available at the research institutes - like NCC. BRU. UCLAS - and the Housing department of the Ministry of Lands Housing and Urban development (MLHUD) should therefor made easily accessible.
b. the diffusion of the available information and documentation (basic dwelling design and engineering drawings and information on the construction process and needed inputs) between the actors of the technology infrastructure (MLHUD/ NCC/BRU/Professional organizations), to provide the dwelling construction project participants with the necessary information and documentation before they start the construction processes on site.
c. The support for the precise specification, proper selection, acquisition and application of the construction output and the required construction systems, materials and process technological components in the construction project.
d. A strong collaboration of the private sector with professionals, universities, R&D institutes, national and international organizations -like UNIDO, UNHABITAT, UNDP, CIB- to gain insight in the opportunities to develop, establish and (re-)vitalize local

building materials and equipment producing and supplying organizations for the benefit of the construction project performance

***Recommendation 2** The actors in the technology infrastructure of the construction industry (various institutions, organizations, enterprises and private investors in dwelling construction) should be aware of the need to strengthen their performance and the interactions between them. The existing basis of resources (capabilities) in these organizations then should be mobilized in order to apply these to the benefit of the building construction activities. Next follow the further development of these capabilities.*

This means that the actors in the actor network of the construction industry should collaborate on the development, diffusion and utilization of technologies for the benefit of them all. At the same time the linkages between the actors in the network should provide a long term improvement of the operating environment for the execution of construction projects through on-going technology developments and technology capability building.

9.3 Implications for project level Technology management

The up-grading of the technological capabilities is expected to have an impact on the technology status in the construction projects and the technological production performance in the dwelling construction industry. At the same time *technology management at project level* should be directed to the alleviation of the internal weaknesses and the optimization of the use of inputs and technologies to achieve a best-practice technological production performance that meets the demand in the housing market.

Based on the data about the strengths and weaknesses of the internal factors in the construction projects the focal points for project level technology management could be identified to achieve an improved technological production performance. The focal points are summarized in table 9.2.

Table 9.1 Focal points for project level technology management

Product technological features	Process technologies	Material inputs
* maintain type of houses > functionality > facilities (water, electricity, sanitation) > durable materials & construction systems > lower costs > simplification site production process	* maintain low capital tools & equipment > availability of tools & equipment > human resources skills & knowledge > information & documentation > organizational framework	> availability > quality > prefab materials on site > use of local raw materials < import content of materials > information & doc on materials > collaboration of actors in materials selection
[illegible] flexibility of small scale and informal sector construction [illegible] qualification [illegible] [illegible] financial means [illegible] [illegible] houses [illegible]		

(* = maintain; > = improve)

These lead to the following recommendations for technology management at project level.

Recommendation 1 *Execute the dwelling construction in mass construction projects to take advantage of economies of scale.*

The project setting of the construction projects should be facilitating for the achievement of an improved production performance. A strategy that could be followed is the execution of dwelling construction projects by the construction of a number of (similar) houses at a time (preferably by using prefab construction systems) to take the advantage of economies of scale. Building construction in this way also could give support to legalize the dwelling construction projects and to ensure a better access to the necessary additional inputs like infra structural facilities, information and documentation and financial resources. Dwelling construction for the lower income households that is organized and executed as a joint effort of a group of potential house owners or a community in mass construction *projects has the advantage of the economies of scale and lower costs.*

Moreover building a number of the same houses at a time, coordinated, supervised and supported by a skilled project manager, might facilitate (1) the legalization of the construction sites, (2)the establishment of basic infrastructure on the sites (water, electricity, access roads) with involvement of the future house owners, (3) the establishment of a system of (pre-financed low capital) tools and equipment supply within the framework of the mass construction project undertaken by a group of house owners possibly under supervision and coordination of an independent organization, (4) the access to financial means.

Recommendation 2 *Prepare and specify the construction project thoroughly.*

A higher quality, timely availability and lower costs of the building materials and process technology components on site should be reached through a detailed specification of the desired house, information and specification of the needed materials

Any construction project should start with an accurate specification of the product technological features of the desired building. This specification sets the requirements for the engineering features (geometry, materialization, physique technical performance) and the costs of the building. Based on information about the available range of construction systems and their specific engineering features, costs and construction process technological requirements, a selection can be made of the system that offers the best opportunities to build the house with. The product technological specification of the house and the information about the construction process technological requirements of the selected construction system form the basic set of information that should be available on the construction sites. This is seldom or actually not the case in the investigated dwelling construction projects. Information and documentation are considered to be an in-extractable and important component in any transformation process in particular when non-traditional production systems are applied.

Recommendation 3 *The process technologies to be used in the construction projects should be kept of low capital intensity in order to keep the houses affordable for the lower income households under the present circumstances in urban Tanzania.*

This means that the process technology complex that involves a set of simple tools and equipment at low cost could be a solution. This type of equipment and tools generally have no built in control mechanism that secures a standard quality of output of the treatment that is carried out with the tool. It thus requires a tailormade availability and quality of labor force that has the ability to carry out the job properly.

***Recommendation** 4 Involve the house owners and their relatives in the construction process as labor force to order to keep the houses affordable for the lower income households*

A prerequisite of project execution in this way is the availability of supervision of the project execution by skilled project manager(s) to increase the affordability of the houses.

***Recommendation** 5 Take advantage and gain knowledge from the use of information and documentation systems during the project execution*

The documents in which the project execution is specified and documentation on former projects gives insight on the proper project execution and prevent the possible pittfalls which might be encountered.

***Recommendation** 6 Direct the efforts to getting access to the organizations and institutes to collect the necessary information on management techniques for the development of proper organizational frameworks for the construction projects.*

Information on the range of available technologies and the specific knowledge and skills needed to apply these on the project is available at the institutes like the Building Research Unit (BRU), National construction Council (NCC) and the Ministry of Lands Housing and Urban Development (MLHUD). It should be diffused to the participants in the construction projects to achieve an improved technological production performance.

***Recommendation** 7 Increase the use of prefabricated standardized construction systems and building materials systems to simplify the construction processes on site.*

The features of the construction process technology components (equipment and tools, labor force, information and organizational frameworks) that are available at present set the requirements for the *construction systems and building materials.* These are expected to secure the achievement of the desired standard quality of the construction output. The materials should be easy to transport and handle on site, available at low cost, have a low import content and should be supplied accompanied with clear instructions and guidelines. Prefabricated standardized construction materials and elements that meet the above set requirements could be a good alternative provided that good instructions for their application are available. The present (low) *level of skills and knowledge* of the majority of the labour force requires construction systems that are composed of building materials and elements that are easy to handle. The non-traditional construction systems also need the availability of adequate information and documentation systems and a proper organizational framework. A careful selection of the construction system and materials contributes to simplify, improve and lower the costs of the construction processes on site. To lower the costs of the construction and to tackle a number of other constraining factors in the construction project at a time the construction project organization should be addressed.

***Recommendation** 8. Start the construction project by taking care for proper site preparations. These should include the establishment of the basic infra structural facilities (access roads, water, electricity and sanitation) and the construction of a decent foundation for the building.*

Proper site preparations will pay off. The future owners of the houses could assist in these activities to cut down the costs.

In ***conclusion*** can be said that Technology Management at project level should be first focussed on gaining more information, knowledge and insight among the house owners and contractors on the available range of construction product technologies and process technologies to execute the construction project effectively and efficiently with the available resources in the country.

The present (low) *level of skills and knowledge* of the majority of the labor force requires an increase of the utilization of the available *information and documentation* on product- and process-technologies. This should also include planning, implementation and control of the construction processes that can be applied in the dwelling construction projects to improve the present technological production performance in the dwelling construction projects. This information should be complementary to the basic skills and knowledge among the future house owners and building contractors.

The total set of information should give insight on (a) the availability of readymade standard design and engineering documents, (b) the availability of examples of standard tendering and contract documents in which the target output and the particularities of the construction project are clearly specified , (c) the availability and quality of building materials and construction systems -preferably of prefab building components- which are easy to produce, transport and assemble on site. (d) the process technological requirements for the application of the construction systems. The information should be accessible through support services, information, documentation and training centers. The construction project management thus has to rely on external sources in the technology infrastructure of the construction industry to acquire this technology component.

The technological production performance at project level depends on the inputs in the construction projects acquired through strong linkages with the relevant actors in the technology infrastructure of the construction industry. This points again at the pivotal importance of the components of technological capabilities for improved technological production performance in the dwelling construction industry. Moreover the above recommendations for project level improvements only can be implemented with full support of proper technology management at sector level and technology policies at national level.

9.4 Implications for Technology Policies at national level

An optimal effect of the efforts to up-grade the technology capabilities for a sector can only be reached through a supportive national environment. At national level technology capability building requires that the government dedicates its policy plans and efforts to the development of a certain technology creative system (technology structure and infrastructure) in order to decrease the technology dependency position and create a technological self-reliance situation (Stewart 1978 in UNIDO ID/262)..

While planning and formulating the national policies and strategies the national policy makers should take into account the focal points for the improvement of the national setting for the construction industry given the non-negligible role that can be taken by the construction industry in meeting socio-economic development targets in the country.

The focal points for technology policies at national level are given in table 9.3.

Only with full government support (in terms of legal, financial or fiscal incentives) for those collaborating in the implementation of the above recommendations - an optimal performance of the sub-sector of dwelling construction for the lower income households in urban Tanzania can be further improved.

Table 9.3 Focal points for technology policies at national level.

Economic	Policies	Education	Phys. Infrastructure	Housing
> employment > income generation > income distribution > diversification of the production structure > industrial production	> legislation of sites > land delivery > building regulations < fiscal consequences of legislation of small scale construction activities < tax regulations for foreign investm. joint ventures building materials production < bureaucracy	> skills and knowledge on site construction activities > management skills < investment	> transport & communication Network > supply of . electricity . water . sanitation	> quantity of houses' > quality of houses > lower costs

Recommendations for improvement of the national setting of the construction activities are the following.

Recommendation 1 *Stimulate economic development*

a. stimulate employment and income generating activities by the formulation of adequate regulations and legislation like fiscal incentives for example for foreign investments under equitable terms and conditions.
b. improve and diversify the production structure by stimulating the economic activities in promising sectors -like for example tourism- which also improve the trade balance and generate foreign exchange.
c. stimulate the increase of quality and quantity of the production output related to the construction industry by making use of an improved exploitation of the available resources, further industrialization, standardized, and mechanized production.

Recommendation 2 *Re-structure the existing policy structure, regulative and legislative system to become less bureaucratic, adaptable to changing circumstances and more supportive for the construction industry.*

a. Establish a full data set with both socio-economic and technological data on the performance of the dwelling construction industry. These data sets should be maintained on regular basis in order to be able to adapt the policies and regulations to changing circumstances
b. Formulate proper policies and regulations based on detailed data on the existing situation.
   1. improve the existing building regulations;
   2. properly plan and legalize building sites for dwelling construction while the fiscal consequences and bureaucratic operations should be minimized;
   3. establish particular tax regulations for the benefit of the construction industry and other related economic activities. This implies for example tax exemption for the informal sector contractors as a mode to stimulate the collaboration between the various parties in the dwelling construction industry by means of fiscal incentives.

***Recommendation 3**: Stimulate the improvement of the training and education system tailor made for the construction industry.*

a. Given the economic situation which does not allow much investment in social services from the national budget, the government should stimulate on-the-job training opportunities.
b. Establish particular regulations and fiscal benefits for enterprises and organizations offering learning by doing facilities.

***Recommendation 4**: Improve the physical infrastructure.*

a. These require relatively high investment for which the national budget is apparently not sufficient.
b. Stimulate the mobilization of the households involved in dwelling construction projects. Building sites could be supplied to the households with the prerequisite that households collaborate in the development of the physical infrastructure. Still investments in material purchases have to be made.

***Recommendation 5**. Establish a proper functioning dwelling construction coordination unit*
Such a coordinating organization should stimulate, support, guide and control the activities of the various participants engaged in mass construction projects for houses for the lower income households, building materials and equipment production and supply, technology developments and international technology transfers for the benefit of dwelling construction for the lower income households. The organization should provide information on the technological and economic opportunities for optimal project performance, organize meetings, seminars, conferences, research exchanges. By means of the common communication channels (pamphlets, bulletins, newspapers, radio, television) the general public and the contractors should be made aware of the availability and accessibility of such information. The coordinating organization should get full government support in terms of being able to set legal or fiscal incentives for those collaborating in the implementation of this first recommendation.

***Recommendation 6**. Formulate specific regulations and fiscal incentives to stimulate and support the strengthening of the linkages between the actors in the technology infrastructure of the construction industry in order to achieve proper technology diffusion processes*
Technological capability building and thus also strengthening of the technology infrastructure in the dwelling construction sector is only possible with a full support from the national setting.

In conclusion can be said that the improvement of the national technology setting forms a prerequisite for the adequate and affordable supply of houses for the lower income households. On the other hand the same aspects are - whenever they are achieved in reality- also the result of an improved performance of the construction industry. This counts for example for employment, income generation and distribution, increased industrial production, increased skills and knowledge on building construction and management and housing supply at required terms and conditions. Given the existing constraints in the national setting in particular with regard to the economic situation, the national policies and strategies should be directed to efforts for improvement of the situation which do not require high investments. This means that the government should create an enabling environment through proper policy formulation, legislation, financial and fiscal regulations in order to improve the housing supply through dwelling construction. There should be a proper policy structure and a political willingness to support the necessary steps for successful steps towards technology capability building and an improved technological production performance in the dwelling construction industry.

9.5 Concluding remarks

The problems and constraints *for improvement of the technological production performance* in the sub-sector of dwelling construction for and by the lower income households to meet the need for adequate and affordable housing- occur at the different levels of economic activity and are strongly interrelated. Thus attention should be directed to finding solutions in which all these are integrated.

Given the major constraint of lagging economic development in the country, the solution should be sought in activities directed to support income generation efforts that are heavily supported by the national policies. Moreover the policies should integrate as much as possible the support to technology capability building - the development and further exploitation of the stock of national resources (technology capabilities) - and at the same time tackle the constraints at the various levels of the economy to achieve the desired developments in the dwelling construction industry.

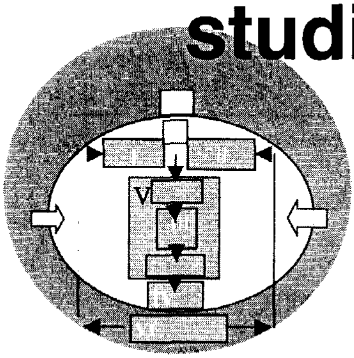
The supply of houses by the construction industry then can be improved to solve the housing problem. However the first most urgent aspect to be solved in the country is the lack of income of the lower income households. The effective demand for adequate and durable houses then will rise and become more in balance with an improved performance of the construction industry.

Thus a *solution* which addresses the major constraints of the current unfavorable housing situation should be found in *technological capability building*. Hereby the following activities should be integrated. Employment and income generation for the lower income households, a sustainable use of the (easy and low cost) available raw materials, education, training and use of the available human resources; the development and further diffusion of information and documentation on product and process technologies and the set-up of organizational frameworks in which these activities can take place. This means the up-grading of all components of technology capabilities in an integrated way.

The stimulation, support and control of the technology capability building activities should be properly coordinated. Professional support for technological capability building is import and in case this is not locally available support should be sought from foreign professionals or international organizations. This all should get full support of the *national government*, which should become evident in an adequate policy structure, regulations and legislative environment in which the construction activities take place.

Part III

Technology Mapping studies in Costa Rica

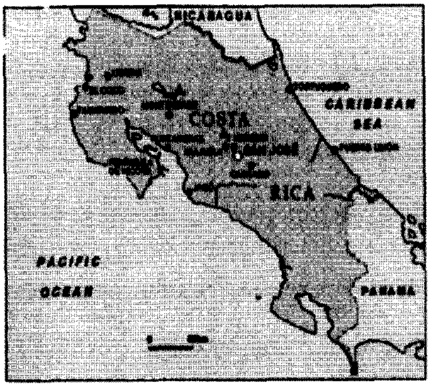


An Application of the Technology Mapping Methodology in the dwelling construction sector for lower income households in the Urban areas in Costa Rica

Contents

Chapter 1

Empirical aspects of the Technology Mapping Studies in Costa Rica



part III

1.1 Introduction

In this part of the thesis a description is given of the results of the application of the developed technology mapping methodology in studies on the dwelling construction sector for lower income households in Urban Areas in Costa Rica. These studies took place simultaneously with the field studies in Tanzania.

The Republic of Costa Rica is a small country in Central America.(51,100 sq km) that has a population of 3,347,000. (1998) San José is the Costa Rican capital, located in the Central Valley that is the most urbanized area in the country.

The aspects that had to be taken into account during the application of the technology mapping studies in Costa Rica are discussed in this first chapter.

1.2 Research procedure and sub-studies

The same research procedure has been followed and the same research instruments as applied in Tanzania were used in Costa Rica. Also here the research procedure for technology mapping includes the execution of a number of *sub-studies* at different levels of aggregation. A description of the studies can be found in the next chapters of this part of the thesis.

1.3 Population, sample and research instruments

The in-depth field studies in this part of the research project -on the *technology capabilities* at *sector level* and *at project level the technologies used in the construction processes* for (and by) the lower income households in urban areas in Costa Rica- took the major part of the efforts. This was also the case in the Technology Mapping Studies in Tanzania. These studies are basically of technological nature. Secondary sources have been used for the majority of data resulting from studies in other disciplines.

The population of the studies in Costa Rica included the dwelling construction projects for the lower income households situated in the Urban Areas in Costa Rica. Within this area a number of dwelling construction projects were selected and investigated. It was again rather difficult to identify the entire population of dwelling construction projects which were executed for (and by) the lower income households within the time span of 1989 up to 1997.

The sample of projects that complied with the basic criteria included thirtysix dwelling construction projects for the lower income households all over the Urban Areas in Costa Rica. The projects included both the construction of individual houses and the construction of a number of houses at one site in one project. For the sampling procedure that was followed reference is made to chapter 4 of this part of the thesis.

1.4 Data collection, analyses and interpretation

The same research instruments were applied in Costa Rica as in Tanzania.

Like in Tanzania during this part of the studies various methods for data collection were applied. The methods included literature studies, unstructured interviews with key persons, structured interviews, non-participant direct observations.

The data sets from the own field studies in the Urban Areas in Costa Rica were compared to the data that were collected from several publications. This applies in particular to the data on the product- and process technologies and detailed data on the backgrounds of the participating parties in the dwelling construction projects for the lower income households. Contractors, persons of institutes and organizations like the ITCR (Instituto Technologico de Costa Rica), the UCR (Universidad de Costa Rica), the Camara Costaricense de Construccion (CCC) MIVAH (Ministerio de Vivienda y Asentemientos Humanos) and the PNB (Proyecto Nacional de Bambu) were interviewed additionally to give their viewpoints on the allover performance of the construction industry.

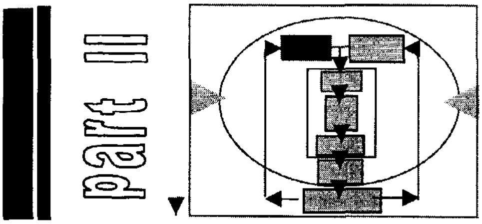
A major difference with regard to data collection in Costa Rica compared to Tanzania was that in Costa Rica more data sets were readily available of reasonably good quality. Moreover the Spanish language gave no problems.

Data analyses are made with (1) the sample mode as central tendency measure and (2) the sample range as measure of dispersion. The mode and the range provide a serious indication of the characteristics of the dwelling construction sector for lower income groups since the sample and the methods of data collection ensure a substantial data set collected in the countries, that provides useful relevant information.

Interpretations are carefully checked with experts of organizations like the Camara Costaricense de Construccion (CCC), the Universidad de Costa Rica (UCR), the Centro de Investigacion de Vivienda y Construccion (CIVCO) and findings in several publications.

Chapter 2

Housing and Technology Needs in urban Costa Rica



2.1 Introduction

The technology mapping studies were -also in Costa Rica alike in Tanzania- applied in the *societal problem area of housing.* The studies that are described in this section focussed on the question regarding the quantity and quality of houses that are needed (product technology needs) in urban Costa Rica. The data indicate the ***sectoral technology needs*** (STN) that call for an optimal technological production performance in the dwelling construction industry. The needs set the terms of reference for the technological capabilities and technology status in construction projects. Secondary sources were used for this purpose.

2.2 Housing in Urban Costa Rica: past and present

Traditional housing in Costa Rica reflects Costa Rican history. In the past the first colonialists lived in thatch roofed huts with dirt floors. Locally available materials and the existing traditional construction systems were applied for the construction of the buildings until the end of the nineteenth century. Adobe was generally used for the structural elements. The materials and construction systems used from the end of the nineteenth century up to the fifties of this century were predominantly timber and zocalo. These were accepted by the various social classes and preferred by the lower income groups for their relatively low-costs and easy availability in the country. Forms and shapes of the houses followed the functional requirements of their users. The houses were all rectangular with gabled roofs. The functional layout of the houses of the lowest income households often involved at the start the construction of a single multi-purpose space for the whole household. Only later this space is sub-divided with partitions whenever the household has been able to acquire materials to do so. Facilities in the house might have included one multi-purpose sink - only in case of a water connection to the house- for cooking, bathing and washing. No particular storage space was generally available for cloths, food or else.

The *present housing situation* in Urban Costa Rica reflects the current conditions of the financial, technical and policy setting in which the national and local governments have to operate. They have to face the limits to the resources to provide for sufficient social and infra-structural services like housing, education, health services, roads and communication networks, water, electricity and sanitation facilities for all their country men. The economic crisis that affected Costa Rica during the first years of the eighties deteriorated the quality of life and made even more noticeable that a high percentage of the population was living in inadequate housing facilities. This was also enhanced by the influx of refugees from neighboring countries living in more or less permanent settlements in Costa Rica. The *economic situation* substantially affected the purchasing power of the households including their ability to acquire affordable decent housing. The determining factors of the housing problem more and more became the rather limited volume of resources that are necessary for the construction of adequate shelter for all sections of society. Also *urbanization and population growth* rates contributed to an increasing number of households living in inadequate housing facilities. The impacts of the economic crisis during the eighties were also noticeable in the supply of houses by the construction sector. Despite a slight improvement during the early nineties the dwelling construction output still leaves much to desire. The deplorable housing circumstances are in particular applicable to the lower income households in Costa Rica.

2.3 Housing: adequacy and affordability

The *adequacy of a house* is measured along the basic standards set for it and formulated in the building regulations. The population that really has access to adequate housing belong to the higher and middle income households in Costa Rica. The housing alternatives for the very poor families are often limited to illegal occupation of land and the formation of squatter areas in the peripheral zones of the principal cities with dwellings that are reported to be below the generally accepted minimum standards with limited living space. A number of illegal squatter areas have been erected in the fringes of the capital San Jose and the larger towns in Costa Rica often located near rivers or streams to have access to sources of water. Traditionally such constructions have been classified as sub-standard or "not-repairable". The buildings have an illegal status since most of them are constructed without any permit. The buildings generally lack a direct legal connection to utilities like water and electricity. The people who live in these houses likely have just one bedroom and several people might even sleep in one bed. When they are present a few small glass windows admit the entrance of light while fresh air only enters through the open door.(Biesanz 1994).

The *affordability* of decent housing not only depends on the household income. It also depends on the prices of houses in the market, the real income available to the families in terms of purchasing power and the financing conditions (interest and terms). Real income per capita has suffered a severe decline during the crisis of the beginning of the 1980-ies. Since then, over the past decade it slowly recuperates but fails to regain its 1980 value. (see appendix III-2)

fig 2.1 Family income index

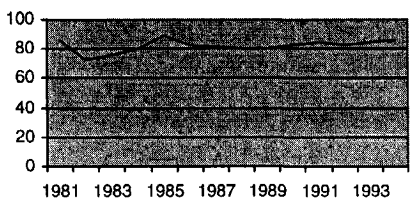
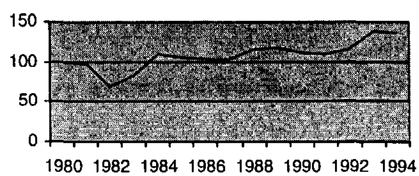


fig 2.2 popular housing costs index (1980=100)



Credit conditions also deteriorated severely in the beginning of the 1980s. Since then the income conditions have been fluctuating according the general economic conditions but never came back to its pre-1980 values and remained typically 40 to 50% less favorable.(CEPAL1996)

The costs of a house are determined by many factors, such as material prices and wages, short term credit conditions and land prices. During the past decade -at first due to the 1980-1982 crisis- prices dropped but after this increased again. This is due to the fact that the prices of construction materials tend to increase a little more than general inflation and by the fact that many building materials are being imported in the country.

Table 2.1 Costs of a house versus income Source: Derks, M. / TUE - CIVCO 1994

Costs of small house 50 m2 (1994)	C1.650,000	US$ 10,000
Monthly costs of loan including interest (32%) and installments 15 yrs	C 45,000	US$ 272
Needed monthly income (3x monthly costs for the house)	C 135,000	US$ 820

Based on the above mentioned three indicators can be concluded that the general trend of the affordability of housing during the 1980-1994 period has been declining. Family income vis-a-vis the costs of a prototype dwelling and the financial restrictions of the mortgage market implied that at least some 20% of the lowest income population have no access to even a dwelling improvement loan, let aside a loan for the construction of a new house. A significant part of the population has no access to the actual official financing programs for long term loans with low interest rates. (see appendix III-2)

Table2.2 Classification of Income groups and their purchasing power for a house
Source: Direccion General de Estadistica y Cencos 1994

Classification of households by income	Income level/month	% of tot population	Range of purchasing power for housing (Colones 1994)
Extreme low income	0 - 28,492 ($172)	17 %	0 - 9,500 ($ 57)
Lowest income	28,493-45,200 ($ 274)	18%	9,501-15,000 ($ 90)
Low income	45,201-70,330 ($ 426)	21%	15,001-23,400 ($142)
Middle	70,331-112,341 ($680)	22%	23,401-37,400 ($230)
Higher income	112,342 and >(> $ 680)	22%.	> 37,400 (>$ 230)

2.4 Housing needs

The actual housing situation in terms of quantity is characterized by a cumulating current annual deficit of houses in Costa Rica from some 85000 units in 1973 up to 189,000 in the year 2000 caused by an increasing gap between housing needs and supply of housing facilities. (see appendix III-2) In 1995 the deficit was 168,141 houses. (INVU 1996) The deficit of houses consists of the total lack of needed houses and the considerable presence of uninhabitable houses. About fifty percent of the deficit is caused by the presence of uninhabitable houses and another fifty percent by a lack of needed houses. In 1995 the housing deficit affected some 22.5 percent of the total population.(the average household size was 4.2 persons). When also the number of irreparable houses is taken into account the situation appears to be even worse. In 1995 a total number of 180,27927 houses were registered as being defective and actually need to be improved but are irreparable. This means that another 24.1% of the population has to deal with housing problems. Some 56% of the housing deficit concerned the necessities for the lowest income groups, 34% those of the middle income groups and 10% for the higher income groups. It can be noticed that the size of the lowest income groups corresponds with the size of those people living in a status of extreme poverty. Here again should be kept in mind that a large part of the needs - in particular of a high percentage of the Costa Rican population that lives in poverty -is seldom transformed to a real market demand.

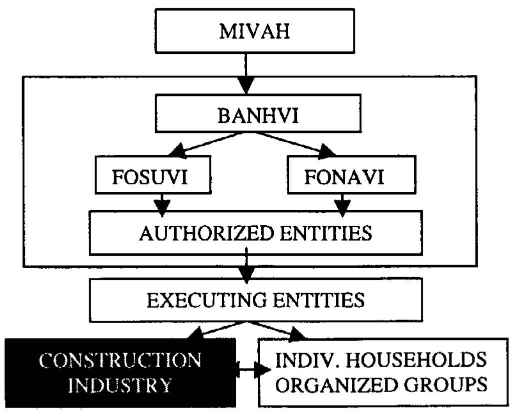
2.5 Housing delivery system

The number of housing units that are built per year is increasing. But still the number of needed houses per year grows at a faster pace than the number of newly built houses delivered per year. (appendix III-2). The construction industry is a major actor in the physical realization of the houses. Dwelling construction takes a dominant position in the construction industry. More than 70% of all construction projects concerns dwelling construction. The public sector is involved in the construction of 66.8% of the dwelling construction projects. This means a state involvement through financing of the projects within the framework of the national housing financing system (SFNV). This is different from the situation that could be seen in Tanzania. In Costa Rica the lower income households can partly rely on the housing opportunities provided direct or indirect with the financial support by the government. The dwelling construction executed by the private sector represents 30% of the total construction projects. These are carried out beyond the national financing system. A small percentage (3.2%) is constructed completely with private means. (MIVAH 1994).

2.6 Housing financing system

The national housing financing system -named Sistema Financiero Nacional de Vivienda (SFNV)- was legally approved by the National Assembly in 1986. The basic objectives were (1) to promote savings and national and international investments, (2) integrate public and private institutes who finance housing (Mutual Associations, private banks etc.) (3) establish the Housing Mortgage Bank (Banco Hipotecario de la Vivienda BANHVI) as a public ruling entity.

Fiq 2.3 the national housinq deliverv system



The Ministry of Housing and Human Settlements (Ministerio de Vivienda y Asentamientos Humanos MIVAH) regulates and finances housing programmes for houses with a size between 36 and 60 m2 all over the country. The Banco Hypotecario de la Vivienda (BANHVI) - the national housing mortgage bank- has become the authorized distributor of the financial resources via two special funds: FONSUVI (Fondo Subsidios para la Vivienda) and FONAVI (Fondo Nacional de Vivienda). FONSUVI offers a particular subsidy method that is known as the Family Housing Bond (Bono Familiar de Vivienda BFV), which is legally established as " a non-negotiable nominative title, issued by BANHVI to the beneficiary, that is free from all tax payments present and in future" (Sala 1988 & Landaeta 1994). FONAVI (national housing fund) offers loans for housing and receives its resources from the Costa Rican Social Security Fund (CCSS).

The financial resources of the SNFV for housing are channeled via State Bank organizations and co-operatives -the authorized entities- to the beneficiaries (households and private housing project development organizations that realize the construction projects)

The resources from the national housing financing system are spent in different ways. In the period between January 1994 and March 1995 only some 56% is spent on the construction of new houses. 28% was spent on the purchase of an existing house. 10% is used for the maintenance and repair of existing houses, and 6% is used for the purchase of a plot. (see appendix III-2).

The establishment of the national housing financing system formed an important stimulant to the housing sector in general. Despite this the deficit of houses for in particular the lower income households still is large. The financing system appeared to be insufficient to reach the targets. The high costs of the built houses were recognized to form a major constraint for the accessibility to decent housing for the common man. This called for further actions in other fields than only the financing of the houses and gave an impulse to investigate the actual causes. Suitable solutions for the housing deficit could be expected from engineering studies.

2.7 Housing policies and regulations

The national housing financing system has been the result of the policies on housing formulated in the eighties. But the Costa Rican government's interest in the housing situation of its inhabitants dates already from the beginning of this century. Since the beginning of this century the Costa Rican government was involved in public housing. (see appendix III-2) The first social housing financing projects were implemented during the sixties with loans from the North American Organization named "Alliance for progress". Dwelling construction projects were carried out with these finances which gave a push on dwelling production in the form of series of housing complexes in rural and sub-urban areas. Unfortunately the constructed housing units became far from affordable for the lower income population due to changes in initial conditions for the repayment of the foreign loans.

A review of the housing supply and the role of the construction sector in the beginning of the eighties identified the problems and constraints for an effective provision of the highly needed housing facilities in particular for the lower income groups. One of the most difficult problems to overcome was the decrease of the costs of housing construction. The reasons that were mentioned are : (1) a high percentage of foreign components used in the construction of the houses, (2) the inefficient use of the potential capacities of the end-users of the houses, who very well could offer labor input, by which the construction costs could be diminished with nearly 50%, (3) the increase of the costs for land by private owners to be acquired by the Government for housing purposes.

Based upon the findings of the review the Costa Rican government launched the "Plan Nacional de Vivienda Popular" (National Housing Program) in 1986. The National housing financing system was a part of this plan. The final objective of the governmental program was not only to establish housing for the lowest income groups but also to find solutions for the increase of income and employment for the families concerned. Integral solutions for the mentioned problems were expected from integrated development efforts. These should include production for food supply and the construction of social housing for lower income groups. Herewith the semi-skilled labor input by the end-users should be used efficiently and the locally available and newly acquired appropriate technologies should be adapted to their purpose. This all should form the basis for the all-over socioeconomic development in the country.

However, there was a significant resistance for these plans among some of the existing institutions: " a natural reluctance of the bureaucracy to a new operation system" (Zumbado , 1991: pp17). Despite this the activities in the "Plan Nacional de Vivienda Popular" proceeded further. In 1987 a new program was launched for Rural Housing. The procedures to implement the program went on remarkable smoothly. Financial resources were set aside for the housing of 2000 rural households. Permits and requirements for allocation were simplified[1]. Selected financial entities were trained[2] and the processing period was better streamlined[3]. BANHVI prepared designs and plans of eight different model dwellings, in order that applicants select one at no costs, by knowing that they get easy approval for the plan from the authorities.

It became clear that through the activities, like those being started through the implementation of the "Plan Nacional de Vivienda Popular", not only houses were to be built in a short period of time. Also other sectors of the economy could be stimulated and experience an increase of their production like that of the construction industry. Through the improved performance of the dwelling construction industry and its forward and backward linkages jobs could be created, traders have better sales and transport organizations would benefit from the activities.

In the governmental development plan of 1994-1998 again series of major changes took place in the housing sector. In the first place the acting national administration proposed to change the set of priorities in the field of housing. It was proposed in such a way that housing was going to be more integrated in the social development like development in the field of education, health etc. (MIDEPLAN 1994). It implied that housing from that moment on had to compete again for resources with the other sectors. In the second place in the period 1994-1995 the Costa Rican SFNV had to deal with various problems that severely affected its operations. The problems were also due to a worsening of the macro-economic situation in the country. Overall the reduction of financial resources for the supply of sufficient houses called for intensified efforts to improve the production performance of the construction industry by increasing its production output both qualitatively and quantitatively. At the same time the costs of the construction should decrease.

One of the solutions that was launched was to decrease the square meters for each functional space in the dwelling. This should contribute to the achievement of (a) lower costs per dwelling, (b) a decreased time-consumption of the construction process and an increased output of the dwelling construction projects in quantitative sense. It formed the starting point for the formulation of a set of specific norms and building regulations for the houses for the lower income households.

The Instituto National de Vivienda y Urbanismo (INVU) had formulated building regulations and norms for minimum dimensions of the functional spaces in a dwelling based upon a baseline study on the existing standards for dwellings in other countries. The impossibility to comply with these norms in the dwelling construction for the lowest income house-holds, urged to elaborate a set of special building regulations for this type of dwellings. The "Reglamento para el Control Nacional de Fraccionamiento y Urbanizaciones" (the Urban regulations) were established in 1994 under the heading "Special construction norms for the

[1] to simplify the processes of getting permits the involved institutions agreed to staff and operate a central permit office only requiring a notarized copy of the property need, which only took two weeks time.

[2] groups of professionals were selected and trained to give assistance and information on the new system to bank agencies, credit agencies etc. all over the country

[3] a target period of one moth was set within which each applicant should surely be guaranteed of an approval for his plans provided that he meets the requirements of the law.

dwelling constructions for lower income households" (Urban regulations 1994: pp 73-75). The particular standards and building regulations are summarized in appendix III-2.

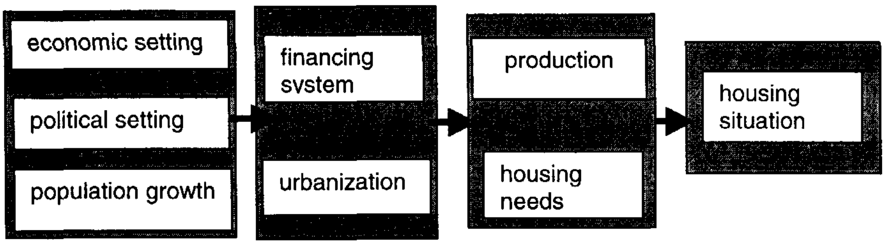
2.8 Conclusions

Like in many other countries in Costa Rica one has to deal with *a human settlements problem*, which has a tremendous magnitude.

In the urban areas of the country one has to face a situation of many unemployed people, inhabitants who live in absolute or relative poverty , *lack of basic facilities such as housing* and a far from favorable development prospect. In particular for those belonging to the lower income households the housing problems are most acute.

The *accelerated population growth* and the *economic setting* that leads to a considerable number of people in the lower income groups who are not able to afford a decent house, are some of the major causes of the housing situation. These aspects give a reasoning to mark housing construction with a high priority in the governmental policy plans.

fig 2.4 Major factors that have an impact on the housing situation



The housing delivery system in Costa Rica is dominated by the public sector as initiating actor of dwelling construction projects that are executed by the construction industry.

The housing policies in Costa Rica have been considered as one of the most successful in Latin America. With the creation of the national housing financing system (Sistema Financiero Nacional de la Vivienda) the sector obtained a rather coherent institutional framework and it reduced the dispersion of activities that characterized the former situation. The creation of the 'Banco Hipotecario de la Vivienda' gave a push to the mobilization of resources for housing construction without precedent in the Costarican history. It was brought about by a combination of *political will, reduction of bureaucracy* and an *innovative financing system.*

It is certain that the housing sector has experienced an important increase in recent years, this might however have been centered around the quantitative aspects of the problem instead of the qualitative aspects. One of the most difficult problems to overcome still is the decrease of the *costs of housing construction.*

In view of these it was acknowledged that efforts should be directed to the evaluation, adoption, adaptation, improvement, development and diffusion of production technologies including construction technologies and systems for housing construction. In the governmental plans it was already indicated that projects that aim at controlling the own production and provision of raw materials and auxiliary material for construction should get a the preference position for financing. Strategies that focus on the involvement of the target groups as much as possible in the execution of the projects then also were to be favored. This could take place by means of their involvement in the production process of building materials and self-construction of the buildings. The purpose is to enhance employment and income distribution as well as to decrease the construction costs.

In spite of the housing plans, the government did not succeed in eradicating the housing deficit. This makes it necessary to reconsider the policies in the light of total development. Financing alone of the dwelling construction projects seems not to render the expected results for the alleviation of the housing problem.

At the very moment the production output of the construction industry appears not sufficient to bridge the *tremendous gap between the supply and the demand of adequate housing* for the lower income households.

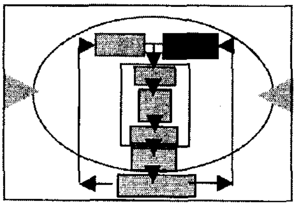
An improvement of the performance of the dwelling construction sector is expected to contribute to close the gap between housing needs and supply. Therefor it is considered necessary to investigate the available technology capabilities and the status of the technologies utilized in construction. The results should indicate the possibilities for technology management and policy interventions to improve the performance of the dwelling construction sector for the lower income households in urban areas.

Traditional timber houses

Chapter 3

Technological Capabilities for the dwelling construction sector for lower income households in urban Costa Rica

part III



3.1 Introduction

In this chapter the results of the mapping of the status of the technological capabilities will be described. These studies addressed the question regarding the nature and availability of a stock of national resources (technological capabilities) that can be committed to the construction of adequate and affordable houses for the lower income households in urban Costa Rica. The complex of four components that are considered to constitute these technological capabilities were investigated by using the findings of literature studies and interviews with local experts.

3.2 The technology stock

The investigation of the present technology stock for the sub-sector of dwelling construction for lower income households centered on the attributes of the available range of (a). *product technologies* and (b). *process technologies* for dwelling construction for lower income households in urban Costa Rica.

a. Product technologies

The *type of houses* that is built in the sub-sector consist in the majority of cases of the modern urban single storey houses. The majority of these are carried out with the concrete blocks system and in the prefabricated concrete elements system. Other types are the modern urban two storey houses and the traditional single en two storey houses carried out in Zocalo and Timber systems (14,29%).

From the fifties on until the end of the seventies the *timber* construction system and the so-called *zocalo* were the *construction systems* that were used in majority for the dwellings of the lower income groups. The zocalo substituted rapidly the timber constructions in particular in rainy and humid areas. This type of system was already introduced during the twenties in Costa Rica, in particular in urban areas. The zocalo system initially was composed of the application of brickwork walls up to the ground-floor and a timber structure for the rest of the dwelling. Since the sixties the concrete block masonry has replaced the brickwork more and more.

The construction systems consist of raw materials and building materials that are further processed on site as well as prefab components and building elements. *Prefabricated construction systems* that can be fixed on site with simple tools and without use of large numbers of skilled labor were introduced in the seventies. The application of these systems in the construction of dwellings however did not take place until the early eighties. The first example of prefab constructed dwellings was the construction of one dwelling with the PREFA-PC system and one with a prefab timber structure.

The results of the studies in this research project indicate that 21% of all inputs in the work-sections (foundations, floors, external walls, internal walls, roofs, frames, windows and doors) are *prefab components*. External walls and frames, windows and doors are the building components that have the highest prefab percentage. The rest is processed on site. The individual single-unit-dwelling-construction projects use less prefab materials and components (6%) in the work-sections. This is in line with the fact that most individual single unit construction projects are built with the concrete blocks masonry system. An increase of the utilization of prefabricated components on the construction site requires improved standardization and modular coordination in the country. The bambu construction system has integrated the various components of the building better than the other systems.

The *disadvantage* of the majority of the advanced construction systems in Costa Rica was that these generally also required advanced construction equipment on site. Moreover the price of the finished houses appeared to be too high for the lower income and even for the middle income groups without any form of financing or subsidy. Do-it-yourself-construction to avoid labor costs was hardly possible without any equipment.

A historic overview *of* the development of dwelling *construction systems* applied in Costa Rica in the period of 1900-1950 summarized from Altezer (1986) is given in box 3.1 in the appendix.

When during the1986-1990 administration the government housing policies were focused on a target of the construction of 80,000 dwellings in that period of four years, the construction industry was put heavily under pressure. This was a major reason for the application and development of *alternative construction systems* ranging from the utilization of non-traditional materials Bambu-ME and Bambu-MC[1]. Also production process technologies were developed accordingly ranging from traditional methods on site to the assembling of prefabricated series of light-weight concrete macro-panels, like for instance the new prefab construction systems such as Prefa-PC. During the late eighties a new prefab construction technology was introduced based on bamboo as raw material which was more handy in use for do-it-yourself builders. Despite the fact that rattan - which is similar to bamboo but less strong and more fragile- was already used in the indigenous construction systems, the use of bamboo constructions was never applied before. Only a small percentage is built with this system yet (4%).

An overview of six most prominently utilized construction systems of the existing range of systems for houses with a size between 36 and 60m2[2] that are at present available in Costa

[1] The bambu construction technologies were locally developed in two different variants: wall panels made outof either split bambu battens (Bambu estrillas = Bambu- ME) or cane (Cana brava= Bambu-MC) nailed onto a timber framework

[2] Dwelling construction projects which are financed through the Sistema Financiero Nacional para la Vivienda (SFNV) need to have a size between minimally 36m2 and 60m2 maximally.

Rica is given in appendix III. The evaluations of CONICIT[3] (1989) executed by the Costa Rican Technology Research Institute INII[4] and CIVCO (1993) [5] were used for this overview. The studies focused on the product technological features of the systems such as durability, strengths and stability (against seismic forces), production requirements and costs. The overview includes the concrete blocks masonry system –that still is the most favorite- and other systems like Concrebam, Ricalit, Prefa-PC, Escosa, Multipref. also Fibropanel, Panel-ex, Fibrolit, Zitro, Facoli and the Bambu construction technologies Bambu-MC and Bambu-ME.

In terms of *functionality* the range of construction systems for the houses for the lower income households offers the opportunities to built houses with sufficient room for living and for future expansion. All houses can be provided with *facilities* such as piped water in-house, electricity and sanitation.

The available construction systems with which the houses can be built offer for more than 90% the possibility of realizing a reasonable to good *physique technical quality* of the product. This means that the quality of the construction systems in terms of fire resistance meets the basic requirements. When the construction systems are applied according to the building regulations the security against wind forces is good. The earth-quake resistance is however in 96% of the construction systems questionable. The houses built with these systems possibly may not directly collapse but certainly will be damaged and at least may show cracks. The Bambu construction system performs best on this aspect. The in-door climate of the houses built with the systems needs attention. The heat accumulation of 40% of the investigated projects in which the construction systems were applied gives problems despite ventilation. The problems were in particular caused by the roofing construction without appropriate insulation. Besides the in-door relative humidity appears to be too high in 98% of the cases, causing rot and the occurrence of fungus.

The standardized prefab construction systems offer opportunities to built in mass construction projects which is beneficial to decrease the site production complexity, the construction time and to increase the quality of the output.

The real *costs* of the construction systems are still beyond the level of affordability of the lower income population. In this respect the bambu- construction system offers the best opportunities, while the concrete blocks masonry system is the most expensive one. The lower income population only has access to a decent house thanks to the existence of the housing financing system in the country.(see appendix III)

Overall can be concluded that prefab systems offer best opportunities to meet the demand for dwelling construction in Costa Rica. (Appendix III)

b. Process technologies

The requirements for *tools and equipment* utilization in the application of the before described dwelling construction systems are in principle limited and involve the use of hand tools only. These can be substituted by powered hand tools and simple electrical equipment. This means

[3] CONICIT (Consejo nacional de Investigaciones Cientificas y Tecnologicas) is the National Council for Scientific and Technological research.

[4] INII (Institutode Investigaciones en Ingenieria) the Technology research institute of the University of Costa Rica

[5] CIVCO (Centro de Investigaciones de Vivienda y Construccion) of the Instituto Tecnologico de Costa Rica (ITCR) in Cartago

that the construction systems do not require high capital investments for the construction activities on site. The equipment requirements for the various construction systems are listed in Appendix III.

The concrete mixer has substituted labor in 93% of the cases for the construction of the foundation, for 100% for the construction of the ground-floor and for 73% for the construction of the external walls. It is the most used electrical equipment on the construction site. The percentage of the work on the subsequent work sections which is carried with powered tools at present is 19% for the foundations, 69% for the floors, 20% for the walls, 27% for the internal walls, 34% for the roofing structure, 62% for the windows, doors and frames. The percentage of utilization of powered tools reflects the type of building material or building component used. The more prefabricated components the less powered tools are necessary on site.

This becomes also evident in the requirements for skills and knowledge of the *labor force* on site for houses built with the prefab systems. These are less critical than those for the traditional masonry systems. A project manager or a professional foreman may supervise the job assisted by semi-skilled labor on site or by a experienced tradesman for only specific parts of the construction process. The houses can be built as *self-help* construction project with family helpers as labor force supervised by a project manager or a professional foreman when the prefab systems are applied.

Information and documentation like technical documents such as project specifications projects drawings, construction specifications and procedures, progress control techniques, material and equipment databases is available to a large extent both on paper in documents and in computerized form. Standardized dwelling designs are made available. Material and equipment databases as well as time planning and progress control systems are for more than 50% available in computerized form.

The requirements for the *organizational framework* of the dwelling construction projects carried out with the investigated construction systems are limited, certainly in case of the individually built projects. The large-scale mass construction projects require a more sophisticated level of project management. This is reasonably available in the country. The organizational framework in most mass construction projects is that of the small and medium scale contractors in case of the mass construction projects. These contractors possess advanced management skills and commercial exposure. Their physical facilities are limited compared to those of the large-scale contractors. But the requirements for these are limited for the dwelling construction projects. The small and medium scale contractors are mostly engaged in small and medium sized formal contracts through open tenders based on working drawings, specifications and materials lists. The construction units involved in the construction of the individually built houses belong to the specific tradesman-type or to the emerging small contractor with some managerial abilities and who uses powered equipment on rental basis. The tradesmen are generally only hired for a specific job. The emerging small contractors are involved in the dwelling construction projects on the basis of simple agreements. Their work is –sometimes- carried out with simple working drawings and material lists in case the owners do not purchase the materials themselves.

3.3 The human resources stock[6]

The stock of human resources indicates (a) the quantity of potentially available and (b) the nature of available human resources relevant for the execution of the dwelling construction projects.

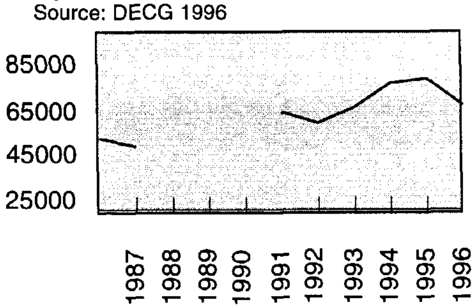
The *population* of Costa Rica is about 3 million (3,464,083 est 1996). The *annual population growth* at a rate of 2,06 % (est. 1996 CIA) per annum is one of the lowest in Central and South America. This growth is not only brought about through natural growth but also by the influx of refugees from neighboring countries, attracted by the relatively stable and favorable socio-economic conditions in Costa Rica. The net migration rate is 0.92 migrant(s)/1,000 population (1996 est.) It is estimated that some 300.000-600.000 refugees -20% of the Costa Rican population- are living in more or less permanent settlements in Costa Rica. Many of these find employment in temporary jobs and in the sectors with low entry barriers like the construction industry. With regard to the *geographic dispersion* can be seen that most of the people live in the Central Valley (63%) where most of the economic activities take place.

The Costa Rican population still is *relatively young*, although the percentage of young people has decreased since 1960. Some 37% of the population belongs to the group of people younger than 15 years (est 1994, INCENEM), in 1960 this was 48%. This means on the one hand a burden for the socio-economic position of a large part of the Costa Rican households. Moreover the country has to deal with a pressure on social services like the education system in the country. On the other hand the current percentage of population below 15 years of age offers an opportunity of valuable human resources to meet the future demand in the production sectors of the country provided that the education system should be appropriate.

The population is highly literate. The *literacy rate* of people of 15 years and over who can read and write is 94.8%. (1995 est.)

Approximately 53.1% of the Costa Rican population older than 12 years is formally *economically active* (1995 est.). A large percentage of the Costa Rican labor force is working in the Public sector (23%), some 20% in the agricultural sector, 18% in trade and 17% in industry (1994). The *unemployment rate* in 1993 was 4.1% of the total population. (INECEM 1995).

Fig 3.1 Labor force in the construction industry
Source: DECG 1996



The average percentage of people officially employed in the construction industry was between 1990 and 1995 *6.5% of the total economic active population*. (DGEC 1996).

The development of the *employment in the construction sector* showed a slow upward trend during the past years. This corresponds with the fact that the performance of the Costarican construction sector is sensible to dynamics in the total economy. It contributes a rather stable percentage of about 3% to the Gross National Product (GNP). Another conclusion that may be drawn is that there is no, or almost no, substitution of labor

[6] The data for this component of the technological capabilities are derived from the Statistical Abstracts of several years, by the DGEC in Costa Rica and by UNESCO (1995) and WB (1995) statistics.

for capital, which is a trend that normally can be noticed in countries with a growing industry. This could be attributed to the fact that labor in Costa Rica still is relatively cheap and abundant compared to the import of capital goods. Capital intensification can only be noticed in the construction projects for more complex buildings to be built in a relatively short period of time. The growing foreign investments in Costa Rica since the liberalization of the economy may increase the time-costs consciousness in the construction industry that is actually lacking[7]. This may imply capital intensification.

The *occupational status* of most labor force (85%) in the construction industry is that of a craftsman or technician. On average 7% of the labor force in the construction industry was employed as professional or project manager since the last decade (DGEC 1994). (Appendix III-3)

With regard to the available *R&D staff in the country* no comprehensive data were readily available. An overview of the available R&D statistics in Costa Rica, Tanzania and the Netherlands is given in the appendix. The R&D institutes are in majority 100% staffed by Costa Rican nationals. The R&D activities are predominantly carried out by government institutes under the National Council for Scientific and Technological research. (CONOCIT).

At present the Costarican construction industry has to deal with a *lack of qualified labor force* in the sub-sector of dwelling construction. An important reason for this situation is the image of the work in building construction. This is induced by the relatively low salaries and the fact that most laborers come from the lower income groups. Furthermore the construction activities are always carried out in open air under less favorable (some times even dangerous) conditions compared to other jobs. These aspects do not motivate people to put their efforts in gaining high quality skills in building construction. The people who are interested in a job in building construction either are not sufficiently conditioned for it or have no financial means to replenish any deficiencies. A continuing situation like this may imply the complete disappearance of qualified personnel, which is a problem all over the Latin American continent.

The *human resource development* in the Costarican construction industry is characterized by the quite sharp division between the higher and lower echelons. On the higher level, engineering and managerial levels, education is quite well organized and fits more or less the demands of the sector. On the lower level formal education is scarce and typically takes place by informal on-the-job training. No education program is seemingly dedicated to fill the apparent gap between the lower and higher level. Middle management and engineering jobs are carried out by relatively over-qualified personal or by people with no or very little formal education who managed to work their way up to a middle management position.

At present three higher education programs related to building exist in Costa Rica. These are the architecture program (licenciatura en arquitectura), the civil engineering course (escuela de ingeniería civil) of the University of Costa Rica (UCR) and the building engineering course of the Costarican Technological Institute (ITCR). A graduation in these studies leads to the registration of the graduates in the 'Colegio Federado de Ingenieros y Arquitectos' (CFIA). Over the past years the registration of architects in the registers of the CFIA has shown a steady increase. At present a total of 977 architects are registered, of which a total number of 790 (∀ 80%) are registered as being active. The registration in the registers of CFIA is a legal requirement for executing the profession of architect or civil and building engineer in Costa Rica. This may indicate that these data represent quite accurately the actual number of such professionals working in the construction sector. (appendix III)

[7] Interview with Roderigo Altmann E. RAE Ingenieros S.A. and Cámara Costarricense de Construcción (CCC).

The registration of graduated civil engineers has shown a decline or stabilization over the past ten years. A total of 2187 civil engineers is member of the CFIA of which at present a number of 1741 (81%) has paid contribution which indicates that they are actively performing their profession.(Appendix III)

At present a total number of 278 building engineers are registered at the CFIA of which 213 (77%) are registered as being active. The patterns of registration over the past ten years are shown in figure 3.3 appendix III.

The *human resource development for the labor force* in the construction industry takes place on a rather informal way. Typically at the age of 15, workers enter the construction sector (mostly housing) as 'peones' or 'ayudantes' and start learning on the job. The obvious advantage of this informal education system is that no resources are directly spent on education for these workers. Disadvantages however are the loss of potential quality and repercussions in terms of efficiency. Formal education efforts are sporadic and therefore difficult to evaluate. Most employers are reluctant to invest in formal education of their workers out of fear of losing their personnel to bigger construction firms or other sectors. The reason for this is among others that working in the construction sector is experienced as heavy and underpaid [8 9].

Formal training courses in the construction sector are offered by the 'Instituto Nacional de Aprendizaje' (INA). The number of graduates in construction related INA courses over the period 1982-1996 is increasing. (see Appendix III) An evaluation of those courses by INA showed that 25% of the course participants already worked in the construction industry before following the course, directly after the course 75% of the course participants was working in the construction industry. After four years 63% of the graduates still was working in construction related activities. On the other hand it became clear that the courses have to deal with a number of problems. In the first place was mentioned that the nocturne courses are more demanding. The drop-out rate of students of the nocturnal courses is considerably higher than of those given during day-time. The drop out rate of the INA building courses is approximately 20%[10]. Another aspect is that the motivation from the part of the workers themselves is low, although normally the employer puts in 2 hours and the employee also. That makes that the INA courses are held from 15.00 to 19.00. After a working day this still appears too much (R. Murrillo) [11].

In the dwelling construction sector - the dominant segment that is responsible for three quarters of the output of the construction sector in terms of square-meters (CCC 1997)- the need for formal education is felt less than in the segment of utilities construction. This is due to the fact that the technologies -and implicit labor requirements- in the dwelling construction segment are rather straightforward and less complex than the requirements in the utilities sector. The larger building contractors who have jobs in the utilities segment (approximately 5 companies) may be described as quite modern and offer their own workers-training projects. The payments in this segment are of such nature that the trained workers do not leak away to other employment opportunities.

---

[8] Interview with Fidrita Dunía and Luiz Ramírez, Ministerio de Planificación (MIDEPLAN).

[9] Interview with Randall Murrillo A. Public Relations and service to the affiliated dept. of Cámara Costarricense de la Construcción (CCC).

[10] INA en cifras 1996, 1995, 1991, 1986. Sector industria número de alumnos matriculados y aprobados.

[11] Interview with Randall Murrillo A. Public Relations and service to the affiliated dept. of Cámara Costarricense de la Construcción (CCC).

In the dwelling construction segment the contractors often work with temporary hired labor force. They work with lower profit margins in particular in the lower income housing sector and have a fear for a drain of newly trained workers to the utilities segment or even to different jobs in another sector[12]. These factors may explain the reluctance and to some extent inability from the part of the middle and smaller contractors side to invest in training for their labor force. Apparently the employers benefits to gain from a training of the workers do not justify a substantial wage increase. From a quantitative-financial point of view of the contractors engaged in dwelling construction for the lower income households one could doubt the usefulness of workers training programs offered by them in the dwelling construction segment.

The contractors in the dwelling construction branch have become aware of the labor problems. It was put forward that the major cause for it is that the industry itself has been too late in taking actions. The branch organization -the Camara Costarricense de la Construccion- has acknowledged its role in education and has made although limited, some financial and human resources available for the development of training programs. (Penaranda,F. CCC, in Civco TemaIV, 1992). Although the existing education programs are considered to be in fact complete enough and of relatively good level, they do not meet the requirements for the labor force which are really needed on the construction site. The idea is that additional programs should be developed. These should be more adequate, practically oriented and should directly follow the technology developments that have taken place in the construction industry since the last decade.

The general *policies and strategies* on human resource development for the construction sector proposed by the Ministry for Public Education, Directorate General for Technical Education indicate that the existing problems and constraints in the field of technology education in Costa Rica is no priority area for the national government. This still is the matter despite the fact that the employers in the construction industry have put forward their complaints on the unsatisfactory level of knowledge and skills of the graduates of the educational institutes that educate the technologists. A major reason for this is the lack of financial means for any improvement of the education system. The graduated technologists and technicians know on their turn that they are only skilled at medium level when entering the labor market. The problem is not only a problem of the course curricula but also one of financing of the programs, the necessary equipment, the quantity and quality of teaching staff and the technology infrastructure. (Civco 2 TEMA IV,1992)

A solution favored by the ministry is the improvement of possibilities for "training on the job". Subjects including sciences, communication, entrepreneurship and management, budget planning and control as well as all relevant technical subjects should be integrated in the training in real practice. The technology infrastructure between educational institutes and enterprises should be enforced to reach this. The education then should take place -all at different levels of education - at various places in the construction industry, like in the materials laboratories, the building construction projects, the construction of civil works, in urban development projects.

Through this strategy for human resources building for the construction industry it is expected that education programs could be provided that comply with the aspects of actuality, technological advancement and the demand for it in the market.

12 Interview Thielemans/TUE with Randall Murrillo A. Public Relations and service to the affiliated dept. of Cámara Costarricense de la Construcción (CCC).

3.4. The natural resources stock

The stock of natural resources relevant for the sector is supposed to indicate the (a) availability of exploited natural resources relevant for and applicable in the production processes in the sector, (b) the capabilities to exploit these natural resources judiciously. For the purpose of this thesis just a simplified overview is given rather than a comprehensive and thoroughly investigated documentation of the actual status. A comprehensive documentation of the status of natural resources requires in-depth studies. Secondary sources like literature complemented with personal interviews with a number of local experts were used in this research. An overview of the state of art of the major natural resources in Costa Rica compared to Tanzania and other countries is given in appendix III.

In principle all building materials are available in Costa Rica. The stock of natural resources in Costa Rica in contrary is limited. The Costa Rican *land* area is small (5.1 million hectares). *Water* is in abundance available allowing the production of hydro-power, which is limited due to frequent earthquakes in the country. (see Part III chapter 7) A concentrated extraction of its *metallic mineral resources* (copper, zinc, lead, mangan, sulfur) is not feasible so far. Only the exploitation of bauxit facilitates the establishment of the aluminium industry.

The available *non-metallic mineral resources* especially relevant for the construction industry, include silicates (sand, clay, gypsum, limestone, pozzuolanic materials, vermiculites and stones like marbles, basalts, granites etc.). Especially lime is of high importance for the cement production in Costa Rica.

The *forests and woodlands* form a major natural resource in Costa Rica. These constitute at present 34% of the total land area. The percentage has decreased dramatically during the past decades. The majority of wood has been used as fuel wood (80%). In the eighties the Government declared an emergency situation concerning the deforestation in the country. This resulted in the establishment of some 28.427 ha new plantations between 1986 and 1989. (Ministerio de Recursos Naturales, Energia y Minas. 1990) The deforestation was largely a result of the clearing of land for cattle ranching, soil erosion, natural hazards such as occasional earthquakes, hurricanes along the Atlantic coast; frequent flooding of lowlands at the onset of the rainy season and active volcanoes.

Enhanced by a consciousness of the limitations of the natural resources stock and the environmental issues of deforestation the cultivation of bamboo has been introduced. The objective was to achieve an integrated solution to a number of problems including the deforestation, environmental degradation as well as socio-economic problems like unemployment and the housing deficit.

A program for the cultivation and propagation of 500 ha of *bamboo* Guadua (Guadua Angustifolia) was established, that provides the necessary material for some planned 7500 houses per year. The plantations were proposed to be located on strategic sites of the country with the necessary agro-ecological conditions to supply the required material for different construction sites. Until that time the bambu Guadua was only growing in very limited quantities. The specimen is preferred because of its strength, thickness (18cm), length, straightness. Other bamboo (Vulgaris) was already available in the country.

In conclusion can be said that the limited stock of natural resources forms -next to the limited financial resources and a relatively small local market in the country- a major constraint for the construction industry in Costa Rica. The building material predominantly used in dwelling construction at present is the concrete (92,7% of all walls 1995 est DGEC) Also for the majority of floors concrete is used (63,6%). The cement is produced locally. A major part of the raw materials and many metal products -like the reinforcement steel and metal roofing sheets- are basically imported, while for roofing the metal roofing sheets are being used in 99% of the cases.

3.5 The sectoral technology infrastructure

The results of the investigations on the major actors of the technology infrastructure for the sub-sector of dwelling construction for the lower income households in urban Costa Rica is summarized in appendix III. The data were derived from literature studies and personal interviews with professionals. The following conclusions can be made.

The ***network of actors*** in the Costa Rican construction industry shows similar characteristics to those in other countries. A diversity of professional and specialized trades in the construction process is involved, ranging from the programming, planning, financing and design and engineering to tendering, contracting and the final realization of the building.

The *Costa Rican technology infrastructure* for the sub-sector of dwelling construction for the lower income households has quite an impact on dwelling construction processes in general. The existence of bottlenecks of the technology infrastructure has implications for performance level of in the execution of the construction projects reflected in the fact that the sub-sector of dwelling construction for the lower income households does not yet meet the actual demand for decent housing. Through the CCC a reasonable communication and *relationship* between the actors in the construction industry is realized. But the performance of the various actors in the network themselves still is not optimal. This is influenced by the factors of the national technology setting such as the economic situation and the policy structure and regulative and legal framework in which the construction industry has to operate.

3.6. Conclusions

The range of product and process technologies in the sub-sector of dwelling construction for the lower income households in urban Costa Rica reflects an increased level of technological capabilities.

The construction systems with their particular *product technological features* belong to the class of conventional and alternative technologies. The locally developed prefab construction systems offer reasonable opportunities to improve the current performance of the dwelling construction industry.

The *process technology* requirements for the concrete blocks masonry system are in terms of labor input, information and project organization considerable. Moreover the costs of the building materials for this system are high compared to the prefab systems.

The requirements for equipment, labor force, information and organization on site are limited for the prefab systems, which reduces the cost barriers for the lower income households. At the same time the projects can be executed by the small and medium scale construction units which do not need large capital investments and benefit from the project execution by gaining experience and (although modest) profit. Also lower skilled laborers get the opportunity to enter the labor market and generate skills, experience through learning- by- doing and income.

The *human resources* profile in the sub-sector shows that a large part of the labor force is employed in the construction industry as technicians or craftsmen.(85%)

The sector still is relatively labor-intensive. The need for skilled and unskilled laborers, as well as highly qualified tradesmen still is considerable.

The human resources development through training for the labor force on site is not adequate. The higher education for the manpower in the construction industry is reasonably good. The number of graduates in architecture, civil- and building engineering is increasing. This stock is beneficial for research and technology development, consultant and management activities in the construction industry.

The lack of skills and knowledge among the labor force on site experienced by the contractors on the contrary shows the low entrance barrier in the sector. It also shows that the performance in the sector highly depends on the country's educational system. Only in case of an appropriate education system the local construction capacity can improve quantitatively, but, more important, also qualitatively.

The Costa Rican *population is relatively young*. The current percentage of population below 15 years of age (37%) offers an opportunity for the development of valuable human resources for the construction industry provided that the education system is appropriate to meet the future demand in the production sectors of the country.

The relatively high level of education, indicated by the literacy rate and enrollment in secondary and tertiary education as well as the relatively promising numbers of graduated architects and engineers provides an opportunity for further technology development.

It can be expected that the R&D Human resources could form an enhancing factor for the improvement of the construction performance in the country, provided that this potential is fully exploited, financing is available and the technology infrastructure is adequate to diffuse developments in this sector.

Costa Rica has a rather limited potential to provide for the necessary *natural resources* which are required by the construction industry given the high import content in the majority of building materials.

The *land area* in Costa Rica is rather small and at the same time only a small part - the Central Valley- really is in use by its population.

In the exploitation of the *natural resources* like for instance the forestry resources Costa Rica has been aware of the fast deterioration of its environment. Efforts that were focused on the alleviation of the problems in an integrated manner lead to the establishment of cultivation of bamboo.

The *technology infrastructure* of the dwelling construction sector is reasonable. The functioning of the actors in the network itself however as well as a weak relationship between them forms a constraint that has an impact on the technological construction performance in the dwelling construction projects for the lower income households. Also factors of the national technology setting enhance these constraints.

The final conclusions are that the technology stock shows a progress in development of improved construction systems that can be used to improve the performance of the construction industry. These improvements could be brought about thanks to the stock of highly educated R&D manpower.

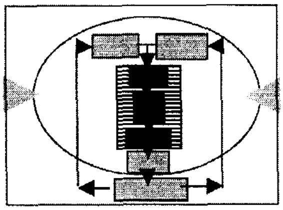
However the application and further development of the technology stock is hampered by deficiencies regarding the labor force on the construction sites. Also the stock of natural resources that can be used for building construction is limited. On the other hand this forms a challenge for further R&D on the efficiency of the utilization of these in building construction. This requires on its turn effective and efficient action from the organizations in the technological infrastructure of the construction industry, which is unfortunately not always the case. A number of actors have to face internal deficiencies. Many of these are due to financial constraints. The interaction between the organizations is stimulated by a well organized branch organization the Camara Costaricense de Construccion (CCC).

The theories followed in this research project suggest an impact of the present status of the technological capabilities on the status of technologies in the construction projects and the performance of the total construction industry. The results of the Technology Mapping studies on these aspects are described in the following chapters.

Chapter 4

The technology status in dwelling construction projects in Urban Areas in Costa Rica

Part III



4.1 Introduction

The technology mapping studies that are described in this chapter addressed the question regarding the technology status in the dwelling construction projects for and by lower income households in the urban areas in Costa Rica setting. The field studies took place in the period from 1992-1997. The set-up of these studies will be described first.

The research units in this part of the studies were the dwelling construction projects in the urban areas in Costa Rica. The population of the studies included the dwelling construction projects in the urban areas in Costa Rica executed for (and by) the lower income households within the time span of 1989 up to 1997.

The prerequisites that were taken into account for the selection of the projects to be investigated were the following. The selected projects should have had similar features with regard to: (a) the target group of the dwelling construction project which should be the lower income household, (b) the major basic features of the dwelling , (c) the sites which should be known as common residential districts.

"Housing" units established in the so-called squatter areas were excluded, despite the fact that they provide shelter for the poorest section of the households in Costa Rica. The reason is that the traditional view was followed of classifying these constructions as sub-standard and in-habitable. They do not comply with any form of basic specification for an adequate dwelling in the country and they are generally not built on a site known as a common residential area.

The construction projects finally selected were either the construction of an individual building or the construction of a complex of houses at one site by one project executing agency.

It was again rather difficult to identify the entire population of dwelling construction projects . The governmental organization -where all (formal) building licenses have to be obtained- has no database in which both the kind of project and the executors (contractor) of the project are indicated. The Housing Mortgage Bank (BANHVI) -the coordinating entity of the National

Financing System for Housing (SFNV)- has a database on the issue of financial means for housing projects. This database has been the starting point to obtain a list of dwelling construction projects for the lower-income households. The list included a total number of 33 approved applications for the issue of finances for housing. Six were left out since they only involved a subsidy for the acquisition of a plot (thus not for the construction of a house). After a consultation of experts of different institutes and organizations like the Instituto Technologico de Costa Rica (ITCR) and the Ministry of Housing (MIVAH) those projects that did not not qualify as low-income housing projects were also excluded from the sample. Through visits and phone-calls to the authorized entities of the SNFV the building contractors and/or project managers of the listed dwelling construction projects were traced. This resulted in a population of 20 building contractors and project managers of the mass construction projects. Some of them were not willing to co-operate in the studies. The sample finally included 17 *mass construction* projects of a number of houses at a time at the same construction site and 19 individually built houses co-financed through involvement of MUCAP. (Appendix III)

The product technological features of the houses built in the 36 projects were investigated. Fifteen questionnaires were answered by the project managers or contractors who were really involved in the mass construction projects and two questionnaires were answered by key-persons with many years of experience in low-income housing projects. For the individual projects house owners who acted as project managers were willing to co-operate in the research and allowed structured interviews by using the same questionnaires.

The same methods for data collection were in principle applied during this part of the research like was done in Tanzania. These included literature studies, structured interviews with project key-persons involved in the construction process, unstructured interviews and expert opinions upon the validity of the found data, non-participant observations during site visits. The choice was made to pay personal visits to the contractors and project managers rather than to use telephone or mail in order to avoid a too low response on mailed questionnaires and a reluctance to answer questions to an unknown person by telephone. Besides personal interviews gave the opportunity to ask additional questions and to control the answers. Indistinct questions could be explained extra, although the time consumption of this type of data collection was rather extensive. Unstructured interviews and site observations are mainly used as secondary methods of data-collection as well as to cross check the collected data and to obtain additional information. Visits were made to low-income housing projects in progress and to finished projects. These gave a clear impression of the Costa Rican situation. The data of the own field studies in the urban areas in the Central Region in Costa Rica were compared with the data collected from several publications. Data analyses and interpretation took place as described before.

4.2 Project setting

The characteristics of the project setting of the 36 investigated dwelling construction projects for lower income households in the urban areas in Costa Rica are given first, before the findings on the technology status in these projects are described.

The majority of the lower income housing projects that have been investigated are located in the Urban Areas of the Central Valley in Costa Rica. In this region 80% of all dwelling construction projects in Costa Rica are executed. The Central Region has a moderate *climate* with temperatures which vary with the difference in altitude. A number of construction projects had to deal with delays due to heavy rains during the rainy season. Vegetation and the presence of trees on the plot had a positive influence on the temperature in the houses.

Costa Rica suffers from *natural disasters* that tend to influence its economic activities. This was for instance the case in 1988 when economic growth suddenly decreased due to the hurricane Juan which passed by the country. For the construction projects especially in open areas one generally has to count with strengths of the construction systems resistant to wind speeds of 120km/h, which corresponds with a basic wind pressure of 720N/m2. The specific norms are formulated and recommended by the Colegio Federado de Ingenieros y Arquitectos de Costa Rica (CFIA). During the project execution of the projects that were investigated in this research no problems were caused by heavy wind speeds.

Earthquakes and volcanic outbursts affect the country frequently. This gave rise to the establishment by law of particular building regulations to avoid disasters by earthquakes by building constructions not resistant to the seismic forces. (Codigo Sismico de Costa Rica 1986) The aspects that have to be taken into account in the projects refer to the construction details of the foundation, the application of reinforcement in foundations and wall structures and the construction of conduits for water, drainage, electricity and sanitary installations.

The *landform* in the Central Region is that of a mountainous area with various differences in altitude. This implied extra work on site preparations in 40% of the projects to create a terraced construction site. The difference in altitude also has an impact on the natural ventilation, shading of the building and accessibility of the site.

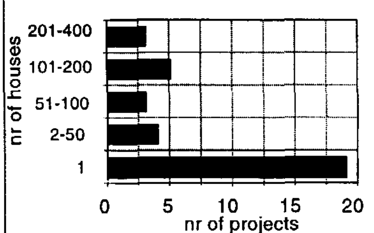
The *soil* usually contains a mixture of clay, sand and (volcanic) rocks. Clay is the most common element in the soil of the investigated projects (80%). The clay is rather soft and sticky during the rainy season, while during the dry season its dries out very quickly and cracks. According to the moisture content it may swell and shrink considerably. On the investigated sites the types of soil permitted to build on strip foundations or on dies, which are considered sufficient for the simple (lightweight) low-rise (single storey) family houses.

The *physical infrastructure* on the project sites showed the following characteristics.

The accessibility of the sites is reasonable. In most of the mass production housing projects the sites are prepared first and roads are constructed. In some 40% of the projects the last 100-500m to the actual building site are not paved. The last 100-500m of the access roads to all individual single unit construction projects were unpaved.

Water and electricity supply is practically no problem in Costa Rica. All the projects were provided with both during construction. Telephone connections were in 50% of the mass construction projects available on site, portable phones not included. No exact data are available concerning the telephone connection available at the individual projects. Portable phone sets are becoming more common on the construction sites.

fig 4.1 nr of houses /project



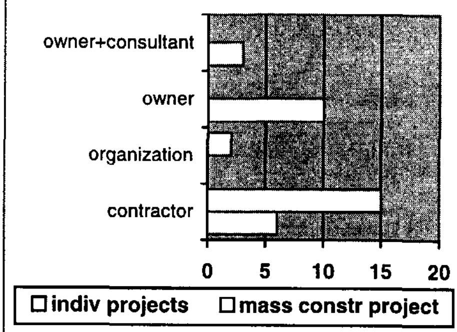
Some 60% of the total construction site is used for plots, 40% is used for roads, parks, childrens playground, commercial activities, etc. The average ratio plot size-total size of the construction site is 49.5% with a range between 16% and 74%. The average ratio dwelling size-plot size is 29%, with a range between 15% and 42%.This is in line with the regulations.

With regard to the legislation can be said that the investigated construction projects are all executed on legal sites. All investigated dwelling construction projects were built with a building permit.

The *finances for the projects* were provided by different sources. The mass construction projects were (co-)financed through the national housing financing system. The individually constructed houses are co-financed through MUCAP.

The *size of the projects* differed (a distinction was made between projects which were executed as mass production dwelling construction projects and those which were executed as individual construction project for one single dwelling). The number of houses per mass production project ranges from projects with 37 up to a project with 322 houses: 148 houses is the average number per project in the mass production type of projects.

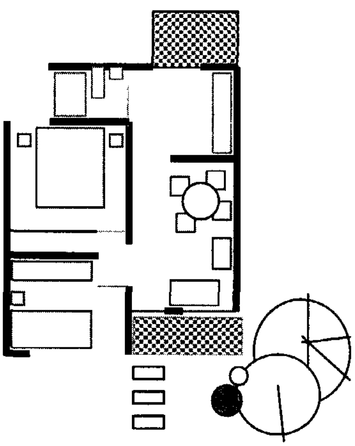
fig 4.2 Project management



The *project management* in the projects with mass production of houses is in the hands of the project manager of the construction company. The project management in the construction projects of the individual houses is in the majority of the cases (79%) in the hands of the owner of the house, who collaborates with a general foreman or contractor during the construction of the house. (see table in Appendix III)

The type of contract is in 26% of the projects of individually built houses agreed for parts of the construction activities like a foreman contract agreement, a contract for labor, for certain construction phases like the foundations or main structure. Most of the contracts for the individual houses (47%) are agreed upon the time spent on the execution of a certain job. In 18% of the cases a contract is agreed for the total project based upon the time spent for the construction activities. In only 5% of the cases a contract is signed for the total project execution in the Prefa construction system. The materials are purchased by the house owner in the majority of cases. Other individual builders leave the selection and purchase of the materials to the contractor, the general foreman or the engineering consultant who is engaged in the project. The majority of projects had to deal with both the dry and rain season during the construction. Bad weather due to heavy rainfall is mentioned as one of the main causes for time deviation during construction.

Fig 4.3 Basic lay-out of single storey family house 42 m2

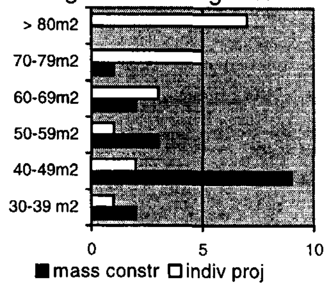


4.3 Product technological features of the Construction Output

The product technological characteristics of the construction output are benchmarked against the requirements for lower income houses as described in the building regulations (appendix III). The results are given below.

The type of the houses is for all investigated projects a simple single storey one-family houses. The type of houses which is generally built in Costa Rica is the modern urban single storey house carried out in the concrete blocks system and in the prefabricated concrete elements system. Another type is the modern urban two storey house. This house has a rectangular shape with a hip and gable roof.

fig 4.4 dwelling size

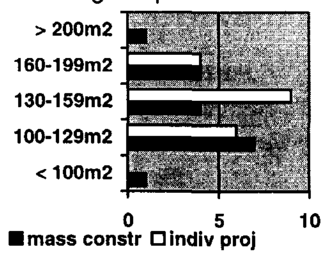


The average size of the houses in the investigated mass construction projects is 44.8 m5, with a range from 36 up till 70 m5.

The houses in the housing programs, that are promoted and supported by the Ministry of Housing and Human Settlements (Ministerio de Vivienda y Asentamientos Humanos MIVAH), have a size of 60 m5 for the largest and 36 m5 the smallest type.(Landaeta, 1994). The houses that are built in individual single unit projects appear to have a larger size. Some of the houses are even larger than 80 square meters.

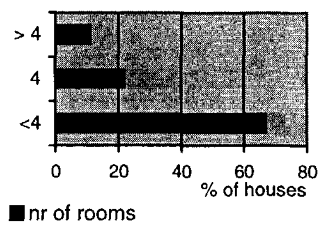
The majority of the plots is between 100m2 and 130m2 of size *(41%)* in the mass construction projects. Some 6% of the plots is larger than 200 m2 and also 6% is smaller than 100 m2. The size of the plots in the individual single unit projects is generally larger.
In general the houses meet the basic requirements with regard to their size and dimensions as formulated in Costa Rica for family houses (reference is made to the Costa Rican Building Regulations). One single household occupies the house.

fig 4.5 plot size



The functionality of the houses in terms of available floor space per person, the kind and availability of facilities is the following. The floor space per person averages 11.5m2 (for a household of on average 4.2 persons). This is more than the recommended international standard that suggests an occupancy of 2 people per room of 10 square meters (UNHABITAT). The houses are not used for other purposes than housing for the family. The possibility of multiple use of the house is limited. The houses do not offer room for multiple use like for example utilization of the house for commercial purposes such as a business, workshop or shop next to space for living.

fig 4.6 nr of rooms



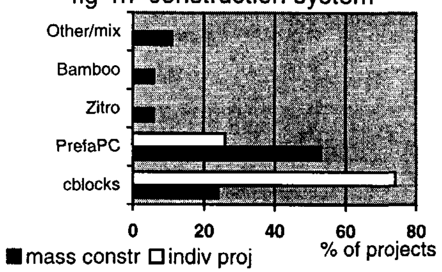
The majority of the houses in the investigated projects has 3 rooms excluding the kitchen and bathroom. (67%); 11% has more than 4 rooms. These concern specifically the individually built single housing units. The rest of the houses (22%) has four rooms, which generally includes one living room, a master bedroom and two additional bedrooms.

The situation with regard to the facilities is fairly well. Cooking and bathing facilities are all available inside the houses. Most houses are provided with flush toilets. All houses have access to piped water in-house and electricity on legal basis. The accessibility of the plots is fairly well, at least by means of a laterite (unpaved) road (39%) and 35% of the plots is even accessible by an asphalt road in reasonable condition.

The construction systems mostly applied in the mass construction projects of dwelling for the lower income households are the sistema PREFA PC, ZITRO or concrete blocks. More than 70% of the projects use a prefabricated building system. 53% of the projects use sistema PREFA PC (horizontal concrete panels), 6% the Zitro (vertical concrete panels) system. 24% of the investigated projects are built with concrete blocks. The recently developed bamboo prefab construction system has captured a small percentage of the dwelling construction market as well. (6% in these technology mapping studies but in reality). Other projects are built with a mixture of different kinds of building systems. (11% of the projects).

The individually built houses are in majority built with the concrete block masonry system (74%). The concrete blocks construction system still is most favorite among the Costa Rican population. The general reluctance to accept new construction technologies might be shown through this phenomenon. The major reason for sticking to the conventional construction systems is that the houses built for the middle-class and upper class are mostly built with concrete blocks. These houses are used as example by the people that belong to the low-income group, since they want their house to be, as much as possible, similar to the houses of the middle-class and upper-class.

fig 4.7 construction system



Foundations are in majority carried out as re-enforced concrete strip foundations (56%) according to the construction system that is applied for the main structure of the house.

The roofing structure in all cases consisted of timber rafters and purlins or trusses system covered in 100% of the cases with corrugated iron roofing sheets. In 16% of the cases the houses have no ceilings. The casements for windows and doors are all carried out in timber and in 91% of the cases produced on site. The houses have windows with wire blinds in 39% of the cases, in 50% of the cases venetian blinds (shutters) and in 11% no glazing. All houses have non-earth floors finished with a concrete screed.

The physique technical quality of the houses is reasonable. According to the building regulations the security against wind forces is in 98% of the cases reasonable. The resistance against earth quakes is in 96% of the cases reasonable. This means that the houses may not directly collapse but certainly will be damaged and at least may show cracks. The houses built with the bamboo construction system have the best earthquake resistance, given the experience during the severe earthquakes in 1993. The ventilation in the houses is good. The relative humidity in the houses is too high in 98% of the cases, which may cause rot and the occurrence of fungus. Despite the ventilation the heat accumulation in particular caused by the roofing construction of corrugated iron roofing sheets, without provisions for a ceiling or enough ventilation to prevent overheating of the house- is in 40% of the cases bad, in 30% reasonable and in 30% heat-accumulation gives no problems. The resistance against rainwater is in 71% of the houses reasonable. The quality of the houses in terms of fire resistance meets the basic requirements in terms of the walls that are made of non-combustible materials. The above means that the houses for more than 90% are in reasonable to good physique technical status. Only the in-door climate of the houses needs more attention.

Regarding the production complexity the following can be concluded. The fact that the houses are in majority built in mass construction projects with the application of prefab construction systems is beneficial to the time needed to built the houses. The construction output ranges from 1 to even 33 houses per month. The Prefa PC system in these mapping studies scores as the fastest construction system. The construction of the individually built houses takes at least one month in case the prefab construction system is applied. On average the construction of a single dwelling takes 3 months by application of the concrete blocks masonry system.

Despite the opportunities to decrease the construction time of the houses -by application of the prefab construction systems- the quantity of output related to the actually needed numbers and type of residential buildings for the lower income households is still too low. Only 16-18% of the actually needed housing units are built per year (1992-1994).

The dwelling construction projects deal with a lag in the scheduled delivery time which was in these mapping studies 17% - 89% more than planned, although one project mentions 25% less construction time than planned.

In more than 60% of the investigated projects bad weather was mentioned as one of the reasons for a delay in the construction process. In 13 projects, 3 times additional work, lack of materials and a lack of funds were mentioned as a reason for the lag in the construction process. Lack of laborers and problems with services were mentioned as a reason twice. (Data collection P. Schreurs/EUT 1997)

The production output of the majority of mass construction projects can be classified as mass production of small batches of simple units with advanced construction systems, composed of similar elements assembled on site (prefabricated concrete panels and bamboo panels systems). A noticeable percentage is still constructed as mass product in small batches of similar simple units by application of conventional construction systems composed of many different products, components and elements. (Concrete block system).

The production output of the majority of individually built houses still belong to the projects in which the houses are simple units built to customers orders with conventional construction systems composed of many different products, components and elements (Concrete block system).

4.4 Material Inputs

The material inputs in the construction processes include raw materials and building materials which are further processed on site as well as prefab components and building elements which can be fixed on site with simple tools and without use of large numbers of skilled labor. Of all investigated houses built in the mass construction projects one could conclude that 21% of all inputs in the work sections (foundations, floors, external walls, internal walls, roofs , frames, windows and doors) exists of prefab components. External walls and frames, windows and doors are the building components which have the highest prefab percentage. The individual single unit dwelling construction projects include less prefab materials and components.

Only 6% of all components in the work sections is prefabricated. The rest is processed on site. This is in line with the figures presented in literature and the fact that most individual single unit construction projects are built with the concrete blocks masonry system. (see appendix III)

Problems with the supply and quality of raw materials influence the construction time of the houses. In 40% of the projects problems related to the quality or supply of timber were mentioned. Especially during the production of the timber structures (internal walls and roofs) on site problems are experienced. Irregular quality and dimensions of the delivered timber are examples that are often mentioned.

The bamboo project is the only one that supplies the majority of materials (raw materials and building materials) produced in own production. The bamboo plantations and the bamboo prefab construction panels production plant are all managed by the same organization. The total vertical production column thus is in one hand. This possibly prevents the material problems.

The supply and quality of prefabricated materials is mentioned to be a real matter of trouble during the construction processes. In 53% of the projects supply or quality problems were mentioned with regard to prefab concrete wall elements. Building contractors depend on one supplier of a certain type of prefab construction system. This causes the majority of supply problems. Bad quality of materials in combination with transportation (along the bad infrastructure) cause damaged or useless materials for construction once arrived at the site.

The import content of the inputs is rather high. Costa Rica has its own cement, metal and plastic products industries but these use a high percentage of imported inputs. At least 5% of the primary materials is imported for the prefab concrete systems. (Prefa PC 1996)

The material costs take on average 70% of the total costs of the building construction. The costs of the building materials have increased under influence of the economic situation in the country.

The increase of the materials costs is slightly more than the inflation. Moreover due to the high import content the costs are highly influenced by international economic dynamics.

4.5 Process technology

The attributes of the components of the process technologies in use at the dwelling construction sites are described in this section. Attention is given to (a) the equipment and tools (Technoware), (b) the manpower (Human ware), (c) the information and documentation (Infoware), (d) the organizational framework (Orgaware).

The *technoware* component of the dwelling construction projects consists of simple electrical equipment, powered hand tools and simple hand tools. Almost 75% of the tools is non-electric and the rest are powered tools or machines (electric equipment). The use of powered tools and machines is seemingly not a matter of the size of the company or the size of the project. In Prefa PC projects on average the largest number of respectively electric and non-electric equipment is used. 29% less non-electrical equipment and 45% less electrical equipment is used to built houses of Bamboo, Concrete blocks and Zitro compared to the Prefa PC systems. The lowest number of equipment is used in the (Fuprovi) self help building project, although the construction time of the Prefa, Zitro and Concrete houses built in this project is reasonable. This indicates that for those construction systems actually no special equipment is required.

In the mass construction projects the concrete mixer is the most used electrical equipment for the construction of the foundation (93%), the ground floor (100%), the external walls (73%). Other electrically powered tools that are used are the electrical saw (in 53% of the houses), the electrical drill (43%), the sanding machine during the construction of frames, windows and doors (73%), the soil compacting machine (50%) and concrete vibrating needle (34%)

during the construction of the foundations and floorbeds. Some 15% of all electrical equipment is rented. The rest is either owned by the contractor (77%) or the employees. The percentage of the work on the subsequent work sections which is carried with powered tools is 19% for the foundations, 69% for the floors, 20% for the walls, 27% for the internal walls, 34% for the roofing structure, 62% for the windows, doors and frames.

The set of tools and equipment used in the individually built houses is similar to those used in the mass construction projects. The percentage of utilization of powered tools reflects the type of construction system that is used. The more prefabricated components the less powered tools are necessary on site. Sometimes specialized subcontractors are better equipped with more advanced tools and machines. (Appendix III-4)

The maintenance is for 53% of the equipment taken care for by an external organization. In some 33% of the cases the equipment is maintained by the laborers of the construction company and for 7% there is no maintenance at all. Equipment maintained by an external organization has sometimes to be transported to that enterprise. This means that it can not be used for several days or weeks, which for example depends on the difficulty of obtaining parts. This can cause a delay in construction time. Spare parts are only held in stock by 29% of the contractors.

The *humanware* component in mass construction projects consists in all cases the contractor's employees since the projects are all built with the involvement of a contractor for the total job. An exception is formed by the houses built as *self-help* construction project with the involvement of FUPROVI. The number of employees working on site per house differs a lot between the different projects. In the mass construction projects all projects have a professional project manager and a professional foreman. The size of the labor force per house (skilled and unskilled) is on average 0.48 persons. The houses built with the prefab systems need less labor. On average 37.5% skilled labor and 62.5% unskilled labor is involved in the project execution per project. The concrete blocks masonry construction system requires more skilled labor. The contractor hires the majority of the labor force on temporary basis: 81% of all skilled labor and 85% of the unskilled labor. The *experience level* of the total manpower in the mass construction projects is rather high. The project managers (93%), the foremen (80%) and the skilled labor (83%) have been involved for at least 5 years in construction projects. The unskilled laborers are for only 43% experienced. Least experienced are the laborers involved in the projects using the concrete blocks masonry system and those in the bamboo and self-help building projects of FUPROVI. This is not strange since these houses are built on self-help basis and a large part of the labor force is formed by family helpers. (appendix III-4)

The education level of the project managers in mass construction projects is rather high: 72% has university level education. The rest of the labor force is at least literate. The skilled laborers have at least primary school education and 28% has secondary level education. Some 23% of the unskilled labor has not finished primary school education. The skilled laborers have more experience and more knowledge about building techniques compared to the unskilled laborers. A higher education level seemingly corresponds with a higher position in the hierarchy of the employees on site. A problem is among others formed by the non-understanding of blueprints by 41% of the skilled labor force and 80% of the unskilled laborers. (Appendix III-4). The employees with less education in general have a considerable experience in project execution with a certain construction system. At Zitro, Bamboo and Fuprovi projects all foreman followed higher education. Only the majority of the skilled laborers working at Zitro projects followed higher education. In other projects secondary and primary school is most common. Most of the unskilled laborers finished primary school, some did not finish any education at all.

In the individual dwelling construction projects the average number of unskilled labor is 2, skilled labor 2,2 and tradesmen 4,6 per house. The project management is in the majority of cases in the hands of the house owner, who is in a number of cases supported by an engineer. These only hire the labor force for certain jobs. The rest of the work (mainly preparations and finishing) is often carried out by themselves or family helpers. This might explain the relatively high number of tradesman per house which are hired for special skills.

All projects have to deal with labor problems. Most is related to the in-sufficiency of knowledge and skills of the labor force, which becomes among others visible in the inability of reading blueprints. The low entrance barrier for employment in the sector and the type of work is hold responsible for the relatively low level of quality of in particular the unskilled and skilled labor force. This is also reflected in a low motivation, absenteeism of employees (not showing up at work in many cases, which is more common on Mondays and after holidays). Indicated reasons for this are alcohol (69%), illness due to malnutrition (in very few cases) and drug abuse (unskilled laborers). Problems with office personnel or project managers are insignificant. Project managers occupy a steady position in the organization They are working permanent in the organization. Two-third of the foremen has a permanent job and lot of experience. Three-quarter of the skilled and unskilled laborers are temporary employed.

The *infoware* component is rather well represented in the projects. Information and documentation is available to a large extent both in written form in documents and in computerized form during the project execution. Nearly 90% of the projects uses construction specifications and procedures, progress control techniques, material and equipment databases. The majority (more than 55%) of the technical documents like project specifications is used in written form. Material and equipment databases as well as time planning and progress control systems are for more than 50% available in computerized form. Only some of Prefa PC projects have no availability of material or equipment databases. It is remarkable that a number of projects executed with the Concrete blocks system do not have any planning documentation at all, while in all projects with Prefa PC a projects planning documentation is used. Specifications of machines are fewest available at Prefa PC projects. Documents on former projects are not used in projects built with Concrete blocks system, Bamboo and Fuprovi. (Appendix III-4).

Less information and documentation was available in the individual dwelling construction projects. Exact data were not found. None of the projects seem to have had a specific project planning documentation, nor any computerized information. Blue prints were in these cases available and the house owner/project manager kept a record on the hours spent on the various jobs during the dwelling construction.

The organizational framework (*orgaware*) of the construction projects is characterized by the involvement of the small and medium scale contractors. The company size of the construction enterprises that was involved in the investigated mass construction projects is for 75% of the Prefa PC projects, the Concrete blocks and Zitro projects less than 15 employees and for 80% of the Bamboo and Fuprovi projects more than 15 employees.

The specialization of the construction units is in principle in residential buildings for lower income households. 47% of the building contractors are all round and have experiences with different building activities. 27% of the building contractors is specialized in low-income housing and do not explicitly have a higher production output than those with another specialization. (Appendix III)

There is no company that has no experience with the applied construction system for low-income housing in all investigated projects. More experience does not always automatically lead to a faster construction time as can be seen with projects of Prefa PC and Fuprovi.(Appendix III).

In almost all the projects up-down *directing on site* occurs often verbally during meetings. Project managers and foremen generally have daily meetings with the skilled and unskilled employees on site. Next to project planning, also problems and complaints are discussed during these meetings. Notice boards or personnel letters are very seldom used. Problems, complaints and information to employees on site are in majority verbally communicated. The staff seldom gives a written answer to questions from the laborers. Only in a number of Prefa PC projects 50% of the information required by employees is given in written or verbal form and written responded. (Appendix III)

For *employment selection* or recruitment of project managers and foremen, personal recommendations are mainly used. This is often seconded by a review of school or study certificates . Next to these methods interviews of superiors and skill testing on the job are being applied. To recruit skilled and unskilled laborers a practice-testing period on the job is very common. Employment selection of laborers upon personal recommendation sometimes takes place as well. (Appendix III).

The *rate of regulation and control* is limited. Quality control of building materials during construction seldom takes place. Concrete elements, the major construction material, are generally best controlled. This takes mainly place visually on site. Next to concrete also timber is often visually controlled at the moment when it is delivered on site. Some building contractors use simple instruments on site for quality control of materials. The use of these instruments is very limited however. (Appendix III). *Stock control* is not applied in the projects. Materials are seldom held in stock. Due to sun, sand and wind materials are affected rather quickly. The supplier is contacted directly when materials are required. It then will take some days before the materials are delivered.

The *safety of the employees* seems to be considered less important. Too often accidents take place on the construction site. Eye protection during welding is the only reasonable protection used for employees. Second best is the use of helmets during construction. Most safety precautions are on average taken in the projects built with Prefa PC. In the Bamboo and the Fuprovi project no safety precautions at all are encountered in our investigations. (Appendix III) Site protection against stealing of materials seems necessary and not different from projects elsewhere in the world. At least once materials were stolen in 80% of the projects and in 47% of the projects at least once equipment was stolen. In the Bamboo and Fuprovi project stealing of materials or equipment did not occur so far. But in most projects not very much building materials are kept in stock. Most equipment and materials in stock are locked in a storage place after working time. One employee is generally responsible for the utilization of equipment and materials on site. Although in 67% of the projects a security guard keeps an eye on the construction sites and in 20% of the projects have a fence and a security guard it still is rather common that materials or equipment is stolen. 13% of the projects have no protection at all. Criminals but also employees on the site and neighbors of the project can be the cause of losing materials and equipment. (Appendix III)

The *management objective* of most of the units involves expansion. Technology development through training facilities for the employees generally is provided by the project organizations. *Training* on the job is the most common training facility, certainly for the skilled and unskilled laborers. Project managers and foremen also follow course outside the company.

Research and development activities are not very common for the construction companies. In more than 50% of the cases no efforts are spent on R&D. Employees spending Full time R&D employees are only found in the large construction companies. (Appendix III).

There are rather few direct *external relations and collaborations* between contractors and other associations. The collaboration between building contractors and the Cámera Costarricense de Construcci6n (CCC) is the most common one. Contractors have contacts and relations with the government mainly to acquire a building permit and other official papers. Universities or higher educational institutes co-operate only with the middle-sized and large building contractors .(Appendix III).

4.6 Conclusions

Project setting.

More than 80% of the investigated low-income housing projects is situated in the central region of Costa Rica, where climatological conditions like bad weather, additional work during construction and lack of laborers are main reasons for the lag of time of the dwelling construction project.

The soil conditions of the construction sites allowed the construction of simple foundations for the houses. Extra site preparations in 40% of the projects are required due to a slope on the sites.

The houses are built as individually built single housing units and in mass construction projects of a number of houses at a time. This number ranges from 37 to 322 houses. The mass construction projects often involved the development and construction of a complete urban area including roads, parks, playgrounds, commercial activities, etc. which take on average 40% of the total construction site.

The supply of water and electricity is no problem in Costa Rica, although one has to deal with regular failures in power and water supply which hamper the pace of building construction.

Product technological features of the construction output

The type of houses was in all investigated projects the single storey urban house, that has a rectangular shape with hip and gable roof, with an average floor space of 49 m5.

The houses meet the requirements of functionality for the lower income households in terms of size per household member, number of rooms -on average 3- and the availability of facilities like water, electricity and sanitation.

The construction of the foundations and floor beds -cast in situ concrete- are mainly carried manually. This implies a rather labor-intensive and time consuming activity.

The construction of external walls with prefabricated building systems is beneficial to decrease the construction time. Moreover the advanced construction with prefabricated construction systems require less skills compared to the conventional construction by using concrete blocks.

The walls of the internal nucleus of a dwelling -generally the bathroom- are generally made out of the same materials as the outside walls. Other internal walls are mainly constructed on site and made of a timber structure covered with timber or cement-based cladding.

Floor finishing is almost never applied other than a layer of cement screed in low-income housing projects.

The roofs are lightweight constructions of timber trusses or rafters and purlins covered with galvanized iron roofing sheets.

More than one-third of the external and internal frames and doors are prefabricated, the rest is made on site. Prefab frames and doors are favorable to decrease the construction time and improve the quality of the construction output. This counts in particular when it is applied in combination with a prefab construction system, provided that they have a reasonable tolerance and are produced in a modular system.

The production complexity of the houses on site is least by application of the prefab construction systems. The application of prefab construction systems offer the best opportunities to build fast with an improved quality of output. If the average construction time per construction system in the investigated projects is taken in to account, then building with the Prefa PC system proves to be the fastest method followed by building with the Zitro system as second best.

The individually built houses are least time efficient.

The extent of the finishing -like that of the internal walls and internal doors, painting, tiles, ceiling etc. is in many projects optional for the future inhabitants, since this part of the construction process generally requires quite some additional construction time.

The costs for the houses built with the bamboo construction system are nearest affordable for the lower income households, next follow the Prefa PC system. The concrete blocks masonry system is the most expensive.

Materials input

The supply and quality of the building materials cause most problems during building construction in the investigated projects. Common material problems are the irregular supply and low quality of building materials. The majority of mentioned problems are related to the prefabricated concrete elements and timber.

Process technologies

The *technoware* component in the construction process involves for 75% rather simple basic tools, the rest are powered tools or machines. No relation could be found between the number of different kinds of electric and non-electric equipment and the construction time of the houses.

Maintenance and repair of equipment is mainly carried out outside the construction company by a mechanical workshop.

The contractors who use most of the electrical equipment do also have more spare parts available compared with the contractors who use more non-electric equipment.

The availability of project managers and foremen on site seems to have a positive impact on to decrease the average construction time.

The majority of *skilled and unskilled labor is employed on temporary basis*. This gives the contractor a certain flexibility, in particular to cope with unpredictability of follow-up of project assignments. On the other hand the contractor has no optimal control of the quality and the availability of the labor force once they are needed.

The *size of the labor force* depends on the applied construction system. Zitro system requires per house on average almost one and a half times more employees than the Prefa PC system.

The *education and experience level of the project managers and foremen* is rather high.

A problem of a large number of the *skilled and unskilled labor* is their inability to read blue prints. The level of skills and knowledge of the labor force on site leaves much to desire. This is due to a rather low entrance barrier in the sector and the temporality of the jobs

Another *labor problem is the absenteeism* of the skilled and unskilled labor mainly caused by alcohol and sometimes drugs, which frequently is the case in particular on Mondays and the days after a holiday or "fiesta".

Building contractors generally have *a reasonable amount of documentation* available and in use including project progress control techniques, manuals of machines, construction procedures, norms and regulations, and databases regarding material and equipment. Time planning procedures, specifications of machines and documents former projects are less available. For the individually built houses the available information and documentation is minimal and certainly not computerized.

The *organizational framework* of most dwelling construction projects for the lower income households is that of the *small and medium scale contractors.* Small-size building contractors -generally all round and seldom specialized in one building activity- are mainly involved with building low-income housing projects. Large-sized building contractors are more involved in and focussed on complicated and economic more attractive activities.

Contractors with experience in different segments of the construction sector have a more favorable production output compared to those who are experienced in low-income housing only.

For employment selection of project managers and foremen personal recommendations are mainly used. To recruit skilled and unskilled laborers a practice-testing period on the job is common.

Progress meetings take place more than 1 time every two weeks. Site management and the handling of problems, complaints and information required by the laborers takes mainly verbal place.

Quality control of building materials during construction is rather scarce. The concrete elements and timber are generally the best controlled, mainly visually on site.

Safety protections for employees on site are seldom taken care for. Site protection- for example by a security guard (in 33% of the projects)- appears to be a bare necessity, due to stealing of materials and equipment.

Training on the job is the most common form of training certainly for the skilled and unskilled laborers.

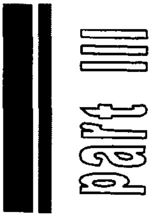
Research and development activities are not very common among the contractors and predominantly take place at random or ad hoc part time basis.

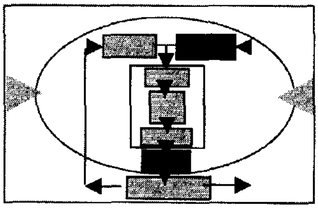
Contractors co-operate very occasionally with other organizations. The majority of relations are through the "Cámera Costarricense de Construcción". Only the middle-sized and large companies are member of this branch organization.

The present technology status is assumed to have an impact on the technological production performance in the dwelling construction sector for the lower income households. The *technological production performance* is described in the next chapter.

Chapter 5

The Technological Production Performance in dwelling construction projects in Urban Costa Rica





5.1 Introduction

The same procedure was followed as in Tanzania for the determination of the technological construction performance of the dwelling construction sector for the lower income households in Urban Costa Rica. (See also part I-chapter 3) The technological construction project performance is considered to depend on the technological efficiency and technological effectivity of the construction projects.

5.2 Technology effectivity of the investigated dwelling construction projects

The technology effectivity of the investigated dwelling construction projects is determined by the quantity and the quality (the product technological features) of the construction output. The last is assessed by bench-marking the found data against the basic requirements for the houses as formulated in the Costa Rican building regulations.

The major question thus is whether the required targets of the construction output quantitatively and qualitatively- are being reached in reality.

In terms of *functionality* the output of the investigated dwelling construction projects meet for 90 % the basic requirements of adequacy for an average lower income household. (Appendix III)

The conclusion – regarding the *physique technological effectivity* of the various building components- is that the output of the investigated dwelling construction projects meets the requirements described in the building regulations for 80%. (Appendix III)

The *production complexity* -in terms of ease of construction on site- becomes evident in the requirements for labor- and equipment-input. These requirements are least in case prefab construction systems are applied on site. Higher requirements for labor input have the construction systems that involve the assembling of a large number of different building materials and building components on site like for instance the concrete blocks masonry. Based on the scope of the opportunities provided by utilization of the available building materials and components for dwelling construction in Costa Rica the conclusion is that 70% of the projects show a production complexity that results in a good quality of output.

The *quantity* of the output on the other hand leaves much to desire and covers only at most 18% of the annual housing needs. The last percentage has much to do with the costs of the houses relative to the income level of the households and the available financing opportunities for the dwelling construction projects.

In other words the overall score of the technological effectivity of the dwelling investigated dwelling construction projects is

$$Teffect_t = f\,(Produtec, Q) = 0.8 \times 0.18 = 0.14 \quad (0 < Teff < 1)$$

5.3 The technological efficiency of the investigated dwelling construction projects

The technological efficiency of construction projects refers to the ratio of actually utilized versus the best practice utilization of process technologies in the construction projects. Improvement of the technology efficiency on site has been enhanced by improved product and process technologies. The best practice process technology is determined by the product technological specification of the desired houses. Hereby is assumed that a higher production output -in terms of quantity and quality- is directly related to an increasing order of more developed and better attuned components of process technology applied in a systematized, standardized mechanized and automated manner in production processes.

For the assessment of the technology efficiency of the dwelling construction projects, the technology components technoware, humanware, infoware and orgaware were examined by making use of the classification criteria that are listed in appendix III-5.

Particular characteristics are: (a) the limited percentage of utilization of advanced equipment and tools, (b) the low level of education of the unskilled labor force, (c) the limited availability of planning and control systems on site, (d) the centralized organization structure, (e) the small scale of a majority of construction units, (f) the limited level of formalization and standardization.

> The conclusion is that the level of process technologies applied during the execution of the construction projects scores 5.2. (0 <Processtec< 10).

The nature of the inputs also has an impact on the technology efficiency in the construction processes. 21% of the building components are prefabricated, which is beneficial to decrease the possibility of failures in construction details, which ultimately has a positive influence on the quality of the construction output. Moreover the construction time of on-site construction process is also positively influenced. The score for the type of material inputs then comes down at 5.3, when a scoring range between 0 and 10 is used. Other characteristics are the (on time) availability of the materials inputs on the construction sites that is the case in 60% of the projects and the quality in 47% of the projects.

The total score for the material inputs then comes down at 5.5 (0<Minput<10)

$$M\ input = f\ (N_m, A_m,, Q_m \frac{5.3 + 6 + 5.3}{3} = 5.5$$

Thus following the starting point that technology efficiency is a function of inputs and process technologies the conclusion can be made that the technology efficiency score as result of the following calculation ends up at

$$\text{Teffic} = f(\text{Minp}\,.\,(T,H,I,O)) = 5.5 \times 5.2 = 28.6 \qquad (0<\text{Teffic}<10)$$

5.4 The technological production performance of the investigated dwelling construction projects in urban Costa Rica

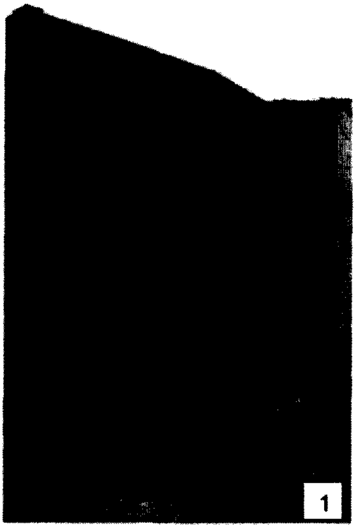
The technological production performance of the investigated dwelling construction projects in urban areas of the Central Valley in Costa Rica thus is

$$\text{TPP} = f(\text{Teff} \times \text{Teffic}) = f(I \times \text{THIO} \times O) = 28.6 \times 0{,}14 = 4 \qquad (0 < \text{TPP} < 10)$$

5.5 Conclusion

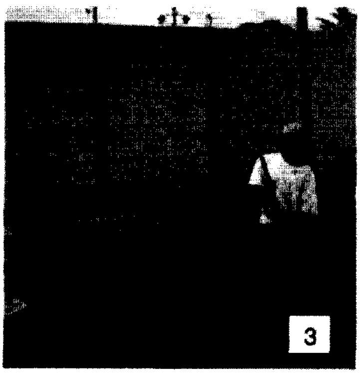
The technological production performance of the investigated dwelling construction projects in the urban areas of the Central Valley of Costa Rica is still relatively on the low side.

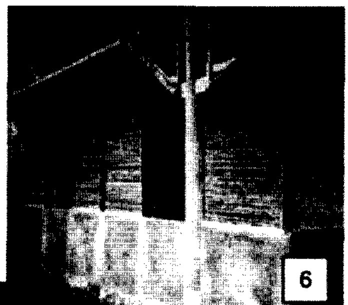
The major causes for the relatively low TPP score can be found in the technology efficiency. This is due to the particular features of the components of the process technology. The product technological features of the construction output score relatively reasonable.

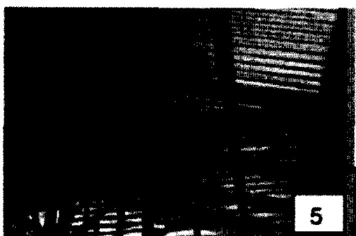

1

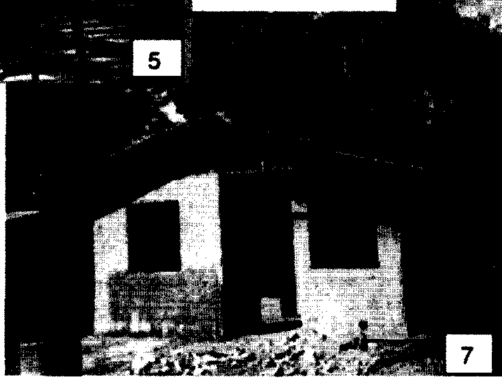

2


4


3

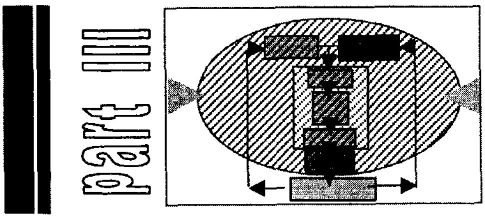

6


5


7

Chapter 6

The Construction Industry and Dwelling Construction in Costa Rica



6.1 Introduction

In this chapter the results are described of the studies on the sectoral technology setting of the dwelling construction sector in Costa Rica. The objective of these studies was to get insight in

a. the structure of collaborating actors in dwelling construction and the position that is taken by them in the total structure of the construction industry
b. the contribution of the dwelling construction sector to the overall performance of the construction industry in Costa Rica
c. the framework of policies and regulations for the construction industry that is expected to have an impact on the performance of the construction industry

This understanding is considered necessary to determine the priorities in technology management and policy making for the construction industry. The data are derived from literature studies and interviews with contractors and experts of the branch organization Cámera Costarricense de Construcción (CCC) and research institutes like CIVCO.

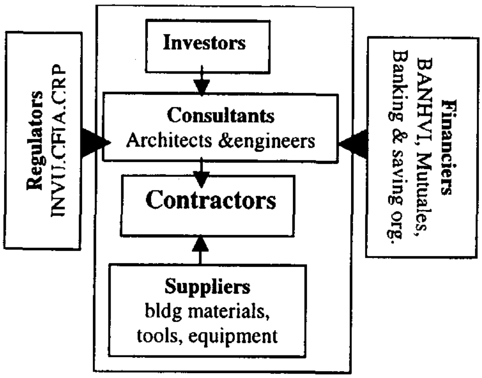
6.2 Actors in the Costa Rican construction industry

Construction projects can be carried out in various structures formed by actors who are to a certain extent involved in the different phases of the construction process. (see Part I chapter 3) The process of dwelling construction takes place with the involvement of the following major actors in Costa Rica.

The initiating actor and investor in a housing project in Costa Rica is in the public sector the national government and its agencies and in the private sector the non-governmental organizations, private organizations, contractors and private households. (Appendix III table 6.1) The private sector investors are in majority involved in housing projects for the middle and higher income households. (MIVAH 1995).

Architects draw the design of the house. A structural engineer takes care ofthe elaboration of the engineering details. In case the house has a size of more than 110m2 an electrical engineer needs to be involved in the preparation of the design and engineering plans in Costa Rica.

fig 6.1 Major actors in dwelling construction



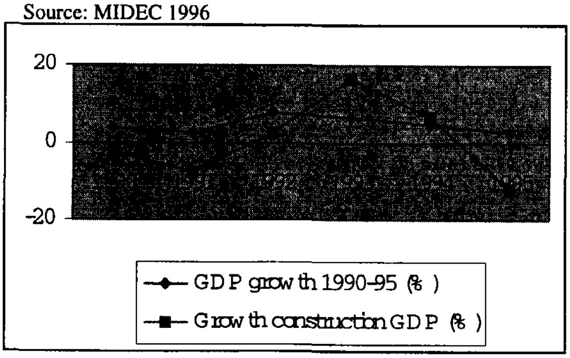
The project plans need to be presented to the National Institute for Housing and Urbanization (INVU) as well as to a professional of the Federation of Engineers and Architects in Costa Rica (CFIA: Colegio Federado de ingenieros y Arquitectos de Costa Rica) to obtain the approval for a building permit from the Commision for building permits (Comision Revisora de Permisos). The building permit is issued by the municipality officials. Financing organizations can be involved in several ways for the project financing .(see chapter 2)

The major actor in the physical realization of dwelling construction projects are the *formal sector contractors* in Costa Rica who get their supplies formally from various materials and equipment suppliers. The majority of contractors that is involved in dwelling construction for the lower income households are the small and medium sized enterprises. Large scale contractors take the projects for other market segments like the segments of commercial buildings and infrastructural works for their account. The major reason for this is that the profit margins in the dwelling construction sector are not attractive enough for the large scale contractors. (CCC 1996)

A number of projects are also realized by households through self-help building activities. The projects executed in the formal sector often take place under supervision of an authorized entity of the national housing financing system in particular in case the construction project is (co-)financed through this system. The actors collaborate in various teams with different responsibilities, during the execution of the dwelling construction projects in Costa Rica.(appendix III-table 6.2) No exact data were found on the percentages of the forms in which project execution takes place.

6.3 The socio-economic performance of the construction industry

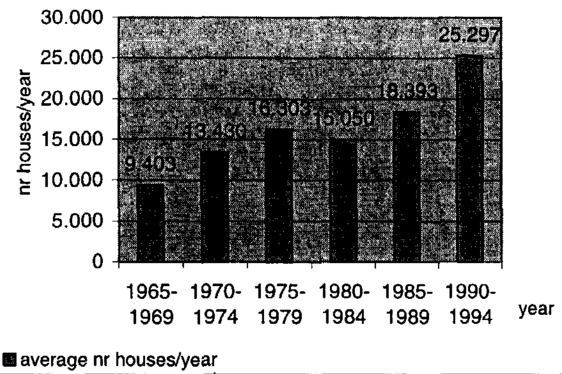
fig 6.2 Growth of construction GDP versus total GDP
Source: MIDEC 1996



The share of the construction industry in *GDP* is on average 3.8 % over the past six years. The correlation between the *inflation rate* and the GDP by construction sector is rather strong. The effect however is the reverse of each other. Increased inflation relates to a decrease of the GDP by construction sector. The same correlation as between the GDP by construction sector and inflation can be seen between the GDP by construction sector and the *exchange rate*. The effect for the growth of the GDP by construction sector is the opposite of the trend in exchange rate. This not very surprising since the import content of many building materials is rather high.(Appendix III-6)

The share of the construction industry in *gross fixed capital formation (GFCF)* has been declining over time. (54.2% in 1982 - 37.0% in 1991). This is in line with the decreased percentage of public investments in construction related to total investments (60.2% in 1982 - 43.6% in 1991). At the same time can be seen that the percentage of investments in the private sector increased from 38.2% in 1982 to 56.4% in 1991. (Banco Central de Costa Rica 1994)

fig 6.3 Nr of constructed houses /year
Source: MIVAH 1997



The residential building sector is the most important market segment for the construction industry. Over the past seven years more than 71% of the construction sector's output - in terms of the total constructed square meters- concerned the construction of houses of which the largest percentage part is subsidized housing. Some 50 % of the total of square meters constructed are houses with a floor area less than 70 m2.

The commercial building construction sector covered over 17% of the total constructed area over the past seven years. The construction activities for the industry reached almost 8% of the total constructed area. (Appendix III)

Between 1994 and 1996 the total output of the construction industry - in annually constructed square meters- decreased with more than 27 percent The square meters for houses decreased in the same period with 17 percent.(table 4.3). Overall the supply of houses is increasing since 1965. As was indicated before the economic crisis in Costa Rica during the 80s affected the construction of houses. The annual average number of houses which were built decreased during '80-'84 with more than 1,000 units per year. After the introduction of the National Financing System for Housing (Sistema Financiero Nacional para la Vivienda SFNV) in 1986, the number of constructed houses increased. But during the last few years the number of annually constructed houses has been decreasing again. Data on the exact number of units that were constructed after 1994 were not available. The average number of units built between '95-'96 is estimated approximately 23,300, by taking the average size of the constructed houses -which is 48 m5- and divide this figure with the square meters of constructed houses in '95-'96. This shows that the trend is thus decreasing again.

Employment in construction sector also follows the fluctuating trend of GDP growth. The official statistics on the labor force in the construction industry should be interpreted with care since the construction industry generally employs a large percentage of temporary not officially registered labor. It is a common wisdom in Costa Rica that many (inexpensive and unskilled) laborers in the construction industry are from Nicaragua staying (illegally) in the country. This may (partly) explain that no direct relation can be observed between the pattern of the total employed population and the employees in the construction sector. A growth of the total labor force does not automatically imply the same growth of the labor force in construction. The average share over the past six year of employees working in the construction sector in relation to the total employed population is 6.5 percent. Some 80% of the total labor force in the construction industry belongs to the skilled and unskilled labor force on site.

The performance of the construction sector is also reflected its *backward linkages* such as indicated by the production and consumption of cement. This indicator is important since the majority of the main structures of buildings are made of concrete blocks or concrete. During the last years a slight change can be seen in the utilization of materials. In 1990, 94 % of all dwelling walls were made of blocks or concrete, while in 1995 the same percentage had decreased to 80 % (Direccion General de Estadisticas y Censos 96). The major building materials for the construction of houses are concrete (walls and floors), timber (frames, doors and timber structures) and corrugated iron sheets (roofing). (see appendix III-6)

Cement concrete products, and metal products are produced in Costa Rica. Primary materials like sand, aggregates and timber are locally available and in principle do not have to be imported. Raw materials and intermediate products, like iron and steel have to be imported. Sanitary products are imported too. For prefabricated concrete building systems around 5 percent of the primary materials are imported (Productos de Concreto, ZITRO, CCC 1997). Steel, fibers, adhesives, foams and plastics are generally imported from the United States. The imports of construction materials have been increasing despite the decreasing trend of construction output in total constructed square meters since 1993. (see Appendix III-6) The percentage of imported construction materials between 1990 and 1994 was on average 3.5 % of the total imports in the country.(MIDEPLAN 1995)

The export of construction materials is negligible.

Forward and backward linkages of the construction industry in Costa Rica can be also be indicated by the estimates on the indirect labor force employed in other sectors resulting from the construction activities. The construction industry has many linkages to the industry and commerce. It is estimated that for one direct worker in the construction industry, one and a half laborers are indirectly employed (CCC 1996).

6.4 National policies and regulations

There is no direct government intervention in the construction sector. But due to its many forward and backward linkages the economic behavior of this sector is highly influenced by general economic and monetary policies and government interventions in other sectors. Examples are the national (social) housing policies and the interventions on the interest rates. Through economic and monetary policies the government intervenes on the costs of the production output of houses. The implication of this situation is that contractors depend on investments with rather small margins. The sensibility of the Costarican construction sector to changes in the national politic-economic performance becomes clearly visible in the share of construction in total GDP. The difference in political orientation during the subsequent the presidential administration periods in recent Costarican history (PLN favors state intervention while the PUSC favors a liberal market economy) tends to have a strong relation to the performance of the construction sector.(see appendix III) A recent situation in the country (1997) represents a clear example of the national policy impacts on the construction sector. When president Figueres decided to finance housing projects with some 200 millions of colones[1] worth of bonds, after three years of governing with quite severe austerity measures in order to fight the internal economic problems, the construction sector almost directly showed a revival. The second year of a presidential administration appears to be worse than the first

[1] On the 14th of september 1997 the exchange rate with the US-dollar was 237.4 colones against one US-dollar.

year except for the 1982-1986 administration period when the economic crisis reached its climax in the first year of government. The reason for this is that the economic performance in the first year of government a result is of the actions taken in the last year of the former administration period. The performance of the second year is a result of the actions taken in the first year and, so on. Likewise the results in the third year are better than those of the second year and reach a climax in the last year of the four year administration period. (Construcción, CCC 9-95)

6.5 Conclusions

The *public sector is a major investor* in dwelling construction projects for the lower income households in particular since the introduction of the SNFV the national financing system for housing in 1986. Private sector investments in housing mainly take place in dwelling construction projects for the middle- and higher income households. The dwelling construction projects for the lower income households are carried out by *formal sector contractors* financed by the SNFV through the intermediary of the authorized agencies. Dwelling construction projects are also carried out by households and groups of households collaborating in self-help dwelling construction supported by the executing entities of the SNFV like FUPROVI.

The dependence of the dwelling construction sector on financing from the national financing system for housing (SNFV) implies that the performance of the sector is rather vulnerable for politic–economic changes in the country.

This becomes clearly visible in the socio-economic performance data of the construction industry related to the overall socio-economic performance of the country.

The *share of construction in total GDP* fluctuates in line with the overall dynamic trend in the national economy. This is also visible in the trend of fluctuations in *inflation and exchange rates*. The highest share of construction activities (71%) is taken by the dwelling construction sector. The *forward linkages* of the construction industry with other production sectors in the country are limited.

The construction sector is rather labor intensive. Although the growth of *employment in the construction sector* correlates with the growth of the GDP by the construction sector this does not exactly reflect the employment situation in the sector. A reason for this might be that labor is employed at permanent and temporary basis; also illegal labor force is employed.

The construction industry heavily relies on *imports of materials* mainly from the United States. This makes the construction sector vulnerable for the fluctuations in the exchange rate. The *output* of the sub-sector of dwelling construction is decreasing since 1994 and does not meet the *need* for housing in both quantitative as well as qualitative sense.

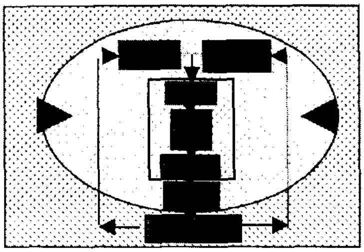
Government interventions in terms of financial measures to achieve the construction targets of houses have shown to be supportive. But overall the Costarican government does not use the construction industry as a macro-economic stabilization factor. Instead the construction industry is subject of the general politic-economic considerations during a certain period of administration. There is no sectoral development plan for the construction industry. It would be better for the overall performance of the construction industry and the Costarican economy as a whole if the government used its influence in particular in the sub-sector of dwelling construction. Therefore the government should unfold long term housing plans instead of managing a four year term compromise which effect, for obvious electoral reasons, accumulates in the third and last year of government.

The present on-going and even increasing gap between demand and supply in the housing market requires an increased output and lower costs of production of houses. An improved production performance could be achieved through technology developments, such as the application of innovative construction systems. These could involve a simplification of the construction processes on site. Although Costa Rica has been able to develop and apply more advanced construction systems, the majority of the currently applied dwelling construction systems are still rather traditional and labor intensive. The trend in changing the technologies drastically is not a strong. Enabling and stimulation of technology developments and their diffusion in the construction industry should thus be on the political agenda.

Chapter 7

The National Technology Setting of the construction industry in Costa Rica

part III



7.1 Introduction

The focus in this chapter is on the national technology setting in which the dwelling construction projects are carried out. The status of Technological Capabilities and Technologies in production processes are seen as essential factors that determine the technological production performance and the achievement of socio-economic development goals.

At the same time they must be seen as an *integral part of the national technology setting* in which the production processes take place. An assessment of the national technology setting could give an explanation of the factors in this setting that have an impact on the technological production performance in the construction industry. The results of such an assessment should point at the opportunities and constraints in the national setting for an optimization of the technological capabilities and the technology status in the sector.

7.2 Geographic setting

The shape and lay-out of the houses, building construction, the patterns of community life and population distribution in Costa Rica reflect its varying natural environment and climatological conditions.

The country is small. More than half of the Costa Ricans live in the Central Valley at an altitude between 800 to 1,500 meters above sea level in and around the country's capital San Jose. The climate is tropical. Along the coast one has to face a high rate of humidity and in the Central Valley it is temperate, cool with a lower humidity. In building design and engineering one has to count with frequent volcanic outbursts, earthquakes and hurricanes.

7.3 Historic backgrounds

Alike in all countries historic backgrounds are deeply rooted in the Costa Rican society, which is reflected in various aspects of its social system like for instance the production structure, the basic infra structural system, urban structures and housing styles. Costa Rica was colonized by the Spaniards since Colombus arrived in the country in 1502, but the country became autonomous in 1821 already. An overview of the general historic backgrounds in chronology is given in appendix III-7

7.4 Political setting

The dynamics in the political setting in the county have an impact on the performance of the construction industry. The republic of Costa Rica is one of the eldest democracies in the Latin American region. Since the political reforms in 1948 Costa Rica has gained a reputation of a stable and peaceful country in the world's politically most unstable and often war-torn region of Central America.

The country has a multiparty political system, but two major political parties dominate the political scene in Costa Rica: the Partido Liberacion Nacional (PLN) comparable with the social democratic parties and the Partido de Union Social Cristiana (PUSC), comparable with the republican parties in Western Europe. Every four years one of the two parties wins the elections causing these two parties run the country's administration alternately. In terms of political orientation the two parties PLN and PUSC are identical in essence. Both parties regard democracy as the greatest treasure. This is reflected in a preference for decentralization through the establishment of over 100 autonomous institutions in the country that carry out checks of power and expertise and take alternative strategies into consideration. The strategies to reach the policy targets that are favored by PLN are state interventions. The PUSC in contrary favors a more liberal political strategy. The dominance of the PLN can be noticed in the great deal of state interventions that took place in Costa Rica over time. The number of governmental institutions grew in particular during PLN regimes. The financing of these institutions currently takes some 60% of the public sector expenditures. (Biesanz, R. 1994).

This has its impact on the performance of the country's production system, among which the construction industry. Literature indicates that the current trend and traditional structure of state intervention in many fields of the social system in Costa Rica gave an opportunity to successfully deal with the short term problems right after the 1948 political "revolution". However this may appear not maintainable in an increasingly competitive and globalizing world. (Lara, S, 1995: pp96-97; see also appendix III-7)

7.5 Economic setting

The economic setting has an impact on the housing situation and the production performance of the construction industry. This is for example visible in the relation between the affordability of a house and a decreasing purchasing power of the population (see chapter 2).

The Costa Rican economy is basically stable and progressive. Costa Rica belongs to the middle income countries with a GDP per capita of US$ 5,400 (1995 est. World Fact Book, see also appendix III-7) But the perspectives are not very promising. Economic growth kept on decreasing from 4,3% in 1994 to 2,5% in 1995 The inflation rate rose to 22.5% (1995). The growing inflation of more than 10% caused a reticence of investments. Future prices were insecure and the entrepreneur could not estimate properly whether the profit would exceed the investments. Increased inflation enhanced an increase of interest rates. Government intervention in the interest rate has always been extreme. Bank organizations have been state organizations since 1949. The wages, however, did not increase proportionally which harmed the purchasing power of the population. Unemployment rose from 4.0% in 1994 to 5.2% in 1995, while underemployment still is substantial. The devaluation of the local currency (Colones) kept going on with a rate of 12-15% per year.

The impact of the economic setting on the construction industry is also reflected in the relation between the exchange rate, the production structure in the country and the costs of building construction. Building construction has to rely on imports of materials. At present the national production system still is dominated by the agricultural sector, that takes care for the most important contributions to the GDP by exports of traditional products like coffee and bananas. The trade balance showed an increasing deficit up to US$ 1,011.700 in 1993 (Banco Central de CR, 1996).

The national policies and state interventions in the economic situation have contributed to the high quality of life in the country, such as the contribution to economic growth by creating a mobile and productive labor force through human capital investments. On the other hand the governmental body (and expenditures) reached extensive proportions and became a kind of bureaucratic giant. The country has limited own resources and a relatively small home market. It has to face quite a number of societal problems like an increasing deficit of adequate housing facilities for its growing population. The Costa Rican economy still depends on foreign financial sources. The government had to agree on an IMF arrangement again at the end of 1995 to re-address the economic problems and to enhance economic reforms like reduction of the fiscal deficit, increase of domestic savings, improvement of the public sector efficiency and increase the private sectors role in the economy.

7.6 Education and health setting

The construction activities in Costa Rica are in majority labor intensive and require a well trained and skilled labor force. This makes the construction industry dependent on the education and health system.

Costa Ricans are the most literate population in Central America with a literacy of 93%. Education is compulsory -for children at the age of 6 to 14 years old- in Costa Rica since 1869. More than 28% of the national budget was invested in primary and secondary education since the 1970s. But during the last years the government expenditures on education decreased to 50% of the total expenditures on social services (44,470 mill. colones) in 1993 which form a constraint to the implementation of the programs. (see appendix III-7) As elsewhere in the world, well-to-do families send their children to private schools.

The rather well performing state sponsored health system is reflected in the fact that 86,2% of the total population is covered by social health services. (see also appendix III-7). But also this sector has to face shrinking social services budgets. The result is a declining percentage of Costa Ricans to be provided with potable water and sanitary facilities inside their homes for the first time (Lara, S. 1995:66)

7.7 Land and natural resources

Land and natural resources are important inputs for a location bound industry like the construction industry. The land area of Costa Rica is small but sufficient for its present size of population. But the land has relatively infertile soil conditions. Fertile volcanic and alluvial soils are to be found in less than 20 percent of the land area, mainly in the Central Valley. (Rottenberg,S 1993). This is also the part of the country where the population is concentrated and where the construction activities mainly take place.

Costa Rica has very limited natural resources. (see appendix III-7) This causes the high import content of the building materials in the country. The consciousness of this and the high rate of deforestation led to the establishment of a program for the cultivation and propagation of 500 ha of bamboo Guadua (Guadua Angustifolia). This provides the necessary material for some planned 7500 houses per year.

7.8 Infrastructure

The location bound construction industry relies heavily on the infra-structural facilities in the country. Most parts of the country are reasonably accessible. The availability of infra-structural and communications facilities seems to be rather well developed. This can also be attributed to the fact that Costa Rica covers a relatively small land area and a population that live in majority in the Central Valley.

The quality of the existing infrastructure is a question of other order. The road network is concentrated on linking the big cities and the Central Valley with coastal areas. The sea harbors are of high importance to the construction industry since Costa Rica has to rely on imported building materials The electricity network is rather well developed in Costa Rica. 100% of the dwellings in urban areas are connected to the grid, and in rural areas some 86,3% has a connection. Most of the electricity is supplied by the hydro-electric stations. The telecommunication system has been fairly well developed in Costa Rica. (see appendix III-7)

7.9 Population and urbanization

Population growth and urbanization were indicated to form the major causes for an increased need for housing facilities that could not yet be met by the output of the construction industry in the country.

The population in Costa Rica is about 3 million. At present the population is still increasing, both due to natural growth and due to the influx of more than 200.000 refugees from neighboring countries.

Still the *population density* is not very high compared to other countries. The population is highly concentrated in the rather small area of the Central Valley, which covers only 8% of the territory and where 30,5% of the total population live. The majority of the Costa Rican population (86.178 inhabitants, which represent 28,51% of the total population) lives in the capital San Jose.

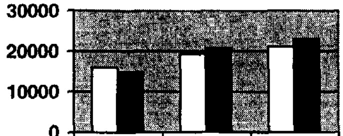
The *age structure* in Costa Rica shows the picture of about 37% of the population that is younger than 15 years and 4.5 % older than 65 years.

Costa Ricans are characterized by their *cultural homogeneity*. This results from the fact that 95% of them have inherited mixtures of the mestizo blend of the Spanish colonists with the Indians and at the same time often some African heritage. The majority of the population belongs to the Spanish-American group, which has a dominant position in the Costa Rican society. This is different from the situation in most other Latin American countries (Adams,R, 1956)

The total number of households is about 720.000 and is still increasing more or less in pace with the population growth. The average *household size* in 1994 was 4,2 persons. The number of children per household has decreased immensely as a result of dramatic reductions in fertility. No significant differences were to be seen between social groups in contraceptive use, reproductive goals or fertility (Behn and Guzman 1979 cited in Rottenberg, 1993: pp 18).

Income distribution is unequal in Costa Rica. In 1993 some 38.6% of the households belonged to the lower income population. 21.2% belong to the low income households and the rest 17.4% to the poor households that are living below the poverty level. 8,6% of the population (46,487 households) which in principal are not able to purchase their basic needs (food, clothing and housing) and some 8,8% (nearly fifty thousand households)which live in extreme poverty .(MIDEPLAN 1995)

Fig 7.1 Living expenses – minimum wages
Source: MIDEPLAN 1995



	1991	1992	1993
□basic living expenses	16040	19346	21151
■minimum	14754	20826	22959

Urbanization in Costa Rica concentrated in the Central Valley. 51% of the population still belong to the *rural population.* (INCENEM 1995). Over time much interaction took place between the urban and rural households in particular in the Central Valley. This was facilitated by the small size of the country as well as by the relatively well developed transport and communication facilities. *Rurality* can thus be seen as a relative rather than an absolute phenomenon. Increased mobility resulted in a spread of residential areas in the previously rural districts around the major urban centers. A high population growth - twice as much as on average in the country- took place in for example predominantly rural districts in the cantons around San José, and to a lesser extent, rural districts around Alajuela, Heredia and Cartago. The pattern of urbanization, on-going concentrated in the Central Valley, causes an increasing need for social services like housing, education and health in this part of the country.

7.10 Conclusions

Costa Rica can be described as a political rather stable country on which both its *geographic location* and its *historic roots* have left their marks. This becomes visible in various aspects of the Costa Rican society, like its population, the production structure, the infra-structural system, urban structures and housing.

Costa Rican political orientation and economic situation in all its dimensions has a severe impact on housing and the output performance of the construction industry. Meanwhile *Costa Rican population* is still growing and *urbanization* is on-going in particular in and around the urban areas in the Central Valley. This puts quite some pressure on the provision of social services like education health and housing in the country. During the early nineties the socio-economic situation has been improving. But a current trend is that the middle class population is increasingly unable to meet the basic needs, while the incomes did not increase and the costs of living did. It implies that their income is not sufficient to cover the additional costs of living This on its turn means that once that they have paid for these costs, the costs for housing cannot be covered. More and more families are thus forced to search for cheaper housing facilities and sell their houses.

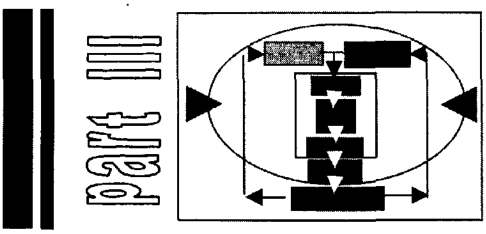
For many of the above mentioned features of the national setting the *national development status* in the country is used as general indicator. This status is hold responsible for the public and private capabilities to invest in various areas of the social system, like education, health, housing, infrastructure, production and technology development. When the country is ranked -by using the official Human Development Indicator (HDI) ranking indicators like was done for Tanzania- one can see that of the 174 countries Costa Rica takes the 42nd position in 1993. This level is lower than that in 1990, which indicates the improved socio-economic situation. The Costa Rican HDI was in 1990 0.916 and in 1993 0.852. Compared to Tanzania the Costa Rican position is more promising. Among all countries (174) over the world Tanzania is ranked at the 144th position of the Human Development Index (HDI) ranking in 1993. (see appendix III-7)

Table 7.1 Costa Rican HDI ranking (1993)

Country	HDI
[illegible]	[illegible]
Uruguay	0.881
[illegible]	[illegible]
Bahamas	0.875
Chile	0.864
Costa Rica	0.852

Chapter 8

Synthesis and discussion of the results of the Technology Mapping Studies in urban Costa Rica



8.1 Introduction

The on-going *population growth* and the deterioration of the existing housing stock increased the housing problem that has a tremendous magnitude in Costa Rica alike in Tanzania. The housing problem is not a stand-alone phenomenon but is a result of various interrelated problems and constraints in the country. (see chapter III-2)

The *construction industry* has the challenging task to contribute in tackling the housing problems for the lower income households. Housing supply largely depends on the production output of the construction industry.

Costa Rica has made a considerable progress in dwelling construction thanks to the stimulating efforts by the public sector. Still the situation is not optimal. Following the theoretic viewpoints adhered in this research project the production performance results from the status of technologies in the construction processes and the technological capabilities in the dwelling construction industry. The technology mapping studies offered insight in the present status of technologies and technology capabilities. A synthesis and evaluation of these against the desired situation indicate the gap that needs to be closed by an improved technological production performance of the dwelling construction industry.

8.2 The strength and weaknesses of the technology capabilities in the sector

The Technology Mapping Studies revealed a number of ***strengths and weaknesses*** of the present status of technology capabilities in the dwelling construction industry in Costa Rica (see appendix III-8)

The *technology stock* indicates an increasing strength of the existing technological capabilities. Costa Rica has made a reasonable progress in the local development of *construction technologies.* It still is a challenge to further develop these in order to decrease construction costs and increase the construction speed.. Technological developments then should be focused on a decrease of the import content in building materials, tools and equipment. This on its turn should decrease the building costs in order to increase the affordability for lowest income households.

A strength of the *manpower* in the Costa Rican *construction industry* is formed by the high education level of the professionals and project managers involved in the dwelling construction projects. The execution of the construction activities on site however is carried out by a labor force that has to face a lack of skilled crafts men. This indicates a severe *weakness* of the human resources component of the technological capabilities for the construction projects. Education and training programs on technical skills and knowledge for the labor force on site are not meeting the need for the quantity and quality of this type of the labor force on site.

The limited stock of mineral resources for the production of building materials severely harms the Costa Rican technological capabilities. This becomes clear from the limited mining opportunities, the present transport facilities, the high rate of deforestation and the available energy sources. The Costa Ricans have put efforts on the optimization of the efficient utilization of the available resources. Still factors at national level -such as the limited financial means in the country for further R&D, deficient transport facilities and the existing regulations and legislation on imports of building materials- appear to form a constraint to further developments

The *technology infrastructure* in Costa Rica has to face internal and external weaknesses. These concern the lack of tailor made education & training possibilities; the limited local production of material & equipment; the inadequate policies & strategies; the level of standardization in the sector; the low income level of the customers and the present lack of financial means.

A relative strength of the Costa Rican situation -the increased inter-linkage in the sector- can be attributed to the reasonably well developed communications and information infrastructure. Organizations, institutes, professionals and enterprises may improve their performance and inter-linkages by taking advantage of these.

The findings in this research project correspond with those found in literature. Some of the strength and weaknesses were already indicated in studies that were carried out in the eighties. The objective of those studies was to find suitable solutions for the problematic housing situation in the country. (Zomer 1982, see also appendix III) The problems and constraints that were determined have been attacked but the housing delivery situation still is not sufficient although the results of the efforts have contributed to improvements

8.3 Technological strengths and weaknesses at project level

The status of the technological capabilities is supposed to be reflected in the project level technological production performance.

The *technological effectivity* of the Costa Rican sector of dwelling construction for the lower income households is the result of a reasonable production output in terms of quality, but a low effectivity in terms of quantity of the output.

The *technological effectivity* -in terms of functionality of the houses- is sufficient in 90% of the cases; -in terms of physique-technical quality for 80%. In terms of production complexity the projects have shown to reach for 70% a most optimal ease of construction on site, thanks to the opportunities provided by the utilization of the available prefab construction systems.

In terms of functionality (type of the houses, geometric appearance and availability of facilities) a constraint for optimal effectivity is formed by the limited accessibility of a number of plots in the investigated projects. The houses also cannot be used for other purposes. The type of houses and their lay-out corresponds with the urban Costa Rican lifestyle and the possibilities to extent the houses when necessary.

A *weak*ness of the physique technical performance of the output product technology refers to aspects like (a) the resistance against earthquakes and hurricanes that does not guarantee a reasonable life time of the house without severe maintenance and repair investments (b) the present heat accumulation and in-house relative humidity.

Problem points are for the concrete blocks system the vulnerability for severe humidity and rainfall without protection. For the bamboo construction system the problem is the vulnerability for fungus and rot without preservation. Both however are easy to overcome. A more problematic aspect is the earthquake resistance. Against these natural disasters only the bamboo construction system appeared to offer an optimal safety in the sense that the building will not directly collapse, given the experiences during the last severe earthquake in 1993.

The projects executed with concrete blocks have the largest *production complexity* and the highest requirements for labor input. This becomes evident in the average construction time. The average construction time by application of the four investigated construction systems is least favorable for the concrete blocks system. The least construction time is required by application of the Prefa PC system in particular when the system is applied in mass construction projects. Next comes the Zitro system. The highest time consumption of the building construction with the bamboo system is during the finishing of the walls.

The costs of the durable houses are still too high for the lowest income households. More solutions should be found to bring these within the reach of the lower income households. The involvement of households in project execution in particular during the finishing phase of the house decreases the costs of the houses.

The score for *technological efficiency* in terms of the process technologies and materials input in the construction projects is reasonable.

The capital intensity for all construction processes is low thanks to the simple tools and equipment that are used on the project site and the applied construction systems which allow the use of this type of tools.

This is in one hand favorable and should be maintained from financial economical point of view, while the accessibility of proper tools and equipment actually should be increased. The used equipment gives less guarantee for a standard quality of output and the construction time is more extended especially in case the traditional and conventional masonry construction systems are applied for the dwelling construction.

A major weakness in the technology efficiency is the limited guarantee of quality and availability of the hired labor at the construction sites.

This corresponds with literature. It was indicated as a major bottleneck for efficiency in building construction. Major reasons that were mentioned are (a) the in-adequacy of the existing training courses, (b) the low motivation among the workers. (CIVCO 1995). The knowledge, skills and experience level of project managers and foremen is good.

The quantity of labor force with appropriate knowledge, skills and motivation to carry out the jobs properly might be increased by on-the-job training and education of the labor force.
The *information and documentation* component is reasonably well represented in the construction projects.

In the investigated projects blueprints and documents were available. The use of information and documentation systems on site can be improved however by optimization of the availability and use of planning and (quality and cost) control systems (see chapter 4).

The *organizational framework* of most projects is that of the small and medium scale contractors.

These have more flexibility to be engaged in various types of projects by hiring their equipment and labor force tailor-made for every job than the large scale companies. A weakness is formed by the limited control on-site, which may result in lower quality of output, loss of equipment and material. These efforts take place - if any- on ad hoc and haphazard basis only. The organizational framework of dwelling construction projects in urban Costa Rica thus should be maintained and improved without loosing flexibility of operations

The pre-occupation of the small and medium scale contractors with their day-to-day construction activities as well as the limited profit margins in their projects does not leave much room for research and development activities.

A *major strength of the Material inputs* concerns the developed prefab building elements.

The contractors, who are involved in the dwelling construction projects for the lower income households, are generally not in the front line of technology developments. This may form a constraint to their competitiveness in future unless they have strong connections with the building materials industries. It is already the case in a number of the projects that use the PREFA PC building elements and in the projects that use bamboo elements. The relatively high production complexity -caused by building with the conventional concrete blocks masonry system- enhances delays in the construction process and gives less guarantee of the quality of the output. These conventional construction systems should be substituted by the prefab construction systems. The production of single houses and building elements on the project sites then also should be substituted by batch production of building elements that can be assembled site. This benefits the qualitative standard and quantity of output. Moreover economies of scale can be achieved. The increased standardization of the materials to guarantee a certain quality of construction output should also be established with a decreased foreign content of materials to lower the building costs.

Other weaknesses regarding the materials inputs on site concern the (on-time) availability and quality of building materials on site.

The *project setting* forms limited constraints that in majority concern the danger caused by the occurrence of natural disasters.

Hurricanes and earthquakes and the land form require extensive leveling of the sites in a number of projects. The construction details should be adapted to these circumstances, which implies for certain construction systems an increase in costs of the project.

A number of weaknesses in the project setting that require improvement include the project site accessibility and the financing model for dwelling construction activities. The building of houses in mass construction projects for houses is a performance promoting factor and should be enhanced to be able to take the advantage of economies of scale.

The project level strengths and weaknesses are summarized in appendix III-8.

8.4 The promoting and constraining factors of the sectoral technology setting

A promoting factor is that almost 75% of the construction output is in the housing sector, which implies the possibility of gaining experience in jobs in the sector.

Another promoting factor is the relative innovativeness in the construction industry in Costa Rica, that becomes visible in the development of construction systems like the like Prefa PC and the Prefab Bambu system. The application of these result in a reduction of costs and production time as well as a reduction of the qualitative requirements for process technological inputs on site, whilst an improvement of standardization and quality of the product technological features of the production output is reached.

The labor intensive construction technologies form a promoting factor for the employment and income generation opportunities. At the same time it is a constraining factor for the quality standard of the output.

A constraining factor at sector level is formed by the increasing pressure on the output by the construction industry due to the influx of refugees and the relatively large percentage of young population.

Another constraining factor for the construction industry is its relatively high dependence on public sector investments. The public sector is the investor in 70% of the housing projects (see chapter 6) This dependence on the public sector makes it vulnerable to politic-economic changes.

A promoting factor of the public sector involvement is that project design and engineering are specified and controlled upon quality although this is less the case for the execution phase on site.

8.5 The promoting and constraining factors of the national technology setting

The promoting and constraining factors of the national technology setting are summarized in appendix III-8.

The country has already made some progress in the alleviation of the *housing needs.* This could be reached by setting up the financing system for housing. However this strategy still does not work out as desired due to deficiencies in the human resources component and the dependence on foreign means for investment on longer term.

A major constraint is formed by the less favorable *economic situation* in the country with a considerable rate of unemployment an unbalanced income distribution with a relative large percentage of lower income population and a lack of financial means to spend on social services like education, physical infrastructure and housing.

The conclusions regarding the aspects of the national technology setting for the construction industry indicate a number of factors that form constraints for the development of the construction industry.

The economic situation forms a major constraint to further development of the operating environment of production sectors such as the construction industry. Constraining factors are the following (see chapter 7). The *high inflation* causes an increase in the costs of living, production and construction costs that are not in line with increase wages and thus enhance a reduction of investments in the construction industry. The *high interest rates and a lack of* *means on the capital market* are also induced as a reaction on the increasing inflation with all mentioned impacts like a reluctance to invest. The *ongoing devaluation* induces risks for contractors in particular in long lasting projects. The l*ow industrialization rate* becomes evident in the present production structure with a *low developed capital goods* sector and high dependence on agriculture (little diversification). This implies a dependence on foreign resources. The l*arge service sector employment* causes overruns of the public sector budget, lower social services expenditures and less financial means for housing. The u*nequal income distribution* causes *a* low investment capacity of target group households. The u*nfavorable trade balance* results in a low investment capacity. The u*nfavorable exchange rate* results in high construction costs due to the need to import building materials. The h*igh dependence on foreign aid* (may) result in a dependence on foreign terms and conditions for investment in construction.

The present policy structure and the regulative and legislative framework in which the construction industry has to operate form a constraint to effective production. This becomes apparent in the following weaknesses: (a) in adequate and vague policies; (b) relatively short four year terms of policies alternatively in favor of government intervention or liberal policies, which implies non- continuity of strategies; (c) a democratic bureaucracy resulting in a large size public sector, with a large government expenditures pattern and overruns of the government budget decreasing the means for social services; (d) the non adequate planning and strategies for housing delivery; government interventions in the supply of building materials for dwelling construction which show a weakness of regulations on imports of building materials constraining the opportunities for local building materials industries to develop;(e) a non-priority position of the construction industry in the government plans, whereas this sector may play a pivotal role in socio-economic development.

As a result of the politic economic situation the opportunities for tailor made *education and training are in-sufficient* to meet the need for skilled craftsmen on the construction sites This becomes evident in a current lack of educational means, a low level of in-company training and an in-adequate vocational training system.

The *deficiencies in transport network* hamper a high quality and timely delivery of materials on the construction sites.

The *demographic features* of the country are not promising. These are reflected in the large percentage young population, relatively large size lower income population without access to housing. This puts extra pressure on the performance of the construction sector. The concentrated population density in the Central Valley enhances a concentration of the housing problem, the urbanization pattern -concentrated in Central Valley-: increase of un-employment, traffic jams, environmental pollution, the influx of refugees.

The *geographic and climate conditions are not favorable.* This becomes evident in the occurrence of disasters – hurricanes, earthquakes and volcanic outbursts- that require extra engineering and building costs for precautions against these disasters. The humidity and excessive rainfall often cause delays in the construction progress.

The *lack of natural resources* which enhances a dependence on imports of raw materials and vulnerability of building costs, a non sufficient energy production and deforestation.

Also in Costa Rica -alike in Tanzania- the international setting of the country that can be characterized as rather peaceful and politically stable attracts many refugees from neighboring countries. This puts quite some pressure at the provision of social services like housing in a country that actually is not able to cope with number of severe national socio-economic problems. On the other hand this peacefulness attracts an increasing number of retired people from the US who settle in the country which is favorable for the economy since they bring in their own resources.

8.6 Conclusions

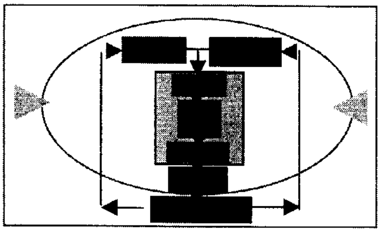
A synthesis of the findings of the technology mapping studies in Costa Rica has resulted in the indication of the strength and weaknesses, the promoting and constraining factors to develop the technological production performance in the dwelling construction industry. Again -like was the case in Tanzania- these factors can be brought back into the clusters of variables that were assumed to be the major determinants for the technology production performance.

The dwelling construction industry has to face a number of problems and constraints resulting in a technological production performance level which is below the level of expectation and thus also cause in an increasing lack of houses especially for the lower income households. The problems and constraints can be found in the weaknesses of internal factors within the production system, but they are also related to a number of constraining external factors to be found in the operational settings of the production systems at different levels of the economy.

By knowing the strength and weaknesses, the promoting and constraining factors to develop the technological production performance in the dwelling construction industry it will be possible to draw conclusions on the required improvements and recommendations for technology management and technology policy purposes. This is discussed in the next chapter.

Chapter 9

Implications of the Technology Mapping results for Technology Management in the dwelling construction industry in urban Costa Rica.



9.1 Introduction

The implications for technology management at project- and sector level and for the national policies resulting from the technology mapping studies are discussed in the next sections. The objective is to indicate the areas for management interventions that should be made to improve the technological production performance in the dwelling construction industry for the lower income households in the urban areas of Costa Rica. An improvement of the technological production performance in the sector is supposed to contribute to the alleviation of the housing problems in the country.

The achievement of an improved technological production performance and competitiveness of industries depends on the technological capabilities in the sector. Technological capability building is supposed to form a gateway to improved technological construction project performance. These were the theoretic starting points for the determination of the interventions by technology management and technology policies.

9.2 Implications for sector level Technology management

An improvement of the technological production performance requires at sector level the improvement of the present technological capabilities. This can be reached by mobilization of the pool of human resources; by sustainable exploitation of the natural resources, by extension of the stock of technologies for building construction and by the establishment of a strong technology infrastructure.

The technology mapping studies revealed the present strengths and weaknesses of the technological capabilities in the Costa Rican dwelling construction industry. These lead to the focal points regarding technological capability building in the dwelling construction industry.

A synthesis of these focal points indicates that dwelling construction for the lower income households in Costa Rica should be continued to be carried out as stated in the National Housing Program coordinated by the Ministry of Housing and Urban Settlements (MIVAH).

Table 9.1 Focal points for sectoral technological capability building

Technology stock	Human resources	Natural resources	Technology Infrastructure
> construction system (low cost, prefab, light weight, easy transport, easy handling on site)	> skills and knowledge labor force > mobilization of human resources > employment	> sustainable exploitation for building materials production	> performance of actors > interrelationship between actors

An adequate execution of the program however requires technological capability building. This implies in the first place a strengthening of the collaboration between the various institutions, organizations, enterprises and private investors in dwelling construction. The existing basis of resources (capabilities) in these organizations then can be mobilized on more efficient and effective basis to be applied in the building construction activities. The pool of "floating" human resources should be united and trained in order to enable contractors to make use of the necessary labor force upon the project needs. These actions do not require much investment. Further development of the technology stock for the dwelling construction industry should follow thereafter. The recommendations for sector level technology management then are the following.

Recommendation 1 *Continue to carry out the dwelling construction plans as stated in the National Housing Program coordinated by the Ministry of Housing and Urban Settlements (MIVAH)*

Recommendation 2 *Increase the linkages between the actors in the technology infrastructure.*

The effects of such a stronger technology infrastructure are: the enhancement of joint efforts in technology development processes; proper technology diffusion processes; the precise specification, proper selection, acquisition and application of the construction output and the required construction systems, materials and process technological components in the construction project. The private sector could increasingly collaborate with professionals, universities, R&D institutes, national and international organizations - like UNIDO, UNHABITAT, UNDP, CIB. They can form consortia that have insight in the opportunities to develop, establish and up-grade the local building materials and equipment producing and supplying organizations for the benefit of the construction project performance.

The general public and the contractors could be informed on on-going basis by means of the common communication channels (pamphlets, bulletins, newspapers, broadcasting and other means for communication). This enhances the diffusion of the available information and documentation (basic dwelling designs and engineering drawings and information on the construction process and needed inputs) among the actors of the technology infrastructure.

Recommendations to the actors in the technology infra-structure are the following.

Recommendation 3 *Extend the stock of construction technologies for dwelling construction.*

This can take place through local R&D or through international technology transfers. The last offers the best opportunities, against the lowest costs and time consumption. Alternative construction systems could be acquired, adapted to local circumstances and produced with locally available resources.

Technology developments should be pursued to extend the stock of technologies for dwelling construction with a high quality of houses, low construction complexity at low cost through either local development or through international technology transfers.

This should be done by taking into account the limited availability of natural resources, the relatively high education level in the country and the low level of skills and knowledge of the laborers on the construction sites. All actors in the construction industry are expected to contribute to establish technology development in its broadest sense. This should include the R&D institutes, the professionals, building materials producers, equipment producers and suppliers, contractors, financing organizations, national organizations and international organizations. The forgoing implies the need for collaboration and mutual support of the actors for

a. the development of construction systems, prefab building materials, components and building elements which are (1)produced with locally available raw materials, (2) low cost, (3) easy to transport and handle on site with low level knowledge and skills
b. search for appropriate and sustainable construction systems and building materials at the international market
c. the investigation of the *opportunities,* negotiation and acquisition of the non-available means for the establishment of local building materials and equipment industries - such as capital goods, management frames, financial means - at the international market.
d. the establishment of joint ventures or international agreements to start-up the local production or supply of materials and equipment
e. courses and training programs to the labor force for human resource development
f. the extension of information and documentation on technologies in the country
g. the establishment of particular organizational set-ups - such as the formation of consortia of professionals, researchers, material and equipment producers and contractors- for technology development and application in the dwelling construction projects.

Recommendation 4 *Up-grade and mobilize the stock of human resources.*

This can be achieved by the establishment of a private sector specialized employment agency in which the "floating" labor force has to be registered before they can be employed on ad hoc and temporary basis in the construction projects. The availability and quality of laborers for the projects then can be better controlled. This labor force shows a lack of skills and knowledge on the application of the construction systems on site. The pool of laborers then can be trained. They will be better prepared for their jobs on the construction sites. In this way the available human resources can be properly mobilized for the benefit of the construction industry. On-the-job training should be a component in the projects and in international technology transfer packages. This counts in particular for the pool of "floating" labor force that is hired in the construction projects.

Recommendation 5 *Exploit on sustainable basis the limited stock of natural resources*

These should serve as material input for the production of building materials and construction systems.

9.3 Implications for project level Technology Management

The Technology Mapping studies resulted in conclusions regarding the opportunities, problems and constraints to reach the desired *technological production performance* of the dwelling construction projects.

In Costa Rica this implied that the constructed houses should show an improved physique technical quality. This refers to the resistance against earthquakes and hurricanes, a better in-house relative humidity and less heat accumulation. The construction time should decrease and the houses should be produced at lower costs. The realization of these improvements partly depends on the strengths and weaknesses of the technology status (internal factor), which could be determined with the technology mapping results. These lead to the focal points for project level technology management to achieve an improved technological production performance in the dwelling construction industry for the lower income households summarized in table 9.2.

Table 9.2 Focal points for technology management at project level.

Product technological features	Process technologies	Material inputs
* maintain type of houses > physique technical details > lower costs > simplification site production process	* maintain low capital tools & equipment > human resources skills & knowledge > information & documentation > organiz. framework: control & planning	> timely availability > quality > prefab materials on site < import content of materials > materials information & documents
Project setting: > site accessibility > taking into account climatological and location bound aspects > financial means > mass construction of houses		

A synthesis of the above focal points for technology management at project level indicates that dwelling construction for the lower income households in Costa Rica should increasingly be executed in mass construction projects with the application of prefab construction systems. These should comply with the physique technical requirements relative to the climate and particular circumstances at the construction site. These systems should be produced by making use of the available natural resources and human resources, at low cost, light weight, easy to transport, to handle and assemble on site. The bamboo construction system corresponds with these requirements for a great deal. Recommendations for the management of construction projects are the following.

***Recommendation 1** Continue and increase the execution of dwelling construction in mass construction projects to take advantage of economies of scale.*

The *project setting* should be facilitating for the achievement of the mentioned requirements. A number of dwelling construction projects take the advantage of economies of scale through the construction of a number of (similar) houses at a time by using prefab construction systems. This is already the case for the majority of the houses built within the framework of the National Housing Financing System.

***Recommendation** 2 Take the particular locational and climatological characteristics like earthquakes, hurricanes, and landslides during heavy rains into account while preparing the project design and engineering details.*

The locational and climatological characteristics form a constraining factor in the project setting and there is no way to change this situation for the project executing parties. These aspects are unfortunately not always taken into account.

***Recommendation** 3 Continue to involve the house owners and their relatives in the construction process*

This will increase the affordability of the houses. The house owners can for example pretty well carry out the finishing of their houses provided that proper instructions are given.

***Recommendation** 4 Take care of the availability of professional instructions during the project execution*

The involvement of (unskilled and un-experienced) house owners and relatives in the construction process requires proper *supervision* by skilled project manager(s)

***Recommendation** 5 Continue to use low capital tools and equipment in the mass construction projects.*

The projects should make use of process technologies composed of a set of low capital tools and equipment; a tailor made availability and quality of labor force; adequate information and documentation systems and a proper organizational framework, in order to keep the houses affordable for the lower income households. This is not always the case in Costa Rica.

***Recommendation** 6. Apply prefab construction systems at a larger scale*

The use of low capital tools requires the application of prefab systems on larger scale to simplify the construction processes on site. The type and quality of the materials and building components that are presently used in the projects are not optimal for the achievement of the desired standard quality of the construction output by using the described process technologies.

***Recommendation** 7 Take the advantages of using information and documentation systems*

Information is needed to be able to select and acquire the right materials and apply these properly in the construction project. Project documents, specifications and progress reports are indispensable to avoid misunderstandings among those involved in the project execution, and mishaps in future projects that may have a negative impact on the technological production performance.

***Recommendation** 8 Enhance and stimulate the improvement of the knowledge and skills among the labor force.*

A large number of the labor force is employed on temporary basis and the investment capacity of the contractors is generally limited to the organization of training by themselves. The improvement of the knowledge and skills among the labor force then could be achieved through courses and training programs offered by building materials and equipment suppliers to groups of laborers, which are registered with specialized employment agencies for the construction industry

***Recommendation** 9 Closely collaborate with professionals (architects, engineers and consultants) and suppliers of materials and equipment*

These can provide the proper specifications of the building construction details on site in order to achieve an improved physique technical performance and a higher durability of the houses.

A successful implementation of the above recommendations for project level improvements highly depends on external factors. Technological capabilities form the major part of the external factors that have an impact on the technological production performance.

Technological capability building in the dwelling construction industry for the lower income households is hampered by a number of constraints. The effective demand for houses in the lower income housing market segment is low due to the fact that the customers have a low or even a negligible investment capacity (without government intervention). Government interventions in the housing market may enhance the market demand thanks to subsidies. At the same time these may set a rather tight framework in which the contractors have to built houses due to tight building regulations. In such a situation contractors are urged to produce houses with a high quality standard and at the same time at low cost for this market. Their profit margins will be marginal unless they invest in technology developments (product- and process innovations) that contribute to the production of houses with a larger profit margin. The problem is that the incentives are lacking to operate like this for most contractors and their investment capacities are limited either.

Specific strategies at national level (regulations, financial and fiscal incentives) should enable and stimulate Technological Capability Building in order to improve the technological production performance. A favorable national technology setting will have a positive impact on the technological production performance of the dwelling construction projects.

9.4 Implications for Technology Policy at national level

An optimal effect of the efforts to up-grade the technology capabilities for a sector can only be reached through a supportive national environment. The government is supposed to have the willingness and the ability to dedicate its policy plans and efforts to the development of a technology creative system (technology structure and infrastructure). The promoting and constraining features of the national technology setting were determined with the technology mapping studies. These lead to the following focal points for technology policies at national level.

Table 9.3 Focal points for technology policies at national level.

Economic	Political	Education	Phys.Infrastructure	Housing
> employment generation > income distribution > diversification of the production structure > industrial production < government budget overruns	> policy structure, regulations and legislative environment < tax regulations for foreign investments < joint ventures pilot national production < bureaucracy	> skills and knowledge on site construction activities > management skills < investment	> transport & communication Network	> quantity of houses > quality of houses > lower costs

A synthesis of the focal points indicates that -given the present national economic setting- any technology policy should imply an implementation at low (local) investment costs. Priority should be given to employment and income generating activities, which are integrated in the programs for human resource development, the improvement of the physical infrastructure and the quality and quantity of adequate and affordable houses.

The strategies to be followed should also integrate the proper legislation and regulation of particular activities- without harming the flexibility of operations- and in the form of fiscal measurements like tax holidays on investments.

The present policy structure, legislative and regulative system in Costa Rica should be adapted to create a better enabling environment for the improvement of the dwelling construction industry.

***Recommendation 1** Stimulate economic development*

a. stimulate employment and income generating activities by the formulation of adequate regulations and legislation like fiscal incentives for example for foreign investments -to circumvent the missing components for the start-up of production- under equitable terms and conditions.

b. improve and diversify the production structure by stimulating the economic activities in promising sectors -like for example tourism and the information and communications sector- which also improve the trade balance and generate foreign exchange. Hereby taking into account the relatively high education level of the Costa Rican population. In other words: *further exploit the available brains*!

c. Make use of the favorable climatological and locational features in Costa Rica for economic activities in sectors such as forestry, horticulture and tourism on sustainable basis.

d. The potential contribution of the construction industry should not be neglected. Investment in the construction industry pays off thanks to the forward and backward linkages of this sector.

e. Stimulate the increase of quality and quantity of the production output related to the construction industry by making use of an efficient and effective exploitation of the limited natural resources, further industrialization, standardized, and mechanized production of prefab components and building elements.

***Recommendation 2** Improve the existing policy structure, regulative and legislative system to become less bureaucratic, adaptable to changing circumstances and more supportive for the production sectors including the construction industry.*

a. Decrease the government budget overruns and the extensive government apparatus.

b. Establish a full data set with both socio-economic and technological data on the performance of the production sectors and the dwelling construction industry. These data sets should be maintained on regular basis in order to be able to adapt the policies and regulations to changing circumstances.

c. Formulate proper policies and regulations based on proper detailed data on the existing situation.

Given the less favorable economic situation in the country the implementation of the policies should take place at low investment costs. For example by establishment of particular tax regulations for the benefit of the construction industry and other related economic activities. This implies for example fiscal incentives like tax exemption as a mode to stimulate the collaboration between the various parties in production sectors

Recommendation 3. *Stimulate the improvement of the training and education system tailor made for the construction industry.*

a. Since the economic situation does not allow much investment in social services from the national budget, the government should stimulate on-the-job training opportunities

b. Establish particular regulations and fiscal benefits for enterprises and organizations offering learning by doing facilities.

Recommendation 4: *Improve the physical infrastructure.*

a. This requires relatively high investments on the other hand the forward and backward effects of improvements on the physical infrastructure will pay off.

b. In dwelling construction projects the project executing parties could get a building permit with the prerequisite that they take care for the development of the physical infrastructure in and around the project site.

Recommendation 5 *MIVAH should continue its tasks as a dwelling construction coordination unit.*

The MIVAH should continue to support, stimulate and coordinate the strengthening of the technology infrastructure in the country for the further development of technologies and an improved performance of the dwelling construction industry.

Recommendation 6 *Establish specialized private sector employment agencies to register and control the availability and quality of the labor force in the construction industry.*

Recommendation 7 *Train the labor force and further develop low cost prefab construction systems that are durable, sustainable, easy to transport and handle and have a low import content should get a primary attention.*

These both can be achieved by local development efforts or through international technology transfers for example by entering joint ventures with foreign industries. A primary condition in a joint venture agreement should be the transfer of knowledge and skills concerning the production processes and the proper application of the production outputs on the dwelling construction sites.

Information, guidelines and short training programs given by the building material and equipment producers and suppliers to the purchasers (contractors, labor force and individual investors in building construction projects) will contribute to mobilize and develop the pool of human resources. In this way the local manpower can be trained and given an improved access to the needed information, knowledge and skills for building materials and equipment production and dwelling construction. The benefit of such an activity is twofold: (1) the suppliers attract a number of purchasers for their products, (2) the clients gain knowledge and skills on the utilization and application of the products on the building sites. Employment and income for the local population then can be secured, which increases the affordability to acquire a decent house.

9.5 Concluding remarks

Costa Rica has to face an increasing need for adequate and affordable housing. At the same time problems and constraints for improvement of the technological production performance in the dwelling construction sector for the lower income households occur at the different levels of economic activity and are strongly interrelated. The Costa Ricans have made a reasonable progress in technology development and technology capability building for the construction industry. Despite this there are still a number of weaknesses that form a constraint to an optimal performance of the dwelling construction industry.

Technological capability building and the improvement of the technological production performance in the dwelling construction industry is hampered by major constraints at national level. A major constraint is the lagging economic development in the country. Therefor solutions should be sought in activities directed to income generation which are heavily supported by the national policies. Attention should be directed to find solutions in which all these are integrated.

In Costa Rica one can make use of the relatively highly educated population. The limited available natural resources should be exploited in a sustainable way to serve as the necessary inputs in the production processes.

The technology management in project organizations should be focused on making use and up-grading of the available human resources. The project organizations should collaborate with the local R&D institutes and professionals to adapt the technologies to the local circumstances and changing requirements in the market. The project organizations should also inform and train their manpower, customers and users on the proper application of their processes, products and services.

In this way the country gains from the increased stock of product- and process technologies, an improved level of skills and knowledge, improved linkages in the technology infrastructure of various sectors, including the construction industry, employment and income generation and ultimately an improved technological production performance and supply of houses.

This all should get full support of the *national government,* which should become evident in an adequate policy structure, regulations and legislative environment in which the production activities take place. Technology capability building can take place provided that the national government (a). is willing to change the existing policy structure and regulative and legislative setting and (b). stimulates the promising sectors in Costa Rica - by means of the policies and regulations-.

Adequate government policies, regulations and legislation, adequate technology management could be based on full information regarding the actual status of technology and technology capabilities to exploit and expand the available national resources to the benefit of the technological and economic production performance. Technology mapping studies are indispensable for technology management and technology policy planning and should be put on the research agenda in the country.

Part IV

research design
tanzania
costa rica
IV conclusions

Conclusions

Contents

Chapter 1

Comparison of the results of the technology mapping studies in Tanzania and Costa Rica

1.1 Introduction

The results of the application of the Technology Mapping Methodology in the dwelling construction industry in Tanzania and Costa Rica were given in the foregoing parts II and III. The subject matter addressed in this part of the thesis is the question of validity and usefulness of the developed technology mapping methodology for technology management purposes.

The results of its application in Tanzania and Costa Rica will be compared first before conclusions are drawn regarding the usefulness of the technology mapping methodology. Indices were constructed for the core concepts of the technology mapping methodology by applying a rating scale to the found data.

It is expected that the comparison of the indices shows whether the theoretical viewpoints regarding the impact of technological capabilities and the technology status in the projects on the technological production performance corresponds -to a reasonable extent in a predicted way- with the results of the studies in this thesis. It is taken into account though that the number of investigated countries in which the technology mapping studies have been carried out is only limited to the two.

The evaluation of the experiences with the application of the technology mapping methodology is discussed in the chapter that follows next. The core question in that chapter is whether the developed methodology is a useful tool to support technology management and policy formulation. It should be generally applicable for a systematic analysis of technological capabilities and the technologies in use in production systems irrespective of sector, region, nation or time.

1.2. The Technological Production Performance (TPP) in the Tanzanian and Costa Rican dwelling construction industry

The index for the Technological Production Performance in the dwelling construction sector for the lower income households in Tanzania was 1.27 while the TPP in Costa Rica was 4. (0<TPP<10).

The technology mapping studies revealed that this difference in performance can be explained by the rate of *technology effectivity and efficiency* that was achieved in the dwelling construction sector. (TPP = *f* (T*effect* x T*efficy*)

The index for the technology effectivity in Tanzania was 0.12, while that in Costa was 0.14. (0<Teffect<1). The technology effectivity represents the rate to which the *quality* requirements (adequacy and affordability) of the houses and the *quantity* of the actually needed houses were met.

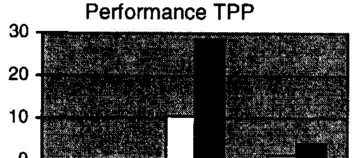


fig 1 Technological Production Performance TPP

	Teffectivity	Tefficy	TPP
□ Tanzania	0.12	10.6	1.27
■ Costa Rica	0.14	28.6	4

The *quality* of the output of the dwelling construction processes in Tanzania does not meet the basic requirements that are stated in the Tanzanian Building Regulations. This means that maintenance, repair and substitution of building components are nearly all the time needed, which may imply a true waste of investment. The present *affordability* of the houses is higher in Tanzania than in Costa Rica, although this counts only for the initial costs for the construction of the house. In Costa Rica the quality of the houses does not require additional investments beyond the normal maintenance expenses for a period of 25 years. However the houses are not affordable for the lowest income households in Costa Rica without support from the national financing system (SFNV).

It is remarkable that in Costa Rica only 16-18% of the needed *quantity* of houses is produced while in Tanzania approximately 20% of the needed houses is produced on annual basis. This last (estimated) figure is questionable though and is assumed to be too high. Nevertheless it does not change the average low effectivity rate for Tanzania.

The Technological Production Performance (TPP) results are achieved with a *technological efficiency* rate in Costa Rica of 28.6, while in Tanzania the technological efficiency was only 10.6. (0<T*efficy* < 100). The index for Technology efficiency is composed of the rating for the Production Process Technology (Procestec) and the rating for the type, quality and availability of the Material inputs (M*input*) in the process. (T*efficy* = *f* (M*input* x Procestec)

An important factor to which the relatively low score for technology efficiency in Tanzania can be attributed is the *materials input score* in the construction projects. In Costa Rica the scores for the type, quality and availability of the materials input are higher (5.5) than those in Tanzania (4.06).

The explanation for the higher materials input score in Costa Rica compared to Tanzania can be found in the fact that a large part of the houses in Costa Rica are built with prefab construction systems. Building with these systems contributes to a higher quality and quantity of output. Besides the requirements for process technologies on the construction site for these systems are less than for the traditional or conventional construction systems.

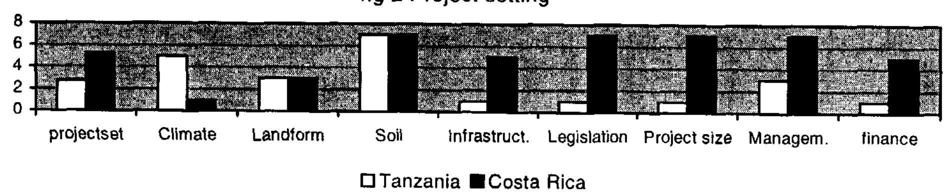
Despite this the level of the *process technologies scores* higher in Costa Rica(5.2) than in Tanzania (2.61). In both countries only simple tools and equipment are used and the labor force on the construction sites shows a lack of sufficient skills and knowledge. A merit for the Costa Rican construction sector is that the level of project organization and the availability and application of information and documentation on site has increased and is higher than in Tanzania.

In Tanzania the majority of houses is built with the soil-cement blocks masonry system, which requires quite some knowledge and skills of the labor force on site. At the same time the largest constraint in Tanzania is the lack of knowledge, skills and experience of the labor force. The situation is even worse since the construction of the houses takes place in the informal sector with a minimum level of information and documentation, a low level of project organization and a limited availability of tools of rather simple nature.

Stimulation of the application of prefab construction systems on the construction sites may contribute to a higher technology efficiency.

The project setting that is the direct environment in which the project takes place also has an impact on the technological production performance A description of *the project setting* in qualitative terms indicates the promoting and constraining factors in the direct project environment. A comparison of the rating of the features of the complex of variables that constitutes the project setting shows that the project setting in Costa Rica is more favorable than in Tanzania. (0<projectset<10, see figure 2)

fig 2 Project setting



The *climatological and geographic* circumstances form a relatively constraining factor for the technological production performance of the dwelling construction projects. This counts more for Costa Rica than for Tanzania. Both countries are located in a similar climatological area with high relative humidity levels. In Costa Rica, however, one has to deal with earthquakes and hurricanes. These require more precautions for the construction of the houses, which increase the costs of the houses.

The *landform* is in both countries is characterized by its differences in height, many slopes on the sites that require in many cases an extra effort regarding the site preparations and leveling of the project site. This implies a need for heavy equipment, which is not always available and affordable, consequently forming a constraint to the project performance.

The *soil conditions* in both countries do not require specific attention for the dwelling construction projects. The houses are rather small and simple strip foundations will do in most cases.

The *legislative environment* forms a constraining factor in the project setting in Tanzania. The house owners often have occupied non registered land on non-legal basis. This harms their access to all kinds of facilities.

Also the *size of the projects* in Tanzania has a negative impact on the technological production performance. In Costa Rica the houses are in most cases built in mass construction projects. This enhances a shorter production time, more standardization, less labor input and lower costs thanks to economies of scale.

The *financial situation* forms a true burden for optimal production performance in particular in Tanzania where the population has to rely on own sources of finance for their houses. Thanks to the national financing system for housing in Costa Rica the situation is less constraining for the lower income households provided that the national budget admits to continue and -even more desirable - to expand the expenditures on social dwelling construction.

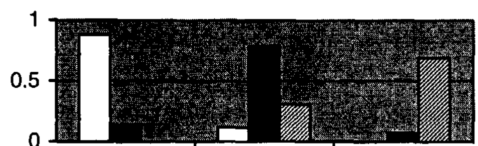
A major difference in the project setting between Tanzania and Costa Rica is the *project management.* In Costa Rica this is in the hands of experienced and skilled project managers, while in Tanzania the houses are built by the house owners who act in the majority of cases as project manager themselves. They are responsible for the choice of the product- and process technologies, for the selection and acquisition of materials, for hiring the labor force unfortunately often with too limited knowledge and skills to do it properly. The conclusion was that legalized building in mass construction projects with proper project management provided with sufficient infra-structural facilities and financial means contributes to an improved technological production performance. For these last aspects the construction units depend on external factors and actors.

The analysis of the Technological Production Performance (TPP) on project level gave insight in the internal project factors (the underlying attributes of the product and process technologies and the project setting) that result in a certain level of TPP. This provides a possibility to determine the strategies to improve these internal project level factors.

1.3 The status of technological capabilities (STC) in the Tanzanian and Costa Rican dwelling construction industry.

The Technological Capabilities were theoretically regarded as the major external factor that has an impact on the project level production performance. A comparison of the technology mapping results on the Technological Capabilities might endorse this viewpoint.

fig 3 Construction systems in Tanzania and Costa Rica



	traditional	conventional	advanced
□ Tanzania	0.88	0.12	0
■ Costa Rica indiv. Proj	0.14	0.79	0.07
▨ Costa Rica mass	0	0.31	0.69

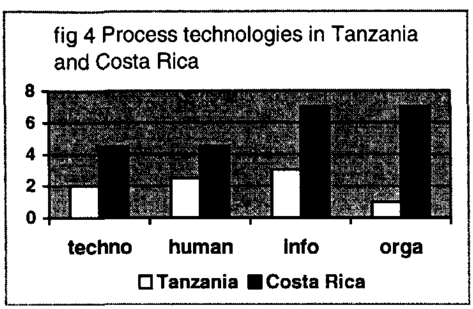
The technology stock

The *product technology stock* for dwelling construction is assessed upon the occurrence (availability), the type and the quality of construction systems.

The construction systems are classified in traditional, conventional and advanced systems.

The range of construction systems that are in majority available and utilized in housing construction in Tanzania can be ranked in the lower class of technological advancement as traditional systems. The houses are still mainly built with the traditional construction systems (88%) throughout the country. The foundations, walls, floors and roofing structure are in 92% of the cases still built traditionally. Only the traditional roof finishing (thatch) has been substituted by the metal roofing sheets in particular in urban areas (67%) and other materials like the ceramic and concrete tiles.

In Costa Rica the construction system technologies utilized in housing construction for lower income households can be ranked in the more advanced class. Only some 14% of the houses is still built on the traditional way by applying the timber and zocalo systems. The individually built houses are in majority built with the conventional concrete blocks masonry system, the rest with the advanced prefab systems. A higher percentage is built with the advanced prefab systems than with concrete blocks in the mass construction projects of houses. The innovations in the construction systems applied to the dwelling construction projects were predominantly enhanced by the desire to achieve a higher value added per unit of produced item.



The indices for the characteristics of *the process technology* components that are used in dwelling construction projects in Tanzania and Costa Rica show that in Costa Rica more progress has been made with regard to the level of advancement of the process technology components. This is delineated in figure 4.
(0< Procestec stock<10)

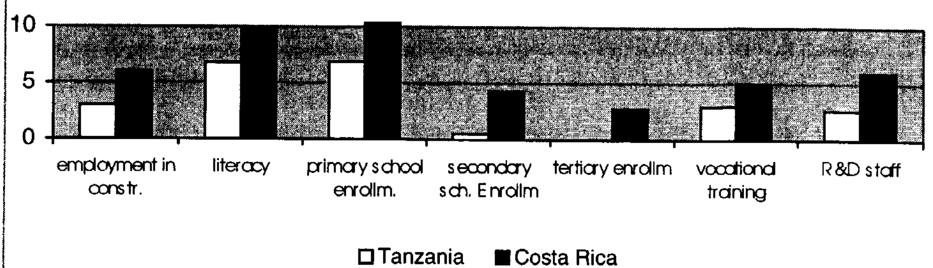
The search for a faster completion of the projects, decreased inputs of raw materials, the reduction of overall construction costs, reduction in skilled labor requirements, easier application of modern management techniques, improvement of the quality of the final product formed the incentives to develop the new process technologies and construction systems in the construction industry. The innovation of construction systems implied that the actual production of the houses partly moved from the construction site to the factory. This happened in many industrialized countries, in Costa Rica as well, but is not yet noticeable in Tanzania.

The stock of human resources in construction

Compared to Costa Rica Tanzania has the advantage of a *population size* that is ten times larger. In Tanzania (40%) and in Costa Rica (33%) the *age structure* shows a relatively large percentage of young people. The relatively large population size in Tanzania forms a favorable market and the number of young people forms an enormous potential of labor force for all productive activities. These valuable resources are not fully exploited though. The problems in Tanzania concern the low life expectancy and the lack of skills and knowledge among the population due to an insufficient health and education system that are reflected in a low labor productivity. The variables that constitute the status of the present human resources stock in the construction industry are rated as delineated in figure 5.

The employment in the construction sector as percentage of the total employment in Tanzania is officially not more than 1%, in Costa Rica this is 6%. (see part II and part III chapter 3)

fig 5 Human resources stock for construction in Tanzania and Costa Rica



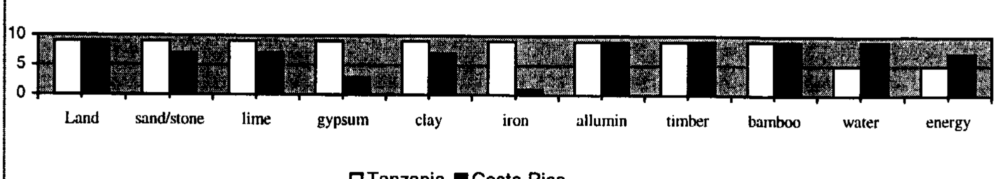
The difference in *level of knowledge and skills* in Tanzania and Costa Rica is reflected in the literacy rate and the enrollment figures in different levels of the education system. The ratio between the total third level teaching staff in Tanzania, Costa Rica (T:CR= 1:10) indicates the existing differences in education opportunities in the countries. A relatively high percentage of the total labor force is not formally trained in Tanzania and a number is trained on-the-job. In Costa Rica too the training of the labor force on the construction sites is not sufficient.

The percentage of scientists and engineers of total population is in Tanzania very limited (0,0026%). The same applies to Costa Rica where this percentage is 0,006% of the total population while in a country like the Netherlands the percentage is 2,5%. (UNESCO 1995) These figures indicate the limited availability of *labor force for technology development* in the countries.

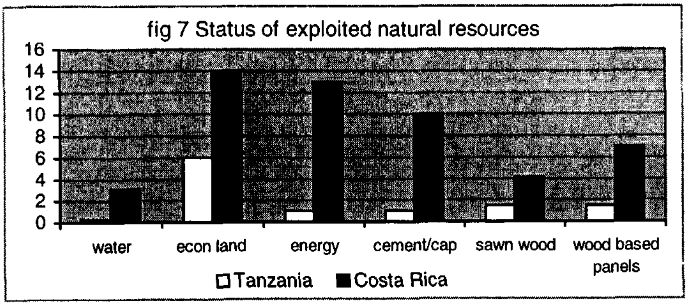
The status of the Natural resources stock

The *land area* in Tanzania is some 17 times more than the land area of Costa Rica. The percentage of *forest areas* in Tanzania is about 1.5 times higher than in Costa Rica. The availability of *mineral resources* in Tanzania is higher than in Costa Rica. (See part II and part III)

fig 6 Available natural resources for construction



The exploitation of these, however, is poor in Tanzania. This can be noticed from the indices of the status of exploited natural resources that are relevant for dwelling construction in the countries. Secondary sources were used for the indices (UN industrial statistics (several issues), the UNDP statistical year books 1990-1992; the UNDP Human development report 1992; several issues of the World bank World tables).

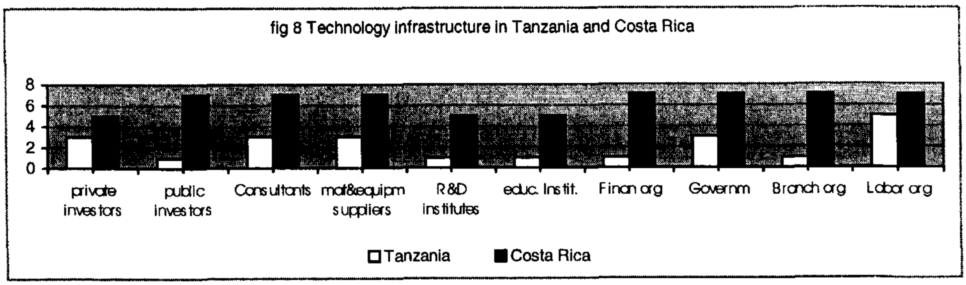


The limited natural resources are next to the limited financial resources and a relatively small local market in the country, the major constraint for the construction industry in Costa Rica. 32% of the total imports in Costa Rica involved the imports of raw materials; 17% of total imports involve the imports of capital goods. All metal products - like the reinforcement steel and metal roofing sheets- are basically imported, while for roofing the metal roofing sheets are being used in 99% of the cases.

Despite this, Costa Rica has made progress in utilizing the available stock of natural resources for construction activities. The renewable water resources in use per capita in Tanzania is only 10% of that in Costa Rica. The economic land-use in Costa Rica is 2,5 times higher than in Tanzania. The local energy production and consumption per capita as well as the local production of cement is higher in Costa Rica than in Tanzania. The production of sawn wood and wood based panels is also higher in Costa Rica than in Tanzania, although this forms a negative point in terms of sustainability for Costa Rica. Deforestation still takes place at a high pace in Costa Rica (nearly 7% per annum). In Tanzania this percentage is only 0.3 %. (See data in part II and part III)

The status of the technology infrastructure

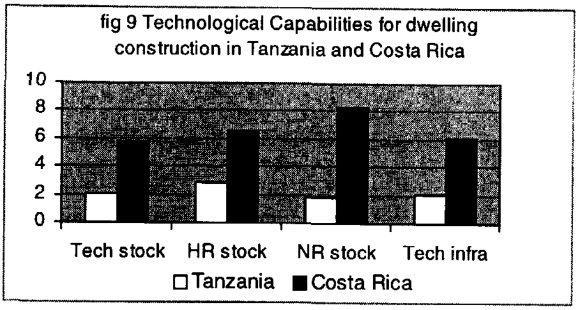
The investigations on the technology infrastructure of the dwelling construction sector for the lower income households in Tanzania and Costa Rica showed that the individual performance of the actors is in Tanzania rather disappointing. (see part II chapter 3)



This is also the case for the linkages between the various participants in the dwelling construction sectors. The project executing parties in Tanzania have predominantly connections with the informal sector organizations. In Costa Rica the participating actors perform better, though still not optimal. The linkage between the actors is stronger in Costa Rica than in Tanzania. This might be due to the limited size of the country and its population.

The indices for the status of the technology infrastructure ($0< Tinfra<10$) give evidence of this situation. (see figure 8)

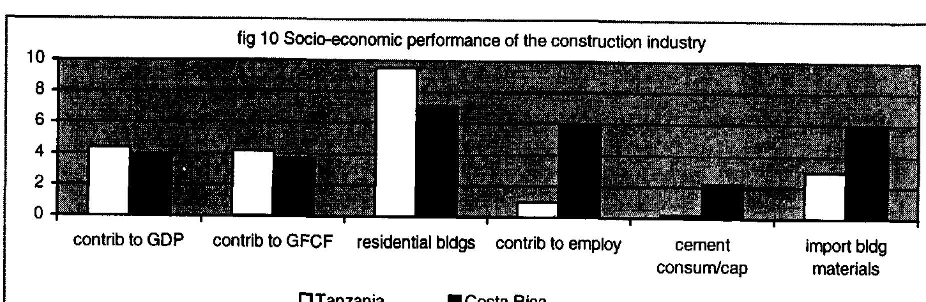
The conclusion on the *technological capabilities for dwelling construction in Tanzania and Costa Rica* that can be drawn from the comparison of the indices is the following.
The present status of the *technological capabilities for dwelling construction* (the stock of national resources that can be committed to dwelling construction) is better in Costa Rica than in Tanzania. (see figure 9, whereby 0<Tech stock<10; 0<HR stock<10; 0<Nrstock<10; 0<Tinfra<10)



However, the Tanzanian situation regarding the potential technological capabilities is promising , when the stock of natural and human resources that is not yet exploited is taken into account. The technological capabilities in Costa Rica, can be up-graded by further development of the reasonable stock of technologies and human resources and an intensification of the collaboration between the actors in the technological infrastructure of the construction industry.

1.4 The sectoral socio-economic performance in Tanzania and Costa Rica

The Technological Capabilities, the status of technologies in the construction projects and the resulting technological production performance are considered to be reflected in the socio-economic performance of the dwelling construction industry. The indices used in figure 10 show the socio-economic performance of the dwelling construction sector and its importance as a part of the construction industry.
Dwelling construction contributes to a large extent to the economic performance of the construction industry in Tanzania and Costa Rica. This does not become clear from the



official statistics in Tanzania since the majority of the dwelling construction projects (95%) take place in the informal sector. (The indices in the chart include the informal sector figures)
In Costa Rica an average of 71% of all construction output (m2) is in dwelling construction.
The contribution of the dwelling construction industry to GFCF and the percentage of needed houses constructed on annual basis is higher in Tanzania than in Costa Rica. This is in line

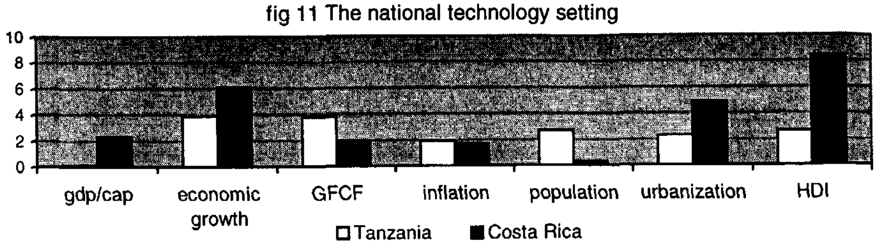
with the project level finding of the comparison of the technological output of the dwelling construction in both countries.

From the figures on cement consumption can be concluded that the application of relatively newer materials like cement and cement products are higher in Costa Rica than in Tanzania. Only in urban areas like Dar es Salaam the sand-cement block masonry is applied on larger scale in dwelling construction. Both countries import a large percentage of their building materials. In Tanzania this is due to the low exploitation level of the available natural resources. In Costa Rica the relatively high import content of building materials in building construction projects can be attributed to the limited availability of local natural resources.
In both countries this enhances a vulnerability of the construction industry to international market dynamics.

1.5 The national setting of Tanzania and Costa Rica

The national setting in which the dwelling construction takes place has an impact on the Status of the Technological Capabilities, the technology utilization in the projects and the Technological Production performance.
Tanzania and Costa Rica are both located near the equator with more or less the same tropical climatological circumstances and with the same kind of differences in height. A constraint in Costa Rica is formed by natural disasters due to frequent volcanic outbursts, earthquakes, land slides after heavy rains and hurricanes. Both countries were colonized, which is reflected in various aspects of the national culture - although Costa Rica became 140 years before Tanzania an independent state.
Tanzanian *size of population* is nearly ten times larger than that of Costa Rica. On one hand this is favorable in terms of potential labor force for its productive activities. On the other hand the relatively small size of Costa Rican land area and its population facilitates policy making in the country. Ethnic homogeneity is large in Costa Rica and despite the many tribes in Tanzania the population is living in peace together.
The rate of *urbanization* is higher in Costa Rica than in Tanzania. This puts Costa Rica in a backward position compared to Tanzania in terms of the pressure to meet the demand for houses in the towns.

fig 11 The national technology setting



The status of the *physical infrastructure* forms a real constraint for an improvement of the technological production performance in Tanzania. (Part II-7) This situation is better in Costa Rica although it is not optimal -compared to the level in other countries in the world- to benefit the technological production performance in various sectors including the construction industry. (Part III-7)

The *economic situation* forms a real problem in Tanzania. Although in Costa Rica the situation is better still the investment capacity is not sufficient to provide for all social needs like education, housing and improvement of the physical infrastructure in the country. This on its turn has a negative impact on the construction industry.
Regarding the *political orientation* can be noticed that both countries have a socio-democratic signature with an open market economy in which not all protective measurements for the local production activities have been abandoned. Tanzania has formulated development policies for the construction industry and the building materials industry, but the country lacks the (economic) power to implement all necessary strategies. In Costa Rica the construction industry has not been given particular attention in the national policy plans, only policies on other sectors -like the national housing plans- implicitly have an impact on construction. (See part III)
From the *human development index* (HDI) of both countries (Tanzania 0,268 and Costa Rica 0,842 in 1993) can be concluded that the national setting of Costa Rica offers more opportunities for improved dwelling construction than the Tanzanian setting. Most promising factors of the national setting in Costa Rica are the relatively small size of the country and its population that is relatively highly educated. A most constraining factor in this country is its lack of *natural resources*, the high reliance on the agricultural sector production and the relative low industrialization -predominant production of consumer goods-, although industrial production has increased during the last decades. In Tanzania the promising factors are the abundance of land area, the low density of population and the relatively large potential of natural resources. A burden in Tanzania is the investment potential, the rather low level of industrialization -reflected in the electricity consumption per capita- and the relatively low education level of its population. This makes it rather difficult to break the vicious circle of low level development, low level of technological production performance -such as that in the construction industry - and the increase of social needs like education and decent housing.

The industrial and enterprise's performance in the countries depend on the interaction of the conditions of the home country and their overall performance in the global setting (Porter 1986). In terms of international trade Costa Rica scores better than Tanzania. Both countries have good international relations. This becomes visible in the support from international funds for the local investments.

1.6 Conclusions and implications for technology management

Tanzania and Costa Rica have to face a tremendous *housing problem.* This housing problem can to a large extent be attributed to the diminishing volume of resources that are necessary for the construction of adequate shelter for all sections of society.

In both countries the *technological production performance (TPP)* is not sufficient to meet the actual need for housing in particular for the lower income households. This TPP results from the *status of technologies (STP)* that are used in the construction projects. The present *technological production performance* at construction project level can be attributed to the *status of technological capabilities (STC)* in the sector. The status of technological capabilities (STC) is equated with *the stock of national resources* that can be committed to the dwelling construction industry in the countries appears to show a number of weaknesses.

The situation as described is noticeable in the socio-economic performance of the construction industry in the countries. The dwelling construction industries in both countries take a relatively large percentage of all construction activities. But their socio-economic performance requires improvement. The national technology setting in both countries is not favorable for an optimal performance for the construction industry particularly in economic sense. The socio-economic development status in Tanzania is remarkably lower than in Costa Rica given the HDI figures.

From the above can be concluded that the technological capabilities that are held responsible for the Technological Production Performance in the sector is not optimal. (see fig 4.1, whereby 0<TCAP<10). This status of the technological capabilities is reflected in the limited scores for the Technological Production Performance in the sector. (see fig 4.1,whereby 0<TPP<10)

A ***remarkable finding*** is that the ratio of the socio-economic development status in the two countries expressed in the Human Development Index (HDI) corresponds with the ratio of the status of Technological Capabilities and the ratio of the Technological Production Performance. This is an endorsement of the theoretical views adhered to in this research project.

Table1.1 A comparison of the Technology Mapping results in Tanzania and Costa Rica

		STP		**TCAP**					**HDI**
	TPP	Teffect	Tefficy	**Total TCAP**	Tstock	HR	NR	Tinfra	
Tanzania	**1,27**	0,12	10,6	**2,2**	**2,1**	**2.9**	**1,8**	**2,1**	26,8
Costa Rica	**4**	0,14	28,6	**6,6**	**5,75**	**6,6**	**8,3**	**6,1**	84,2

Implications for technology management

It is clear that both countries are encountering serious problems in providing adequate shelter. Given the limited status of technological capabilities a most obvious route to improvement of the performance of the dwelling construction sector should be sought in technological capability building:

> *It is recommended to increase the quantity and quality of the total complex of technological capabilities that can be committed to the construction sector.*

This means that technology management in the construction industry in both countries should be focussed on the

1. Up-grading of the Technology Stock (Tstock)
2. Development and more efficient and effective utilization of the available stock of Human Resources (HR)
3. Development of more efficient and effective utilization of the available stock of Natural Resources (NR)
4. Improvement of the performance of the individual actors in the Technology Infrastructure of the sector as well as improvement of the relationship between them.(Tinfra)

It should be stated that these recommendations comprise a complex set of actions that are largely interrelated.

The Tanzanian situation points at an opportunity for Technology Management to emphasize on the development of a more efficient and effective utilization of the available stock of Natural Resources available in abundance.

In Costa Rica the availability of a stock of Human Resources with a relatively high education level gives an opportunity for Technology Management to emphasize on a more efficient and effective utilization of these Human Resources for a further development of the Technology Stock.

The national setting of the countries is not very favorable. The setting is largely determined by factors not directly manageable at sector level. This has to be taken into account for the implementation of the Technological Capability Building efforts. Aspects of economic and politic-regulatory nature have to be considered.

The technology mapping studies however give a clear direction of priorities to be set to effectuate an improved living condition for the population.

The comparison of the results of the technology mapping studies in the dwelling construction industry in Tanzania and Costa Rica endorsed the theoretic viewpoints regarding the impact of the technological capabilities and the status of technologies in the construction projects on technological production performance in the dwelling construction industry.

Chapter 2

On the usefulness of the Technology Mapping Methodology for Technology Management

2.1 Introduction

The primary objective of this research project was to arrive at a *useful methodology for technology mapping*. This should serve as an adequate management tool to support the processes of management and policy making for efficient and effective production performance in sectors that contributes to the achievement of sustainable development goals in a country.

In the following sections of this chapter the attention is turned to the usefulness of the developed technology mapping methodology for the purpose of technology management and technology policy formulation in sectors like for example the dwelling construction sector.

2.2 Discussion on the developed research methodology

The theoretical framework developed and used in this research had to meet a number of requirements (see part I chapter 2)

It was meant to be *comprehensive*. It includes the major determinants that were supposed to have an impact on the level of technological production performance in a sector, in terms of its contribution to socio-economic development. The data found in this research project by means of the application of the developed research methodology made a detailed and comprehensive description of the industrial technological production performance possible.

The theoretical framework was also supposed to be *generally applicable* for a systematic analysis of technologies and technology capabilities in production systems irrespective of sector, region, nation or time. It constitutes a blueprint for the collection, measurement and analyses of the data on the technological capabilities, the status of technologies and the technological production performance in any production sector. Included in the framework are the factors of the *production environments* that are supposed to have an impact on the technological production performance.

The conditional particularities that were assumed to have an impact on the scores of the variables have been taken into account. This refers for example to the geographic conditions in the different countries in which the investigations took place. Herewith the multiple applicability of the theoretic framework irrespective of time place and sector might have been shown.

It is possible to translate the variables included into the framework into measurable units. The major concepts of the theoretic framework are for all sectors the same. The particularities of the production processes in each production sector differ however. The complex of indicators, that determines the features of the core concepts, therefor needs to be adapted to the sector in which the field application of the theoretical framework takes place.

The multi-disciplinary character of the theoretic framework highlights the relevance and need of collaboration between researchers with different disciplinary backgrounds. The framework was developed by synthesizing the relevant elements of a number of analytical frameworks that were utilized in various disciplines to carry out research on technology. (reference is made to part I-1)

The operational definitions of the core concepts point at the need to make use of the analytical tools of disciplines like sociology, economics, engineering sciences. The methods of the engineering sciences are needed for the techno metric analysis and valuation of the utilized technologies. Not all data need to be collected by one researcher however.

An emphasis was given to the techno-metric analysis in this project given the disciplinary background of the researcher.

The concepts in the framework -like technology and technology capabilities- are complex and multi-dimensional. The consequence is that more than one indicator was necessary for their analysis. This also enhances stability to the scores and it improves their validity. The different indicators were later combined into one single index.

Nominal and ordinal measurement scales are applied in the technology mapping studies. The scales that were applied to measure qualitative aspects in this research have been developed on ad hoc basis. This means that the researcher has gathered as much as possible the generally accepted and possibly formalized opinions on the topic area thereby relying on her own experience. The results were cross-checked with experienced professionals in the topic area of the study. The technique is applied with being conscious of its limitations. One of these is the particular frame of reference that the researcher may have in devising a certain score for the observation or object. The rates were discussed with experts in Tanzania and Costa Rica. This was done to be able to omit any bias to a certain extent and in order to increase the reliability of the scores, that were based on her evaluation. Pretests with the questionnaires were carried out and reverse translation of these in English, Swahili and Spanish to avoid as much as possible any additional forms of bias. Other possibilities of a bias could also be traced by investigation of additional literature and comparison of the data in these publications with the findings in this research.

A merit of the way of data collection and subsequent scaling that was applied is that the underlying information for the scores can always be traced back and thus add more information and meaning to the research results.

With regard to the *practical usability* can be said that –thanks to the relative comprehensiveness of the theoretical framework- the methodology provides a reasonable coverage of the topic under study. The developed *measuring instruments* supplied the *information* that was needed.

On the other hand -regarding aspects like time spending, costs and convenience- can be noticed that the research methodology requires a rather extensive data set that is not always readily available. In particular the technological data require in-depth surveys to get reasonable data sets. The non-existence of technological data banks -in contrast to most economic data banks- may make a research project like this expensive and time consuming.

It is worthwhile, however, to set-up and to maintain a databank for technological data for every sector in a country. Technology mapping studies offer a good opportunity to realize this .The experience is that the measuring method is reasonably easy to administer in particular by using software for spreadsheet programs.

2.3 Conclusions on the usefulness of the developed Technology Mapping Methodology

The technology mapping studies rendered valuable information on the performance of the construction industry that is found to be a useful supplement to the information from the conventionally applied socio-economic methods.

The theoretic framework is multiple applicable irrespective time, place and sector of application. The research instruments however need to be translated to the sector in which it is applied for the measurement of the variables that constitute the concepts of the theoretic framework.

The Technology Mapping studies require a close collaboration between professionals of the relevant technical disciplines with social scientists in multi-disciplinary teams

The data from Technology Mapping Studies are useful to indicate the focal points for technology management and technology policies in various enterprises, sectors and countries.

Epilogue

Part IV

Chapter 1

Chapter 2

3.1 Introduction

Curiosity regarding the phenomena around the use of technologies related to socio-economic development in nations raises many questions. The issue in this final chapter is whether this research project has contributed in lifting the seemingly heavy lid of the black box that is generally named technology in production systems.

3.2 On this research project

Technological capabilities and the status of technologies in production processes are core elements for competitiveness of production sectors and societal development in a nation. Mapping of the technological capabilities and the technology status in production processes is thus needed, once this theory is adhered. The resulting mapping data should support technology management and policy interventions to guide the production performance in the sectors into the desired directions. This research project was centered at the search for and development of a useful methodology for Technology Mapping.

Literature investigations revealed that insight in the technological capabilities and the technology status in production processes could not to be gained through the execution of the conventional mono-disciplinary studies on the performance of production sectors. (research question 1)

Based on further extensive literature studies a research methodology for technology mapping could be developed that is considered to be applicable in any production sector. The major determinants of technological capabilities, the status of technologies in production processes, the technological production performance in an industry and its contribution to the socio-economic development targets were identified. (research question 2)

The operationalization of the theoretic framework of the developed technology mapping methodology needed adaptation to the particularities of the industry that is investigated. (research question 3)

The application and testing of the research methodology in the dwelling construction industry in Tanzania and Costa Rica took place during several field studies in a period of four years. During this period adaptations to the basic research methods could be made where necessary. The usefulness of the methodology could be ascertained after all. (research questions 4, 5 and 6)

Evidence for this could be noticed from the achievement of the second objective of the field application: The strength and weaknesses of the technological capabilities, the technology status and the technological production performance in the dwelling construction industry for the lower income households in urban Tanzania and Costa Rica could be identified in a comprehensive way.

The findings of this study correspond with the general statements in literature on the performance of the construction industry in many developing countries. This performance is unfortunately too often below expectations. (see appendix IV)

A most problematic situation regarding housing and the performance of the dwelling construction sector -such as delineated in several publications- was found in Tanzania. There is a lack of progress in this situation, thus action is required at corporate, industry, national and international level. The results of this research have shown that Costa Rica has been able to make a move forwards in improving the contribution of the construction industry to the alleviation of the housing problems in the country.

A *remarkable finding* was that the difference in the performance of the dwelling construction industry in Tanzania compared to that in Costa Rica corresponds with the difference in development status between the two countries.

A comparison of the findings of this research project with the existing literature on the construction industry in developing countries indicated further that -as far as could be noticed - most studies only partially covered the various aspects that are related to the performance of the construction industry. The result of this has been that recommendations for improvement of construction activities addressed only single aspects. Many factors and actors in production sectors appear to be interrelated. This necessitates a search for solutions that address the various deficiencies in the construction industry in an integrated way.

The data found in this research described the various aspects that are related to the performance of the construction industry in a comprehensive and detailed manner. The execution of the Technology Mapping Studies contributed to a better understanding of the particularities of the factors and actors regarding dwelling construction. The opportunities and constraints to develop the national construction capacity and its technological production performance could be identified as well. Further in-depth studies can be executed to assess more precisely the feasibility of the steps to be taken for the improvement of the efficiency and effectivity of the construction industry in countries based on the Technology Mapping data.

Technology Mapping Studies thus render the technological data that are needed - complementary to the economic data- for the formulation of recommendations for technology management in the sector and governmental technology policies that lead towards the desired improvements in the industry.

3.3 Final remarks

The findings of this study endorsed that the technological capabilities and technology status can be considered as the core concepts that determine the competitiveness of sectors in terms of their technological production performance.

This indicates that data sets on technological capabilities and the technology status in sectors are indispensable for proper technology management and technology policy making in enterprises, sectors and countries.

The data facilitate decision making on the priorities regarding the steps that need to be taken for technological capability building and upgrading of the technology status in production processes. These should lead to an increase of the competitiveness of the enterprises and the industry in total for the benefit of socio-economic development in the country.

The selection of a proper mechanism, such as indigenous technology development or international technology transfer, resulting in technological capability building and upgrading of the technology status in production processes will be facilitated as well.

Technology management in companies and national technology policies therefor should be based on technological data sets that are complementary to the traditionally used economic data sets.

It is recommended to establish and maintain a technological data bank for every sector in every country equal to the economic data banks.

The data sets should be derived from Technology Mapping Studies that need to be carried out in the various sectors in a country. Scholars with various disciplinary backgrounds should collaborate, since the Technology Mapping Studies have a multi-disciplinary nature with a strong emphasis on the engineering sciences.

It is a true challenge to engineers and technologists to fulfill a leading role in these studies.

A basic guideline for the execution of Technology Mapping studies is given in the appendix.

Appendix I

I	II	III	IV
research design	tanzania	costa rica	conclusions

RESEARCH DESIGN

Contents

APPENDIX I-1

Additional notes and illustrations regarding the Literature Survey on Technology related Research

Box 1.1 A Sociological View on Technology and Technology Developments as determining factors for Societal Changes

This *hypothesis* represents the most influential theory of the relationship between technology and society and is generally named the theory of "*technological determinism*".

Technology in these views is an *independent* and *autonomous* factor in society. Basic sciences, research and development result in technology development that is the cause of societal changes. (Ogburn and Nimkoff 1964, 571-5, Lynn White 1978 and Large 1980).

Schumpetrian views (Schumpeter 1934) even indicate technology as the most important factor for societal change. The different authors claim that both social structures and socio-cultural elements (values, norms, expectations) are forced to change through technological developments (reference was made e.g. to the introduction of the micro chip - Large 1980).

Remarks: Critical notes that were given on these views are for instance that

1.a society itself can make decisions on whether to adopt the technology or not. *Societal characteristics are determining for the adoption of new technologies* (Morison 1966))

2. same technologies have different impacts in different societies, depending on the location – societal characteristics- and time of introduction of the technology (See Mackenzie, D and Wajcman,J. 1990 pp6). Various authors mentioned factors that then should be taken into account while studying the impacts of technology on society. (Freeman, Clark, Soete 1982, Cooper and Clark 1982).

Conclusion: *Technology can be seen as an essential element in societal development. At the same time it should be recognized to only play a partial role in societal development processes. First and for all one should have a thorough insight in how society works, in the overall dynamics of society*

Box 1.2. Sociological views that consider the social changes determining for the technology status and technology developments

The idea behind this hypothesis is that even when science and technology development are seen as essential motors for societal development, one should have the notion that science is affected by societal forces. This was indicated by empirical findings (Barnes and Shapin 1979, Collins 1981/1982). It also has been admitted that not all technological developments are science based. *Technology thus should not be seen as a result of development in basic sciences.* The most important arguments that support the views on the social shaping of technology can be found in the publications of Ogburn and Thomas (1922/1990). They argued that technology should be seen as the result of unpredictable flashes of inspiration and inventions are inevitable once the necessary constituent cultural elements – expectations, norms, goals- are present.

Remarks: Criticism has been put forward on these theories. (reference is made to the works of Usher 1954, Hughes -1971/1983). Hughes argued that technology development seldom is a matter of great inventions rather than *a matter of modification and improvement of existing technologies and extending the scope of techniques.* Hughes based the ideas on his studies on the works of great inventors such as Edison and his development of the electric light-bulb. Individual adaptations and changes may add up to an overall important improvement in both products and production processes that result in a higher efficiency and effectivity. New technologies thus emerge from existing technologies by a process of incremental change and new combinations. These views (see also Sperry, Elmer -gyrocompass and automatic pilot development; Constant 1980- aircraft propulsion from propeller to turbo jet). correspond with the evolutionary economic theories on technology development, "technology trajectory" and "technology learning" (Arrow 1962, Rosenberg 1982). Technology is seen as an important element for further development, in particular on the *basis of existing technologies.* At the same time arguments were put forward that technologies should be considered as a development promoting factor that is embedded in a social system. The technology trajectory, which is seen as the subsequent process of technological changes and combinations was considered to be conditioned by social factors inside and outside the organizations where the technology developments take place. (see Hughes,T. on technology development in Germany I.G. Farben 1969).

Box 1.3. The sociological view regarding the total social system, including the technology system as determining factors for the technology status.

Arguments for this *hypothesis* on the dynamics between technology and society are developed around ideas of technological paradigm (Constant 1980, Dosi 1982) and technological system.(Hughes 1971, 1986, Rosenberg 1976).
The idea of the technological paradigm was taken from the Kuhnian idea of scientific paradigm. This is seen as (1) a particular scientific problem solution that is accepted as successful and which becomes the basis of future work, (2) being constituted by the constellation of beliefs, values, techniques and so on shared by the members of a given scientific community (Thomas Kuhn 1970, 1975).
Technology development in these views point at development of particular (scientific) constellation of beliefs, values, techniques and so on which are applied for the production of goods and services. Similar to the technology paradigm ideas Hughes used the ideas of *technology systems* for his explanations of the technology trajectories followed in diverse technological developments.(for example the development of the washing machine) The technological artefact (product) itself is seen as a system composed of different elements. The system is part a of a wider system, a network in different layers of aggregation.
Theories of social change from this point of view rest on descriptions of societies as systems, their dynamics and their patterns. A variety of forces (economic, political, educational) are present in the social system which may have their impact on both technology and societal development. Each of the institution based forces with their entire constellation of beliefs, values, techniques and so on (cultural components) may have a decisive impact on the *cultural need* for technology (Ogburn and Thomas 1922/1992). Also the reverse might be the case.

Box 1.4 Evolutionary economic theories

In the evolutionary theory technology developments are grouped in technological systems. The technology systems are defined as a model and a pattern of solution of selected technological problems, based on the selected principles of from the natural sciences and on selected material technologies.(reference is made to Freeman, Perez et all in Verspagen 1992)
The process of evolutionary selection is seen as being enhanced by competition. The relative competitiveness of a technology system in its selective environment is considered to determine the outcome of the process.

Technology competitiveness is considered to be related to *production performance* in terms of *production costs* and *quality of production output.*
The market demand, which varies with *income, location and time,* is a decisive factor in the determination of the production targets (in terms of costs and quality) and plays an important role in the competitiveness of a technology system.
The more recently developed ideas are that technology competitiveness reflected in production performance and the efficiency and effectivity of meeting the market demand is related to the available technological capabilities in the production environment.
The evolutionary way of looking at the world takes heterogeneity of individuals (and thus firms, sectors and nations) as the starting point and when applied to economic processes it leads to an explicit dynamic representation of the market processes. This closely meets the points of criticism to the use of market equilibrium as a regulatory mechanism in the neo-classical economic models.

Box 1.5 The neo-classical economic theory and the production function model to explain the role of technology in the economy

The *efficient production technologies* are considered to form a set of combinations of production factors which yield a maximum of production output of a certain good. A certain combination of production factors is directly related to a certain maximum of production output. The production function is thus considered to be an unambiguous figure of the set of quantities of production factors in the set of produced output quantities.
The *set of technological possibilities* from macro-economic point of view exists outof the micro-economic balance solutions, which in one hand depend from the ex-ante micro economic production function and on the other hand from the mechanism with which the balance situation is created. The *results of technological changes* on micro level, which aggregated to macro-level are expected to be generally beneficial to economic growth.

Starting points for these ideas are that. (1) the major physical effect of an innovation is a new and more efficient production process; (2) productivity increases and capacity expansions lead to lower unit costs of production; (3) lower unit costs increase returns on investment and growth of the firm. – (these impacts constitute the main incentive for further efforts to improve technologies); (4) there is an inherent congruence between the objectives of the firm and those of the economy as a whole, because improved productivity means resource conservation and growth is a societal goal, which thus indicates a potential congruence between policy- and decision-makers expectations and the actual results of innovative activities.
The technological possibilities for an entrepreneur form a set. Each technological possibility represents a certain production process that exists out of the production of goods, end-products by means of the conversion of goods, with the means of production. The choice for any production technology depends from the objectives of the enterprise, the prices to be paid, etc., related to the required production output.(Schumpeter 1934)

The production function model is based on the above mentioned theories. The basic assumption is a direct correspondence between the physical and economic effects of the innovation. The production function model is applied to analyze technology development from micro economic perspective and to demonstrate the first three inferences mentioned in the views above within the framework of the Schumpetrian theory of profit-maximizing enterprises.

Box 1.6 A Particular aspects of tools and equipment

Tools are used for the Transmission of energy This takes place in different ways for different applications like hammering with a hammer (the transmission part of the tools is often the handle; the same is applicable for a chisel, scoop, shovel.). Drilling. has a particular form of energy transmission: pieces of material are cut outof the artefact in a circular form through the circular movements with a tool and putting the tool at the same time under pressure. **The same type of power or energy transmission is applicable for other tools: saws, knives, scissors, etc.**

Attributes of tools: All tools can be (1)replaced, (2) adapted for particular jobs, (3) changed and interchanged -for subsequent jobs, (4) combined, (5) improved. Parts of tools can be standardized, normalized, etc. Tools can be moved in six different ways:(1) through movements in three directions and (2) through rotation in three directions.

Box 1.6B : Classification of tools and equipment

I a. tools as direct reinforcement of human energy/ force: like stone, chisel, hammer
b. tools with extra transmission part (hammer with handle)
c. transmission part and actual tool combined: drill (man needs one hand to transmit power/energy and the other to guide/steer the process)

II Tool with non-human energy source (electro motor)

III a. tool with control mechanism of handling in certain direction (guiding, stopping, etc)
b. tool with fixed position with regard to the material and fixed actions. Man is only needed to move the tool.

IV Totally mechanized tool: man only needed for making the tool run (push on a button).

V a. tool which can be programmed manually, in order to reach identical end-product
b. computer aided manufacturing tool (CAM tools) which can be programmed automatically

VI Tools grouped in a certain efficient sequence. Since production processes in most cases are multi-staged a variety of subsequent tools might be needed in the production process. Efficiency will be reached through the grouping of the "tools" in a most efficient sequence.

VII The integrated computer aided design and manufacturing production tools CAD/CAM tools) which are multiple purpose machines for industrialized production processes

Box 1.7 The input-output engineering studies.

During the 50's technical relationships were used for the determination of technical coefficients in input-output analyses. Process analyses were carried out to analyze production processes to find answers on e.g. product mixes available to an economy from the various alternative combinations of its resources. Markowitz 1956 investigated first the production processes at industry level, subsequently at multi-industry level and extended it to the entire economy. Based on this approach various studies were carried out within a Harvard research project focused on the structure of the American Economy with contribution of Chenery, Holzman, Anne Grosse and Allan Ferguson (on air transportation, see also Leontief et all 1953). These analyses of industrial processes were executed to estimate the industrial capabilities at the level of plant operations (blast furnace capacity, metal machining operations) versus other capability indicators such as inter-industry sales and purchases and GNP analyses The process analyses resemble the requirements analyses.

Advantage of process analyses that use engineering data and engineering based capability analyses of an economy: (1) opportunities to make distinctions between alternative ways of producing the same product., (2) possibility to examine the merits of substituting one process for the other because of the scarcity of one resource to the next: the coefficients of requirements analysis depend on the shortages and surpluses of resources to be predicted. Engineering data thus contribute to the quantification of the physical input requirements per unit of output, including the investigation of labor requirements and labor substitutability in a closed input-output model (including households as productive sectors).

Drawback. The extensive nature of technical information -that is required for input-output analyses- this way forms a drawback. Nevertheless Yale University showed the contribution of these studies to facilitate the identification of the technical coefficients in industrial processes. (Manne petroleum industry in USA; however only used to alleviate certain rigidities in the standard approach of input-output analyses). The data were not used for optimization of processes.

Box 1.8 Studies on factor substitutability in discrete processes.

These studies made use of engineering data to provide information on factor substitutability. The studies did not really consider the aspect of optimization over disaggregated processes. Examples:
Kurz and Manne (1973): analysis of capital-labor substitution in Metal machining. (physical output of any machine expressed in terms of quantity of tasks which could be performed on the machine concerned during the work period). Rowe and Markowitz (1955): Machine tool substitution possibilities as published in a Rand Corporation paper. Furuboth (1965a) criticism on Kurz and Manne: argued that a major problem was their use of prices of machines to define a production function. Lave (1966) indicated the difficulty of sticking to the pure technological data, since costs and prices are rather decisive in optimization processes. Boon. G.K, (1964), Woodworking, metal working and earth moving operations attempted to examine the possibilities of factor substitution on the level of the complete processing activity. This study provided important insights for the analyses of production processes since he showed the appreciation of the dimensions and complexities of composite production processes. He addressed aspects like efficiency, lot size, concept of capacity, influence of machine design and working capital requirements. Furuboth (1965) argued that Boon did not link up his engineering data with production function nor made use of the production function concept and missed a change Also Boon's work did not provide an adequate method for optimization.

Box 1.9 Technological progress studies.

Engineering analyses contributed to the studies on technological progress and analyses of technological change.
Examples : Vernon Smith (1957) Fuel requirements in the trucking industry (Harvard project)
Cowing TC (1970) Technical change in steam electric generation (University of California Berkeley).
Pearl, DJ (1971) economic analysis of technological progress in crude oil pipe line technology (Oxford university).
Pearl and Enos J (1975-76) engineering production functions and technological progress, based on the work of Cookenboo on changes in the transport of crude petroleum by pipeline. They kept input and output constant and changed the technology, compared the sets of results and tried to isolate the differences.

Box 1.10 Technology choice studies

University of Glasgow: David Livingstone Institute of Overseas Development Studies.
Technological and engineering data were used to specify real production relationships at the level of individual unit operations. Subsequently this information was used to construct model factories or composite synthetic technologies (combinations of sub-processes or unit operations technologies that represent technically feasible overall composite plant technologies.

Box1.11 Technology based studies

Uhlig and Bhat (1977) Maize milling industries: aim of their study was to show that choosing between different bits of equipment is one way of reducing investment costs and modifying labor intensity (labor intensity being measured by the ration of present value wage costs to present value investment costs). Equipment combinations were chosen involving European and Indian equipment for core and ancillary operations. The physical parameters used in their models to assess the available choices (by means of an economical appraisal of model factories) were based on their observations and measurements undertaken at existing maize and wheat mills in Europe, Africa Asia and US . They included the scale of operations, yield, specification of finished product, power consumption, spares and maintenance.
Other studies in which sub processes were examined in an attempt to link sub-processes to form a complete technology: (a) Bhat and Pandergast (1977) Iron foundry industries; (b) Keddie and Cleghorn (1977) Brewing industry. They tried to escape the difficulty of optimization by assuming independence of sub-processes, by looking at technological data of the sub-processes but did not take into account the reverse influence of the sub-processes. Aspects of appropriateness played a role. (c) Kleghorn and Keddie indicate the advantages of simple direct transactions of technologies for sub-processes viz-a-viz turn key acquisition of technology. These studies did not add more insight than did the studies executed by Boon(1964) and Stewart (1974).

Box 1.12 Engineering type studies

Pack (1974) :on the relationship between choice of technology and employment in the textile industry, using engineering data of activities on sub-process level to trace out production isoquants (linear programming isoquants). Fundamental question in his research: Do old technologies available in DC's allow more efficient substitution of labor for capital and if so do these substitutions prove to be economically advantageous for DC's. Parameters used: type of machines and numbers of each, power requirements, material wastage, space use and labor requirements. He traced out substitution possibilities among inputs and examined the economic efficiency of such substitution at a variety of relative factor prices. The age of the equipment was not taken into account in this study: the focus was on purchase price and availability.
Picket and Robson (1977): on technology and employment in the production of cotton cloth. They made a more extensive use of engineering type data but also fell back to simplifications to alleviate problems related to the construction of technologies. They also assumed that the sub processes were independent form each other. They were able to indicate these in relation to capital and labor use for some 81 technologies capable of producing a given quantity of cloth (yield of approx 20 million square meters). In their capital costs they included not only machinery but also investments in buildings installation charges and working capital. Differences in wages between skilled and unskilled labor were taken into consideration, by designating labor into equivalent units. Technology is related to a constant value added and associated with a given physical output. They compared profit, surplus and number of employees in relation to main technologies identified under different country conditions. Starting point was the assumption that technology choices are made either on the basis of the rate of profit or the absolute surplus earned. They could come up with interesting conclusions, like the statements that Africa and L America should be more profitable locations than W Europe and that variation was more in employment across technologies than there was in profitability.
Mcbain (1977): on footwear manufacturing; a similar exercise like Pickett and Robson.
Uhlig and McBain :on Nuts and Bolts manufacturing (1977); a study of the Strathclyde University; The first to deal with batch production. They indicated that savings could be made by selectively drawing on different technologies to manufacture the different batches included in a product mix. Their contribution was in the field of the need to consider the interrelationships among stages or sub-processes in a composite production process. However they did not consider the effects of large scale production (for example a firm with several identical machines will have to stack proportionately fewer spare parts than a plant with only one)
Forsyth (1977) sugar manufacturing Forsyth compared the technologies at four levels of scale. He came up with the conclusion that capital intensive technology is shown to be clearly superior at all but the smallest level of scale and unit costs are found to fall sharply as output rises. (all three last mentioned authors were associated with the University of Strathclyde).

APPENDIX I-2

Additional notes and tables regarding the development of a technology mapping methodology

Table 2.1 Definitions for technology

DEFINITION OF TECHNOLOGY	Major elements	Author
The forms of real capital employed in technology investments and/or international technology transactions. Distinctions can be made between embodiments of technology that are present (1) in plant, tools, machinery or other forms of capital equipment (material capital), (2) in tangible assets such as marketing principles, financing structures, specifications, blueprints, patents, etc. (knowledge capital), (3) in specialized skills, such as management, marketing, sales, finance, organization, which are employed in order to create new information and ideas, and to efficiently make use of -other- capital (human capital)	material capital knowledge capital human capital technology investments international technology transactions	various authors of economic publications
The concept of technology transcends the use of machines, and encompasses the materials, procedures, processes, information and often the goods and services produced, and how they are used	machines, materials, procedures, processes, information, goods and services	Stewart,F., 1977
Technology refers to the application of the existing body of knowledge and skills to the production of goods and services required by a society in which and by which it is used.	knowledge & skills; production of goods & services; society	Bertholet, C. 1990
Technology also refers to the systemized, formalized, standardized, (generally) accepted and applied forms of technique. Thus technology can be seen as the frame of reference -knowledge, ways, means- on which techniques are being applied for the production of goods and services required by a society in which and by which it is being used.	forms of techniques; frame of reference for techniques; production of goods and services	Bertholet, C. 1990
Technology refers to a particular body of knowledge. It may be considered at the level of a specific process or activity (hence of an individual or group of a few persons), an organization, an industry, a district or region, a country, or even at global level	body of knowledge, process or activity, levels of economic productivity	UNCHS, Habitat, 1991
Technology as an essential input in the production process is considered as a "commodity" as it is bought and sold on the world market. The commodity can be embodied in (1)capital goods (in particular in conjunction with investment decisions), (2) human labor (in particular qualified and specialized manpower, able to efficiently use equipment involved, to carry out trouble shooting activities, to offer information and advisory services), (3) information (either technical or commercial, both provided in markets or kept secret in a monopolistic situation)	capital goods human labor information production process commodity bought and sold on the world market	Unctad 1972

Table 2.1 continued next page/ ...

.../ Table 2.1 continued

In the context of transformation of resources, technology may be regarded as a combination of the physical tool and the related know-how either to make or to use that tool. Viewed in this manner technology can be dis-aggregated into four embodiments (categories of components of process technologies) used as input in production processes. There is always a minimum of all of four technology components present in any process technology TECHNOWARE: phys. facilities (embodied in objects, like machinery, equipment, tools, etc) HUMANWARE: *human abilities (embodied in persons, skills,* knowledge, etc) INFOWARE: documented facts (embodied in documents, e.g. processes, procedures, specifications, observations, evaluations & relations documented in publications, blue prints, patents, etc) ORGAWARE: organizational frameworks (embodied in institutions, management, organizational structures, logistical system)	TECHNOWARE HUMANWARE INFOWARE ORGAWARE process technology production process	UNESCAP ATLAS project (1990)

Box 2.1 The function of the technology institution in society

a. Internal function:

Internally technology here serves its "own objectives", in coherence and mostly executed simultaneously:

the *management of technology inputs (technology flow stream)*, (2) *the implementation and* advancement of indigenous technological capacity (technology stock and capacity for autonomous technology generation), (3) the optimization of (production) output.

b. External function:

Externally technology serves as an input in society, oriented to demands existing in other institutions, optimally integrated at national level, subservient to (1) the national cultural features, (2) the structural features of economics, politics, education, religion, kinship, etc.

Table 2.2: Technology as a sub-system in a society
Source: Bertholet, CB, EUT, Eindhoven 1991

System Element	Comments
technology structure the structural or organizational components and their characteristics positions, relations between the categories group adhesiveness, collectivity integration, differentiation, hierarchical structure, stratification	Positions in a social system within any (technological) institution are being hold by "organizations", "institutes", specific "societies", either or not formal, legitimate or generally accepted, e.g. . technological policy organizations . technological planning institutes . techn. R&Dinstitutes (design & engineering services) . techn. consultancy services . techn. extension services . techn. standardization organizations . techn. information & documentation services . techn. manpower dev. institutes (education, training) . techn. labor force in its diversity of categories . techn. branch unions and associations
Technology infrastructure Network and interactions between the various structural components of the technological institution and with structures of other institutions.	Interactions between above mentioned actors interactions between the techn institution and economy, education, health, army, etc
Technology culture With a. Immaterial components b. *Material* components	**a. immaterial** refers to *Values* that are being established along different criteria: inherent appreciation for technology, like efficiency, optimization, mass production possibilities, substitution opportunities for human labor, which might be dangerous, exhausting, un-healthy; energy producing or preserving features; optimal use of sciences. *Objectives*, generally laid down in technology policy, planning and technology programs and projects *Expectations*, technology forecasts through assessments *Norms*, set along criteria such as labor: ethics, discipline; profession: professional codes; technological quality: quality standards. *Know-ledge*: the level of technological know-how *Skills:* proficiency to use techniques **b. material** refers to . the totality of artefacts needed to reach human needs and demands . the tools and prod facilities, like publications, archives, libraries.
Technology infraculture The interaction between cultural components of the technology institution and with cultural components of other institutions	Interaction of technology culture and other institutional cultures a. as inputs for the technology institution b. as the context for the output of the technology institution.

Table 2.3 Technology promotion agents in the technology infrastructure

Technology promotion agent	Form & field of technology promotion	Resulting in
1. national government	Formulation and implementation of technology policies	Favorable technology development climate by means of e.g. subsidies, incentives, tax-holidays etc. to enhance technology development
2. educational and training institutes; consultancy companies	training and education	Human resources development (Humanware)
3. Documentation and information centers, libraries, statistical organ. patent and registration offices Consultancy companies Museums	storing and lending of documented facts training and informing	Improved documentation and information on technologies (Infoware + Human ware)
4 Testing, certification and standardization laboratories	up-grading and standardization of technologies	Improved and standardized technoware
5. Development organizations, banks, Venture capital banks, design and management consultants	Offering of assistance for setting up of management and organizational structures	Improved orgaware

Table 2.4 Overview of technology status and the 1st, 2nd and 3rd Industrial Revolution characteristics
Source: Lilley, S. 1980

KEY FACTORS	I 1760 –1840	II 1870-1914	III 1940 - ONWARDS
CENTRE	BRITAIN	GERMANY & UNITED STATES	UNITED STATES
BASIC RESOURCES	coal iron wood cotton	steel (Bessemer + Siemens Martin) non-ferro metal alluminium chemical basic material cement	synthetic material
SOURCES OF ENERGY	coal hydro power wind horses	coal oil/petrol electricity railways	oil/gaz electricity nuclear energy
TECHNICS	steam engine labor saving engines	combustion engine chemical/synthetic dyes electro technics wire (less) communication electrical light transport of energy	electronics cybernetics electronic engineering automation fast machines process industry robotization
FOCAL POINTS	users and consumption goods textile/cotton railway/steam navigation	capital goods machine building iron industry chemical industry radio and car industry transport production equipment industrial designing	information science electronics militarism cybernatics mass consumption
ORGANIZATION	family enterprise genesis of factories division of labor labor discipline	Ltd's bank capital trend setters commercial large enterprises monopolies/oligopolies scientification of production technology	government transnational corporations TNC's
EDUCATION	on-the-job (for skilled labor and engineers)	specialized higher-technical education training within enterprises	universities-enterprises linkage: technology-research linkage systematic R&D
FORMATION OF CAPITAL	no differentiation between profit and interest private accumulation expansion of enterprise	Banks financing capital patents	internally within TNC's government
RELATION WITH REST OF THE WORLD	free trade under leadership of Britain	coming up of modern imperialism, regarding natural resources, market and investments	neo-colonialism pushing primary industries to developing countries
LIMITING FACTORS	capital	Management Capital skilled labor	knowledge and skill high-tech schools

Box 2.2. Interrelated aspects of technological dependence in developing countries.

The asymmetric relationship between developing countries and the industrialized ones becomes evident in the following.

a. The weak production and trade structures in developing countries compared to the industrialized nations. This refers to the
   - commodity pattern and the consumption pattern, in particular of the upper-class, which reflects the influence of industrialized nations.
   - the limited means of production and a sharp difference between developing countries and the industrialized ones with regard to the abilities to produce machinery, equipment and other capital goods needed for production, which might indicate one of the main causes of difference between technological capabilities of different countries.
   - trade bonds and the fact that the power to influence trade policies in DC's rests in industrialized countries, since most DC's depend from the industrialized countries for the supply of technologies, finance, etc. (e.g. export restrictions as a condition in technology transactions)
   - the fact that exports on the international market require an international competitiveness both in terms of quality and price. The pace of dynamics in international trade is set by the industrialized countries. DC's depend for most of their production on technologies from abroad.

b. Technological and financial dependence situation. This refers to the
   - asymmetry of technical knowledge, skills and financial means

c. dependency in the field of capabilities to control and initiate technological development . This refers to
   - the asymmetry of control and the abilities to make decisions and to control the decision upon their effects on development. Moreover it is re-enforced by the asymmetries in terms of regulations. Imperfect markets for technology and capital often permit foreign firms to obtain specific treatment in DC's concerning governmental regulations.
   - the asymmetry of taking initiatives.

Box 2.3. About technology choices in developing countries.
Sources: (Stewart 1977, Bertholet 1989)

often production decisions were made, by selecting "in-appropriate" products, imitating western consumption patterns.

- technological developments and innovations sometimes appeared to be applied by researchers and technologists generated during training courses overseas, reflecting western views on prerequisites for the implementation of the technologies concerned
- imported technologies, were applied completely substituting local technologies, without any adaptation and smoothing the path for absorption in the social system
- imported technologies incorporate often contractual obstacles to develop further domestic insight and understanding regarding the technologies concerned, due to e.g. patent limitations.
- the expansion of the use of the acquired technologies is often limited through contractual agreements: e.g. export prohibition clauses
- in many cases is shown that unnecessary purchases of goods and technical processes had to be made due to contractual agreements which were tied to the necessary acquisition of know-how and knowledge

Table 2.5 The particularities of a dualistic technology system
Source :Sagasti, 1979

modern sector	In urban areas, linked to the international market, employing imported technologies, requiring specific production factors (skills, use of materials, organizational styles),alien to the local environment
traditional sector	Usually within a rural setting, containing and utilizing know-how and skills which are accumulated over centuries

Box 2.4Technology self-reliance through the establishment of a proper technology infrastructure?

The establishment of an own technology structure and infrastructure means that the country has developed capabilities in the fields of

(1) Design and engineering, (2) research and development, (3) consultancy, (4) manpower creation (education), (5) policy making on standardization, (6) the development of support services with regard to information, documentation, computer assistance, (7) professional organizations, (8) established industrial forward and backward linkages, (9) an industrialization policy, (10) technology policy making, (11) technology development promoting legal system, (12) technology development promoting governmental directory system.

For most of the developing countries the establishment of such a technology structure and *infrastructure is rather difficult , since*

(1) the industrialization process in most developing countries is a discontinuous process. There is no structure and infrastructure (both horizontally ands vertically) like that which was developed during the past 200 years in the industrialized countries.(2) the industrialization process has a rather forced character: shock-wise and in a rather short time span. (3) the industrialization process which takes place is generally based upon demonstration effects which can have rather negative impacts on society. (4) developing countries have a rather unfavorable the market position on the technology market, (5)the more simple and traditional know-how and skills which were available in the past in the now-a-days industrialized countries have disappeared. When these types of technologies are available then they often do not fit in the reality of the now-a-days context of developing countries.

The industrialization process and the development of capabilities to attain the necessary technology structure and infrastructure to support the productive activities require right decisions and steps to be taken. This implies the necessity of insight and knowledge in technology, economics and the dynamics of social systems to plan, guide and control technology development at different levels of *the economy. Professionals with this insight and knowledge should then (1)convince the government* that an industrialization policy should go hand in hand with a technology policy, (2) render their support to the formulation of a technology policy and take care that this indeed can be implemented, (3) guide, monitor, evaluate and adapt the technology policies, thus control the processes of implementation of the technology policies, (4) support the technology acquisition processes; thus give support in selecting, negotiating and decision making sub-processes, (5) execute research , such as (pre-)feasibility studies for the acquisition, generation and implementation of the right technologies. (Bertholet 1989)

Box 2.5 The emerge of a new theoretical views around technological capabilities

The consciousness of a concept like technological capability was born based on empirical findings when seemingly the traditional theories and policies which should give the right answers questions of societal development did not work out as was expected in reality.

A new assumption thus has entered the technology and development studies: "The technological capability and the potential which is to be found at the different levels of economy can control as well as respond economic change is a core element for development". This hypothesis, has been a new starting point in many of the recent research activities (see various publications by Rosenberg, Freeman, Lall, Fransman, Bell, Stewart, Romijn)

The recognition of the importance of the concept of technological capabilities in studies on development problems, the technology development processes and the relationship between technology and societal development has only come into existence less then two decades ago.

By the late seventies the neo-classical economic theories began to loose a great deal of their influence on the field of technology. Another major reason for this was explained to be (see publications by Nelson, Katz, Lall, Stewart) that neo-classical economics could not precisely explain the processes and causes of technology development. It was even stated by authors like Nelson, Winter and Rosenberg that based on the neo-classical theories highly un-realistic and misleading assumptions were made about the processes of technology development (Fransman 1984). For example a form of technological change that appeared to have a more important impact for productivity improvement than investment is the creation of new production facilities through activities like trouble shooting, changing operating procedures, redesign or adaptation of installed equipment, standardization, etc. of the existing technologies. The inputs in these efforts are seldom taken into account in the conventional calculations.

The newest ideas were based on the assumption that the conditions under which the technology utilization and technology developments take place either through indigenous R&D efforts or through international technology transfers, play an extreme important role. (Katz and Lall). Herewith reference was made to the issues of technological capabilities of the firms and the nations indicating the abilities to (1)expand the production output; (2) meet the demand for local and /or new products; (3) diversify to new production lines; (4) make new investments (developing countries have generally no access to means for investments); (5) upgrade managerial organizational skills (in developing countries these are often poorly present), (6) eliminate deficiencies in labor skills and know-how; (7) facilitate the access to information and documentation; (8) to enhance technological advancements; (9) make use of and up-grade existing (small scale) production, (which in developing countries has often a traditional and rudimentary character, with low outputs and poor quality).

Due to lack of technological capabilities, a country may fail to use the scarce resources efficiently, resulting in rather high costs to enterprises and to the national economy. This refers to the inefficient use of the existing facilities, declining productivity over time, a high and continuing degree of dependence on imported inputs and of technologies from abroad, a lack of local technological infrastructure and therefor limited integration in industry.

The common experience that can be drawn from the industrial history of countries as divers as the European, United States in the nineteenth century, Japan after world war II and South Korea since in the last decades of the twentieth century indicated that their successful industrial development seemed to have been based firstly upon and accumulation of a pool of skilled human resources: craftsmen, engineers, scientists, technicians and managers. Secondly they had been able to use these indigenous capacities to devise technical solutions to their own problems, both by adapting and improving imported equipment and know-how to suit local conditions and by developing entirely new and more appropriate ways of solving their problems. This competence was attributed to a central element that seem to exist in the countries "technological capabilities". International competitiveness in technology based industries relying on indigenous technological capabilities seems to become a new metric of national economic performance

Table 2.6 Definitions of technological capabilities

Definition	Major elements	Author
Technological capabilities are a combination of three independent capabilities which can be applied for the production of goods and services in a society. *Production capability* Production management Production engineering Maintenance of capital equipment Marketing of produced output *Investment capabilities* .project management .project engineering .procurement capabilities .manpower training *Innovation capability*: creation & diffusion of new technical solutions through economic practice	Production capability Investment capabilities Innovation capability	World Bank (WB Staff paper 717, 1985)
Technological capabilities are seen as the abilities to train manpower to carry out basic research to test facilities to acquire and adapt technologies to provide information support and networking in support of the production of goods and services in a society	technology training testing, acquisition and adaptation documentation and information services	UNIDO (UNIDO/IS 608, 1986)
Technological capabilities are the abilities to purchase technology for plant operation for duplication and expansion for innovation	Purchase of technology plant operation duplication and expansion innovation	Desai (Achievements and Limitations of India's Technological Capability, Desai, A.V., , 1984
Industrial technological capacity: a stock of Disembodied technical knowledge and information, Human embodied knowledge and experience, Institutional resources	disembodied technical knowledge& information human embodied knowledge& experience institutional resources	Bell (1984: Learning and Accumulation of industrial technological Capacity in Developing Countries, Bell, M.)
Technological capabilities refers to the Independent technology learning capacity Independent technology creating capacity Independent world technology reconnaissance cap.	Technology Learning Creating Reconnaisance	Dore (1984: Technological self reliance, Dore, R.)
Technological capabilities refers to the local capability to create, adapt and modify technology	technology creation . adaptation, . modification of imported technologies	Stewart(1984): Facilitating Indigenous Technical Change in Third World Countries.)

/...to be continued on next page

table 2.6 continued from foregoing page

Technological capability refers to "the general ability to undertake the range of tasks: not just to change a given technology, but also to master it, to make it operative in a particular environment, to suit local scales, materials, climate, skills and market needs". After the first applications, the technology might be improved, by minor innovations of various kinds and subsequently the technology itself can be altered, copied and based upon the experiences with the technology new technologies can be generated	technology change master operational tasks adaptation to local scales, materials, climate, skills and market needs Improvement, innovation. Copying Generation	Lall, S Learning to Industrialize WB staff paper 1989 & Building industr. Competitiveness in dev countries /Paris OECD, 1990
Technological capability of a society, was seen as the different degrees of people and organizations to experiment with, to learn and to become proficient in new technologies, in order to be able to select the most appropriate technology to achieve the policy objectives, but also to master it, to improve it, to adapt it to local circumstances, and in particular to generate new technologies.	. experiment with . learn about . be proficient with . select , master, improve, adapt, generate technol.	Dosi, G., Sources, Procedures, and mincro economic effects of innovation, 1988, Journal of economic literature
Technological capabilities include the following capabilities: to search for available alternative technologies and to select the most *appropriate technology for importation* to master imported technology and succesfully use it in transformation processes to adapt imported technologies to suit it to local conditions to further improve and develop the adopted technologies as a result of local incremental innovations to institutionalize the search for more important innovations (R&D institutes) and breakthroughs with the development of local R&D *facilities* to carry out basic research for further up-grading and generation of new technologies.	Searching & selection Mastering technology operations Adapt imported *technol.* Improve technologies Institutionalize R&D Carry out R&D and innovative activities	Fransman,M Technological Capability in the Third World,.1984

Box 2.6 Towards a workable conceptual definition for technological capabilities

The starting points for the definition for technological capabilities that is considered useful in this research were the following :

- Technology development can be seen as the development of the elements of the technology sub-system of the national social system: development of technological structural, cultural and infrastructural system components.
- Technology utilization and developments were understood to contribute to the achievement of a competitive position and the creation a technological self-reliance (Stewart 1978)situation.
- Technology utilization and development implies the dedication of efficient and effective activities: technology- purchase , plant operation, duplication and expansion innovation, invention.
- The resources that are necessary to carry out these activities thus can be seen as technological capabilities.
- The technology sub-system does not operate without influences from the other sub-systems in a country s social system. Influential forces are expected from the other sub-systems (economic-, political- , educational – subsystem). (Fransman M 1984, Wheeler, J, 1991) These influences are also named the "circumstantial specificities" (Evenson and Westphal 1994), and are assumed to operate as either promotional or constraining factors to effective technology utilization and technology development. The totality of the national technology promotional system can be seen as the technology creative system. (Fransman, M. in UNIDO V.89-61150, pp 137-145).
- An efficient and effective technology creative system implies the input of the totality of national resources for the benefit of technology utilization in and technology development for production along with national policies that streamline and support linkages between science and technological development and production.
- In other words a nation should dedicate its capabilities to the development of its technology creative and technology using system to achieve and maintain a competitive position on self-reliant basis.

Technological capabilities thus *refers to the totality of national physical and social system resources* which can be committed to the production system, giving the necessary inputs for efficient and effective production.

This stock of national resources should supply the country with the means, skills, know-how and knowledge, not only to select, master and adapt the technologies needed and most appropriate to the social system of the country concerned. But the technology stock should also enable the country to develop and generate its own new technologies (self-reliant technology generation)

This definition differs from the majority of definitions given in the table, in which technological capabilities are defined only by mentioning a number of activities without any indication of the particular nature of the capabilities. In other words no indication is given which particular capabilities are needed for technology acquisition, selection, utilization, development.

The only definition in which is indicated which specific components constitute the complex of technological capabilities is the definition which was given by Bell. He referred to the stock of (1) disembodied technical knowledge and information, (2) human embodied knowledge and experience, (3) institutional resources as the components of industrial technological capacity.

Moreover in a number of the above cited definitions can be noticed that an emphasis is given to the capabilities in technology development processes and the role of "technology learning" in these in terms of the accumulation of knowledge and skills.

Improved production performance through technology development may be a result of better skilled and more experienced labor force. But in the first place technology development includes more than only human resources development. Thus the question can be raised at the same time, whether the level of knowledge and skills should be considered to be the sole indicator of technological capabilities. Knowledge and skills alone in any form available are not enough. Technology development in itself can be seen as a "production" process. In any production process at least a minimum of the four process technologies (technoware, human ware, *infoware and orgaware)* is needed to achieve the desired outcome (product technology the result of the utilization of process technologies for the transformation of the inputs).

Thus capabilities necessary for the activities which were mentioned in the technological capability definitions should include all resources which are generally needed in production processes and processes of technology development.

Box 2.7 Remarks on the effectivity of the production output

The matter of concern is here the planned production output, which in fact forms the terms of reference for all efforts in the production plant. This means that the aspect of quality of the desired production output should be considered here next to the quantity of this output. The measurement of the effectivity of a production unit in terms of quantity is relatively not such a difficult exercise. The major determinant here is the market demand for the produced product. Although one has to take the dynamics and the influencing factors on the market into account.

For the measurement of the effectivity of a production unit in terms of quality, the precise definition of the concept of quality is important. When we consider the concept of quality as "what is delivered outside the organization" then we deal with whether the delivered goods or rendered services represent what the outside customer expected, wanted or specified. It has to be admitted that some of these measures, in particular concerning customer's satisfaction are quite subjective. They appear as post-audit reviews, complaints or satisfaction surveys.

Feigenbaum (In: Christopher WF., et al, (ed) 1993) indicates a number of fundamentals for quality measurement, o.a.(1)quality is what the customer says it is - not what an engineer or a marketeer or merchant says it is- and it is a continually upward moving demand (2) quality and costs are a sum, not a difference – partners not adversaries - and the best way to make products and offer services quicker and cheaper is to make them better. Thus in order to find a measure stick for effectiveness in terms of quality one should consider the terms of reference for the product technology set by the market demand for it.

Box 2.8 Production performance versus competitiveness

Improved production performance, expressed in productivity, efficiency and effectivity of production, on both national and global levels and within an organiztaion or enterprise is nowadays seen as nothing less than "the key to our collective security and prosperity". For a production unit or an enterprise improved production performance is fundamental to profitability and survival.

At national level production performance improvement through increased productivity, efficiency and effectivity can enhance the competitiveness of an industry and/or nation versus other industries and nations. Sumanth (1984) also mentions the link between the productivity level in a country and its political power.(See in Christopher, WF et al (ed) :Kendrick,JW; Smith, FW.; Conway, EC 1993; and Sumanth, DJ.,1984.)

Box 2.9. Impacts of the operating environment on production performance

Each production process takes place in a certain operating environment. Several authors have acknowledged that the performance of a production process is influenced by factors from the environment (Erkelens, PA.,1991; Hershauer & Rusch (1978) in : Sumanth, DJ,1984, Bertholet & Gaillard 1978/1992/94 , Porter 1990) Such factors were also named productivity factors. The recent socio-economic theories point at the concept of sectoral technological capabilities in their national and international technology setting. Effective control of these environmental factors may result in an efficient use of resources in the production process.

Table 2.7. The major indicators for the features of the production environment

Source. Bertholet& Gaillard,1978; Porter, M., 1991, ESCAP, 1989

Bertholet and Gaillard (1978)	Porter (1990)	ESCAP (1989)
International environment (international economic and political order)	Economic order Market	International technology market National technology climate: . natural resources
national environment (national social system, incl. politics, economy, education, culture)	Network of sectors (national and international)	. human resources . physical infrastructure . national social system (economy, politics, education etc)
sectoral network of relations of production unit concerned (attributes of the sectoral infrastructure)	Government Uncertaincies	National technological capabilities: aggregated abilities for technology management to run production processes efficiently and effectively

APPENDIX I - 3

Additional notes and tables regarding the particularities of the construction industry

Box 3.1 On the adequacy of houses

Adequate housing is seen as a human right. This view gained increasing attention and promotion among human rights. The human rights for housing are seen as a complex of economic, social and cultural rights. (UN Global Strategy for Shelter 1988)
The adequacy of a house is determined by psychological, socio-cultural, economic and technological factors, which differ from country to country. The adequacy of a house following the United Nations Global Strategy for Shelter to the Year 2000 (1988), refers to "adequate privacy, space, security, structural stability, comfort , lighting and ventilation, basic infrastructure, location with regard to work and basic facilities - all at reasonable costs, which means affordable to the inhabitants." Adequate housing is thus a complex question. It refers to the extent to which the required qualities of a house are met. It also refers to the extent to which the needed quantity of houses are supplied at costs that are affordable for its inhabitants In other words a house should adequately meet the basic requirements and be affordable for anyone.

Box 3.2 The affordability of a house

The affordability of a house means that it should be within the financial abilities of the inhabitants. Affordability of a house directly depends on the income level of its owner, renter or tenant and his purchasing power. This again is related to the overall income level in the country and the possibilities to finance adequate housing facilities. In practice every household itself decides which percentage of income it will spend on shelter. (Gaillard 1996).The extent to which the lower income households actually will built a house which meets the general standards, depends largely on the existence of housing finance systems and institutions.
Conventional methods to assess the affordability of housing assume that a household could devote up to 25 percent of its income to housing repayments. It has been suggested that, while the 25 percent figure is acceptable in general, it is too high for the lowest-income households in particular in many developing countries. The percentage of income those households can afford should therefor be taken at 10 percent. (Gaillard, H, 1996)
However, studies of rents paid by lower-income households show that payment can be as much as 40 percent of their incomes. On that basis it could be argued that it would be safe to assume figures of 30 - 35 percent of income being devoted to housing repayments. Obviously only the household can really determine what its ability to pay will be. The amount of money a person can borrow is determined by a mathematical formula which uses rate of interest and duration of loan to calculate the annual repayment (expressed as a per cent of the capital borrowed). If the amount that a borrower is willing and able to devote annually to repaying the loan is expressed as a percentage of his annual income, it is possible to express the capital sum as a multiple of the borrowers' annual income. There are various programs and tables that allow the value of any of these variables to be read off, if the others are known. This implies for example that for a loan of 20 years, at 5 percent interest, the annual repayment would have to be 8 percent of the capital borrowed. If a household devotes 24 percent of its annual income to repayments, it can borrow a capital sum equal to three times its annual income. But the extent to which the households of the lower income groups actually will built a house that meets the general standards, depends largely on the existence of housing finance systems and institutions. When these specific institutions are not available, the assumptions and calculations made regarding the affordability of the lower income groups, remain to a large extent purely academic. In fact, in such a situation, every assumption and calculation has only academic value. Therefore, data regarding aspects such as housing demand or housing need and affordability can serve only as an indication as it involves magnitudes of "adequacy", which is subject to individual household characteristics. Moreover accurate data on demand for housing or, for example, the investment value required to adequately shelter the population in a developing country, are very difficult to determine. The problem is further compounded by poor national statistics in most of these countries. *(Gaillard,H. 1996)*

Box 3.3 The lower income households

A household is defined as (1) a person, who lives alone in whole or part of a housing facility and has independent consumption or (2) a group of two or more persons who occupy the whole or a part of a housing facility and share their consumption. Household characteristics are determined by factors like composition, income level, number of incomes per household, nature of employment, rural or urban life, demographic dependency and economic dependency.

The lower income households are those households with an income below the current minimum wage in the respective country. Generally speaking in a typical developing country 70-75 percent of the population belongs to the lower income groups.

An exact determination of the population belonging to the households with the lower income level is in most cases a difficult exercise especially in developing countries. Households are not only reluctant to divulge such information, they might actually not know what it is exactly, particularly when it comes from a variety of sources and is irregular as is the case for the large majority of the lower-income earners in developing countries. Moreover in many developing countries reliable data sets are difficult to obtain since statistical databanks are in many cases poorly maintained. For these reasons the following rules-of-thumb of the UNCHS (Habitat) to assess the characteristics of the lower income groups in particular in developing countries are considered useful. In a typical developing country, 5 percent of the population makes up the high-income group, 20-25 percent makes up the middle-income group and 70-75 percent makes the low-income group.

When no precise definitions exist the following four income categories in developing countries are distinguished by the UNCHS as a rule-of-thumb : (1) Lowest-income households 0 - 20 (poorest households); (2) Lower-income households 21 – 75; (3) Middle-income households 75 – 95; (4) High-income households 95 – 100% .

If the level and distribution of income is not defined, another rule-of-thumb is applied : half of GNP per capita times the average household size is used as the lower limit for defining low-income households and that figure should be doubled for the upper limit.

Lower-income households donot live necessarily below the so-called "poverty level", that is the level of income that cannot even afford a basic minimum of goods and services as defined in a particular context. Wages and minimum wages vary, not only between countries, also between regions, zones and economic sectors of a same country.

Box 3.4 The demand for housing

The effective demand for housing for and by the lower income groups is in general relatively low due to the lack of household income, which makes that they cannot convert their need for housing into an effective demand on the housing market. (Erkelens 1991: pp51).

The housing market for lower income groups in many countries is characterized by a actual deficit houses which exceeds the production output of the construction industry. The determination of the size and characteristics of the lower-income households facilitates the search for adequate solutions for the housing problem.

Table 3.1 Definitions for the construction industry

Definition	purpose	author
Construction projects are carried out by those enterprises which are engaged in the actual physical work on new or existing buildings and civil, mechanical and electrical engineering works. These entrepreneurs carry out their activities either as general or specialist contractors, public agencies directly involved in such activities, for the on-site fabrication of construction components and some aspects of off-site manufacturing of construction materials and components.	national accounting and economic planning	UN ISIC 1968, 1971
The construction sector consists of (1).construction industry proper: contract constr. by general builders, civil engineers and special trade contractors, (2) contract constr. carried out for others by the establishments or organiszations classified to industries other than construction, (3) own-contract constr. carried out by independent units of enterprises or other orgnizarions not classified to the constr. industry proper, (4) own account constr. Carried out by establishments or other organizations not classifeid to the constr. Industry, with no independent construction unit, (5) own account construction carried out by individuals.	used for statistical data on constr. Enterprises and value of work	UN Ecosoc 1988
The construction industry comprises "the construction, extension, installation, carrying out, repair, maintenance, renewal, removal, alteration, dismantling or demolition of any building, structure...road, motorway, harbour works, railway, cableway, canal aerodrome, any electrical, water gas or telecommunication works, any bridge, viaduct, drain, reservoir, pipeline, sewer, shaft, tunnel or reclamation"	Legislation, regulations or policies	Constr. Industry Develop m Board Act, 1984 Singapor e.
Companies involved with construction activities or parts of it like (1)Building construction (houses & other buildings), (2) Civil engineering construction. (roads, bridges, sewers, water, etc), (3) Masonry, stonesetting and cement work, (4) Painting, (5) Plumbing, sewerage & sanitary installations (incl. central heating), (6) Roofing, (7) Tile setting (mosaic, marble, stone, parquet), (8) Plastering, (9) Carpentry, joinery & other woodwork, (10) Renovation contractors, (11) Building construction not elswhere considered, (12) Excavation, Site preparation and piling, (13) Earthworks, (14) Electrical wiring & installation (incl. airconditioning)	Legislation, regulationslicen sing for the establishm. of enterpr. In the constr. Sector	Dutch Law 1954

Box 3.5 The function of a building

The general function of the finished products of the construction activities is the provision of a built environment and shelter to meet human needs. Human needs are un-limited and diverse, as diverse as human activities are. Many human activities require for shelter.
A number of authors, like Tellegen, F.Ph.A, (1965), Meyer-Ehlers, G. (1963), Bouwcentrum (1964), Zeldenrust-Noordanus,M., (1956), Burns, LS and Ferguson, B (1987) have explained this as basic instinct and search for safety, security, protection against external forces.

The requirements for shelter are sometimes surprisingly contrasting! Shelter should provide for room for (a) social activities and human interactions, (b) integration of various interrelated activities, (c) separation of different activities and personal privacy, (d) separation from and protection against outside world, (e) opportunities to interact with outside world, (f) interior environmentally safety and comfort.

Table 3.2 Attributes of a building

Attributes	Indicators
Function	In this research project function refers to the functional properties of the finished building. The purpose of the housing unit is to provide shelter to a family. This function of shelter provision is qualified by means of the following indicators (1) number of persons which can be sheltered, (2) kind of activities which can be sheltered, (3) number and kind of facilities, (4) flexibility NB In this research project a generally accepted basic housing unit for an average household in the countries under investigation is taken as the unit for the production technology assessment.
Geometry	a the form and shape of the housing unit, elements, work sections and /or construction products. A classification of different types of shapes of housing units can be made in for example (1) rectangular - round, (2) single storey - multi storey, (3) traditional - contemporary b dimensions in m^2 or m^3
Physique-technical perfor mance	Physical properties refer to those attributes which indicate a. physique-technical strengths and stability b. durability against climatological (heat, cooling, humidity, water), chemical, biological factors c. fire resistance, d. sound proof
Construction system & materialization	d.1 Construction system refers to the properties of the primary work sections of which the production output is composed. Work sections are the physical parts of the facility which are established by the application of particular skills and techniques, building materials and/or building components during the production phase. A classification which can be used is for example the following applicable for the construction of housing units for lower income groups:1. Masonry (brickwork) with timber rooting construction and concrete floors 2. Timber construction systems (incl bamboo); 3. Pre-cast concrete block systems; 4. Earth construction systems; 5. Pre-cast concrete elements construction system; 6. Steel construction systems. d.2. Materialization refers to the particular classes of material which can be applied in the construction of the housing unit: 1. *undefined*, 2. *stone (natural and reconstituted)*, 3. Cementious and mineral bound, concrete, 4. minerals, excluding cementious 5. metal, 6. timber, 7. organic materials excluding timber, 8. rubber, plastics and chemicals, 9. combined.
Producibility	the time- consumption and complexity of needed procedures, to produce, store and transport objects, elements and construction products.
Price	the costs of producing, storing, transporting and the buying , selling and tax prices.

Table 3.2 Socio-economic significance of the construction industry
Source: Tassios UNIDO 1992

societal significance	*Indicators*
politicial significance	• attainment of policy objectives for the construction of shelter and infrastructure • provision of support for the attainment of the objectives in other sectors like education, health, etc.
economic significance	• contribution to GDP(10% EC, 3-9% DC's) • contribution to GFCF 35% -81% DC's • contribution to reduction of import dependency • backward and forward linkages to other economic sectors
social significance	• *employment generation* The construction industry is a labour intensive industry. It absorbs a rather extensive quantity of un-skilled and semi-skilled workers. This is even frequently used by governments to stimulate economic activities. Employment figures show that the construction industry counts for more than 6% of total employment in OECD countries , 3% in Africa, 4% in Asia, 6% in Latin America.(UNIDO 1993) • *income redistribution:* Effects on income redistribution become evident in he construction activities directly linked to activities such as skill up-grading, financing systems for low-income housing, the construction of schools, hospitals, capital investment for large scale civil engineering works, that all may have their effects on income redistribution of the national product to other layers of the society in a country. employment (social justice component) • *skill generation:* Technology capability building through human capital development. Skill generation takes place not only by formal education but also by the on-the-job training and skill upgrading through learning - by-doing which frequently leads to further specialization and which even may be beneficial for other industrial activities. Building construction projects require a higher skill level then manufacturing, since construction is still rather labor-intensive. Dissemination of knowledge and skills generally takes place through: experience and tradition, formal education, continuing education, documents- standards and codes -, technical information centers, international technology transfers, research and innovations. • *improved productivity* through improvement of the quality of shelter and infrastructure.(provision of better shelter and infrastructure contributes to higher productivity

NB The interpretation of the figures on the performance of the construction industry in various countries, should take place with the consciousness regarding a number of measurement problems:

- The contribution of the construction sector to GDP is based upon the value added in the sector and does not include value of purchased building materials, components, fuel, transport, professional services, insurance and legal fees
- The GFCF (Gross Fixed Capital Formation) figure does not include maintenance and repair activities in the construction industry.
- The activities in the construction industry do not all take place in the formal circuit.
- A figure on employment is sometimes also tricky. Employment in the construction sector is subject to seasonal fluctuations.
- There is a lack of standardization in measurement units world wide.

Box 3.6 Construction industry's contribution to GDP
Source: UN National Accounts Statistics 1988-1989 ; Wells 1986

There is a direct relationship between investment, the rate of growth and the percentages of value added of the construction industry in GDP (Gross Domestic Product). Construction activities need resources for investment and investments need construction activities. This is why during periods of economic growth the construction industry grows at a faster rate than the all over economy. Constraints in the construction industry may thus hamper capital investment programmes.
Construction was indicated to be a major component in investment programmes.
Expansion in the demand for construction products seem to be most rapid during the early development stages in countries which are still at relatively low levels of income. This is due to the fact that the construction industry supports the productive capacity of other sector (forward and backward linkages).
Wells (Wells 1986) argued that the construction sectoral growth can be sub-divided in growth initiating and growth -dependent construction activities. These two kinds of growth stimulators effect the pattern of growth in the construction industry.

Box 3.7 Construction industry s contribution to gross fixed capital formation
Sources: ILO 1985 ...; Lewis 1955, Turin 1980

The significance of the construction industry for socio-economic development is indicated through its contribution to Gross Fixed Capital Formation (GFCF) in percentage of the total GFCF in a nation. (25% in developed countries like US, Canada, Japan, Germany and 19 - 30% in in Latin American countries like Brazil, Mexico and Venezuela: ILO 1985)
More than half of capital formation consists of work in building and construction. Hence the expansion of capital is a function of the rate at which the building and construction industry can be expanded..." (Lewis 1955)
From this point of view also the reverse effects of poor construction activities to overall national development were indicated: "unless the construction industry of a country grew faster than the economy as a whole it might be a constraint on development. Wells formulated development programmes showed that spending targets could not be achieved without an effective input of local construction industries. However owing to inadequacies the poor construction capacities used delayed project implementation". Turin (1980)

Box 3.8 Forward and backward linkages of construction industry
Sources: Moavenzadeh (1987), Ofori (1990)

The forward and backward linkages of the construction industry with other industries are not always recognized. The stimulating character of this industry to other economic sectors can be rather extensive. These linkages make the construction sector relatively vulnerable to distortions: factors influencing the performance in a certain economic sector can also influence the performance of the construction sector (and vice versa). On the other hand these linkages imply that optimizations in construction performance could contribute to a more overall development of a country. These linkages can also have a clear impact on an individual contractor and his construction activities. In general, the linkages introduce (extra) productivity factors, which may affect the contractor's performance.
A quantitative overview of the construction sector's contribution to GNP and its forward and backward linkages to other economic sub-sector was given by Moavenzadeh (1987). The construction industry bought between 50-60% of its inputs from other sectors of the economy.(Turin 1973) Other authors who indicated the importance of these linkages are Bon (1988), Drewer (1980), Flores (1971), Riedel and Schultz (1978), Park,(1989), Schumacher(1973), World Bank (1984).

Table 3.3 Impacts of the socio-economic situation on the construction industry

Economic situation and market demand	The construction industry highly depends on investment capacity in the country. This in essence directly relates to the market demand in the construction industry. There is a wide variety in demand for construction output in a country, ranging from most sophisticated works, such as infra structural works and airports needing the most advanced technologies up to low cost housing for which the locally well-known traditional technologies might be used. In a number of developing countries the percentage of imports to local construction output forms a forex constraint. This the case for nearly all inputs: technology and materials. The effect is a strain on the balance of payments (also because a percentage of the value added of the productive activities is remitted to the foreign country) and often an on-going dependency on foreign resources.
National policies	Policy decisions directly affect the output and the performance of the construction industry. Examples are the following: • *general development policies and strategies* like family planning policies (pop growth), *income generation strategies, fiscal incentives, salaries and pricing* policies (construction industry is a high labor consumer in particular in many DC's), health policies (health and safety of workers) • *energy and environmental policies* like interventions on energy efficiency in the production of building materials like binders (cement, lime, ashes, etc), use and imports of fuels versus use of low cost less pollution indigenous sources of energy; *environmental protective issues: extraction* of aggregates from small rivers, irreversible destruction of timber forests, etc. • *land-use and town-planning policies* like interventions on land costs (in African and Asian DC's 20%-60% of construction project costs); policies and planning directed to avoidance of land speculation, minimization of infrastructural costs, optimization of transportation costs, secure low-hazards sites versus accidental events • *financing policies* like a financing system for individuals for shelter, including savings and credit systems, loans in cash, loans in kind, loans in construction-work hours, allotment of services of building brigades; a financing system for contractors directed to alleviate constraints like payments in installments long after delivery of the "product", no-payments for all preparatory activities on site, exposure to the quality of many different un-skilled and semi-skilled workers : affect consequences of performance bonds and waranties!, working capital needed more than 5% of the annual turn-over!, delays of payments, or no banking facilities • *policies and regulations regarding the national market dynamics* like technology policies, industrialization policies focused on interventions in the (a). demand for buildings, (b). building material industries, (c). machine tools & equipment industries; import-export policies, policies regarding enterprises: private-state, foreign-local, large-small scale, formal-informal, R&D and education policies. Despite this the construction industry is too often not included as integral element in development plans, sometimes even ignored by planners and economists. A reason might be that it is not considered as clearly identifiable industry and not seen as such.
Education and health	The construction industry highly depends on a well operating education and health system in the country due to its labor intensity. The in-sufficient means to maintain a reasonable level of education in many developing countries is noticeable by the lack of skilled labor on the construction sites.
Demography	Population growth, composition of the population by age groups, density concentration, urbanization patterns have an impact on the need for shelter

Box 3.9 On building construction phase A: project planning, design and specification

A-1. Project planning: initiative and preparation of documents (a) description terms of reference for the project, (b) land acquisition (c) feasibility studies,(d) overview of financial situation and conditions, (e). conceptual design of the building (based on the program of requirements): "product technology" (g) inventory of aspects and factors (design codes) which have to be taken into consideration before the conceptual design can be converted into a physical appearance. "production –technology".; (h) transformation of the conceptual design into the final design by analysis, evaluation and interpretation of data found in the inventory and making the necessary technical calculations; (d) elaborated final design into detailed construction drawings and final specifications for the construction readable for the contractor and the labor force.(e) estimate of the quantities of building materials and works needed in the construction process (bills of quantities) and final cost calculations. Actors: commonly architects and consulting engineers

Remarks : (1) Problems regarding one of the inputs factors: the site, that have not been solved before start of the production process may negatively affect the contractor's site performance,

(2) Feasibility studies may prevent financial problems in a later phase of the project that can lead to delays in the production process. (3) The design is the basis for production. For an optimal site performance it is necessary that the design is complete and accurate before start of the production process. Design changes during the production process may lead to wastage of direct input factors (and thus increased costs) and/or delays. Increased costs for the contractor can be compensated by submitting a cost claim, depending on contractual arrangements between client and contractor. A longer construction period may negatively affect the site performance level of other projects, due to the fact that equipment and labor are not available for these projects on time.. (4) This part of the process is characterized by its rather human-capital intensity. A well elaborated design and engineering specification of a building project is based on long formal education, thorough experience and knowledge of all aspects of information needed for the exercises. It depends from the size of the project whether specialists will be engaged in this phase of the project. In many cases in developing countries the smaller projects go through the same procedure without the preparation of any formal document

Box 3.10 On building construction phase B: processes from the extraction of raw materials and intermediate products to the final composition of the built products

Extraction of raw materials and production of building materials

In many industrialized countries these processes are completely separated from the actual realization process of the construction project on site. Timely ordering and supply of the produced building materials will enhance a smooth building construction process on site without delays. This requires appropriate planning procedures from the side of the contractor. Deficiencies with respect to delivery times of the supplying building materials industries might affect the site performance of the contractor. In industrialized countries contractual agreements with building materials suppliers work as precautions in order to prevent delays in the construction process on site. In a number of cases in developing countries this part of the construction process life-cycle is carried out by the contractor himself .

Production of prefabricated building components and building elements

Construction site performance might be improved by the application of prefabricated building components (doors, window frames, etc.) and even complete building elements (walls, roofs, etc.). A particular characteristic of the construction industry is that the finished products of this industry generally require adaptations to the specific location and terms of reference set by the potential owner, client or architects and construction engineers. This makes that the output is subject to wide differences in requirements which is common to construction projects in nearly all countries. Processes of rationalization led to the prefabrication of building components and elements. This way of carrying out construction has some specific requirements: (a) the construction process requires a high degree of coordination and forecasting of the actual demand for building components and building elements, (b) the availability of a proper infrastructure to transport the components, (c) the willingness to accept the uniformity and standardization of the finished buildings. On the other hand an advantage is that a certain quality of the finished product can be guaranteed. This is not always the case in on-site construction projects. In many developing countries the infrastructural situation for example forms a tremendous bottleneck for the prefab. operations in the construction process.

Box 3.11 On phase C: the realization stage of the building on site

Tender phase. The phase in which the contractor is selected is a very important phase from the viewpoint of his site performance. Only from this moment on the contractor can influence his site performance himself. (This is based on the traditional project organization form). The tender procedure starts with a call for bids. During the tender phase various contractors compete for the same project by submitting a tender to the client and his consultant. The tender contains the price against which a contractor will realize the construction work. The tender is based on documents and drawings provided by the client and consultant. Core of the contractor's tender is formed by the Bill of Quantities (BOQ). The BOQ contains the basic costs for the contractor of realizing the construction work, also called direct costs. All indirect costs as well as a margin for risk and profit are added to these costs. The size of the risk and profit margin very much depends on the characteristics of the operating environment as perceived by a company's management. The most important characteristic in this respect is the degree of competition experienced from other contractors. In case this is high, the profit margin may be lowered for the sake of winning the contract. Whatever the exact characteristics of the operating environment, a contractor should make sure he submits a tender that is realistic in view of his own capacities and capabilities. In case he is awarded the contract, he is contractually obliged to realize the price and construction period as offered in his tender. If he does not succeed, he will suffer the (financial) consequences (affecting his site productivity performance). Only in some cases, which depend on contractual arrangements, he may be financially compensated for a deviation from the planned costs and/or construction period.

Realization of the construction project. To make sure that the production process runs efficiently, a contractor has to make preparations. These should include the preparation of a detailed project plan including labor-, materials-, time- and cost planning. Basis for this detailed planning is the tender. The planning will again be the basis for control systems applied by the contractor during the production process. From the viewpoint of an optimal site performance the tender and the planning have to be as accurate as possible under the specific circumstances. Only then a sound basis for control is obtained.

Box 3.12 On the contactors in building construction

Construction units are the -officially registered- civil engineering contractors and building contractors which carry out construction projects in the so-called formal sector in countries. These units are usually responsible for the required resources: next to the materials, the unit provides for human resources, equipment and tools, information and documents, organization and management of the construction project. The contractors can be classified into a number of classes. The financial size of the projects, the number of employees or the nature and size of the equipment is taken as measure stick for the classification. In developing countries a lot of construction work takes place by individuals, building for their own purpose. This so-called informal sector can form a very important part, and even the majority of a developing country's national construction activities. Both formal and informal contractors are part of the construction sector. In some countries the informal sector contributes even 50% to the output of residential buildings (Moavenzadeh 1987)

Table 3.4. Classification of construction units in developing countries (Ofori 1990)

Type	Characteristics
International operating contractors (civil construction, infrastructure, hotels, offices)	Foreign owned, some foreign consultants, imported materials and equipment, professional and management personnel
conventional large (offices, highways, factories, blocks, flats)	large local contractors, some imported material, plant & equipment, skilled personnel
conventional medium or small (modern technologies: schools, houses)	small local contractors, imported/local material, few skilled managerial and technical staff, skilled operatives
Self-help (formal co-operations) (social communal facilities, roads, houses)	government technical aid, local/imported material/ voluntary labor by community
Monetary traditional and subsistence (informal operations: houses, shops, communal facilities)	traditional materials. Traditional skills, Traditional informal labor, semi- and unskilled, owner and cooperative labor.

Box 3.13 On the importance of construction management

Due to the involvement of various parties during the physical realization of a building the problem may rise *who* is going to balance out the pros and con's of the alternative technical solutions. The major limiting factors on meeting the actual terms of reference (that represent the preferences of the end-users) are of financial nature. The end-user or potential owner of the building will not always be the final decision maker, neither is the contractor. Moreover the contractor and end-user do not always communicate during the construction process. In many cases a property owner who invests in the construction of buildings will be the one who makes the final decisions on the technical as well as the financial aspects, whereby the preferences of the future end-user of the building are not always taken into account. Often investors in dwelling construction projects like for example national governments, which have the objective to build as many houses as possible in a short time, at best tend to take investment decisions based on short term analyses of the preferences of the future end-users, without taking into account the possible changes in these preferences at longer term. *Construction management*, attuning of the various tasks and responsibilities of the various parties in the construction process becomes rather important for the ultimate efficiency and effectivity of the construction process.

Box 3.14 Professional consultants in building construction

The position of architects, professional consultants and executing organizations in construction projects has changed and still is changing. In Western Europe the master builder was the one who made the building design some three to four centuries ago. The construction industry in those days was centered around the activities of guilds of carpenters, bricklayers and masons. In many developing countries this situation is applicable in particular for the lower cost building construction projects.

When the guilds disappeared to exist the construction projects were carried out by contractors. The project was given to these organizations via open tender procedures. Building construction projects only were executed upon order. When principals discovered their incapability to coordinate and evaluate the contractors operations and end-products the need for a principal's representative with insight in and knowledge of building construction was born.

Architects became the confidants of the building owner or principal of the project, to carry out the translation of a client's needs and intentions into documents and other information and later to coordinate and manage the conversion of these by the contractor into a physical item: the construction object. In the project design an integration was laid down of the various aspects and elements and of an optimal attuning of requirements the building should meet. The documents containing the terms of reference for a building cover spatial, functional, esthetic, structural and financial requirements.

The architect was supposed to be the one who provides the design and engineering, the project document and bill of quantities, estimate and subsequently in charge of the coordination and monitoring of the execution phase of the project. To be able to carry out these activities and take the responsibilities for the finalizing of the project, the architect was supposed to have a thorough knowledge of the different building production technologies, processes and costs of the construction. Assuming all these responsibilities by one single person was possible as long as there was a limited availability of materials and construction technologies.

Developments in building construction technologies and materials assume large proportions during the last decades of this century, despite their slow dynamics in comparison with those in other technological fields. The supply exceeding demand for building construction in Western Europe after World War 2 enhanced this. Due to this demand other product technologies were developed as well as other process technologies. The role of the architect as single person responsible for carrying out all tasks ranging from provision of information on all aspects of design and engineering up to the overall management and coordination of construction projects changed as well as the position of architects in relation to other parties involved in the execution of the construction project.

Next to the traditional construction project organization new organizational structures developed. Project developing organizations took the initiative for the establishment of buildings for direct sale or letting. Often these organization have their own design, engineering and contracting company. Ready-made buildings, also named "turn-key projects" came on the market, produced on more or less industrial way. The only difference with products from the manufacturing industry seemed to be the immobility of the end-products of the construction industry. However also this in some cases seems to be history.

Table 3.5 On the supply side actors in the construction industry

Equipment suppliers	Provide for a considerable wide range of production tools and equipment, varying from simple tools (hammer, saw, etc.) up to advanced heavy machinery Production of the more advanced equipment and machines generally takes place in those countries with a relative higher development level. Moavenzadeh (1991) states that both developing and industrialized countries have a similar consumption pattern of construction equipment. But developing countries generally need to import the totally of needed equipment. The fluctuations in demand for construction equipment is related to the fluctuations in the construction industry itself. This hampers the investment in equipment by the majority of construction units in developing countries. Moreover most of these countries have a prospect to substitute their need for imported construction equipment by an abundance of labor.
Building materials suppliers	Crucial actors for the construction industry supplying products from a very wide range of industries. In EEC the building materials industry is one of the largest industrial sectors next to the construction industry (Jacobs 1991). The building materials industry includes (a) the suppliers of building components and elements – elements particularly made for construction purposes - concrete, ceramics, steel, timber, etc. and (b) those suppliers of products with multiple applicability in a variety of industries, like chemicals like paint, electrical supplies. The first comprise the low- and medium tech industries highly dependent on the construction industry and often suffers from a decline in construction activities, the second group are the high-tec industries dominated by multinationals.. (Mishgofsky see Jacobs 1991).In most developing countries expenditures on building materials represent some 3-5% of the GDP. They account for 5-8% of the total value of imports. (Moavenzadeh 1991) Foreign exchange problems have formed a burden to the supply of building materials in many developing countries. Strategies were developed to establish domestic building materials industries. Also the infrastructural situation, shortage of skilled labor and managerial capacities and inadequate support services (e.g. maintenance of equipment) hampers the supply of building materials in many developing countries. .
Education. institutes	Provide adequate knowledge and skills for all levels in the construction sector. This is a prerequisite for achieving an optimal construction process: only with the required skills and knowledge the actors involved in the construction process will be able to execute their function(s) optimally
R&D Institutes	Have the potential to contribute to solve the bottlenecks in the construction process. This is a first prerequisite for the optimization of the construction process. In fact R&D takes place on-going in the construction industry and not only by R&D institutes.:(a) the development of materials, equipment, systems, techniques under the (physical) circumstances of the particular construction site, (b) preparation and revision of building regulations and codes, (c) preparation of construction guides, practice manuals, project organization and corporate operations guidelines, (d) the (re) formulation of public policies. A major problem which is encountered in both industrialized and developing countries with regard to construction related R&D is the lack of coordination and information in order to formulate, execute, evaluate R&D programs and disseminate the results to beneficiaries, in a way and of a nature that is relevant to the specific needs of the construction industry in the country.

Table 3.6 Financing and regulating actors in the construction industry

Financing institutes	The need for capital in the construction industry can be classified in (1) credit assistance for individual potential owners of buildings and (2) credit assistance to construction units. The first can be obtained via (a) savings and credit systems, (b) loans in cash, (c)loans in kind - e.g. by supply of land, building materials, (d) loans in "construction work hours", of skilled labor force, paid by the lender, (e) allotment of services of "building brigades" generally in small communities. Credit assistance to construction units are compared to enterprises in other sectors bound by rather unfavorable financial conditions, such as (a) payments in installments by clients long after the delivery of the product, (b) site work preparations which are generally prepaid by the construction unit, (c) exposure to uncertain qualities of labor force, which affects his performance bonds and guarantees, (d) relatively high working capital requirements, (e) in many developing countries moreover delays in payments and non-availability of adequate banking facilities. In most developing countries commercial banks only partially can meet the need for operating capital. There is a reluctance of these institutes to supply credits to construction units or manufacturers of building materials, in particular when these units are new and recently established. The construction industry is a capital consuming industry. It needs advance purchase of materials and equipment as well as cash available for wage-payments. This forms in countries with a relative high interest rates a burden to construction units, which often are ending up with double costs of the construction project. Moreover the fluctuations in the construction market even may induce the need for capital.
Government and public agencies	Policy interventions on the construction industry can have a considerable impact on its performance. Through regulations and incentives the government can guide the production towards the desired objectives in the country. Public agencies carry out services in the construction industry such as planning and coordination of the activities of persons and institutions to improve the performance of the construction industry.
Labor unions and branch organizations	have no specific, direct activity in the construction process although their activities may have an impact on it. Their general function is to represent their members (e.g. laborers, contractors, consultants). They may form a certain pressure group and safeguard the interests of their members in the activities in the construction industry. Through this activity they may be involved in the construction process whenever considered necessary by the organizations themselves, their members and/or the government and thus may have their impact on the site performance of construction units. The diversity of actors which may be involved in the construction processes is generally also reflected in the diversity of branch organizations (e.g. branch organizations of the metal-, plastics, timber-industries, etc.). In a number of countries the most important branch organization in the construction industry is that organization which represents the contracting companies.

Box 3.15 On policy making for the construction industry

In a number of countries still no particular policies are formulated for the construction industry. The *potential contributions of the construction industry remained by far unrecognized* thus no efforts were directed to exploit this potential. Policy making for the construction industry is like for any other sector generally based on economic considerations! Moreover the priorities in the policies are generally assessed along the same criteria.(Tassios, 1992)

A number of countries mention the necessities of developing the housing facilities in housing policy plans, with marginal attention to the construction industry to provide these facilities. This situation has changed, seemingly following the European trend after world war II, to bridge the gap between demand and supply of construction output by mechanization and prefabrication in the construction industry. During the decades of the sixties and seventies the construction industry has received some more attention. In developing countries the idea was that these developments should be complemented with import substitution by the local production of building materials and components and expansion of training and education programs.

Despite all positive intentions, not much was achieved. Some constraints which hamper the successful implementation of the policies to improve the performance of the construction industry are the lack of needed resources and particular technology choices. This counts in particular for the developing countries.

Materials shortages often caused a decline in construction output. There also often is a shortage of skilled construction personnel. These aspects enhance the application of extensively tested conventional construction technologies by which a desired standard of output might be attained. Moreover building regulations often are conservative and forbid the utilization of locally produced materials and technologies.

Technology choices still seem to be made upon wrong considerations. The terms of reference for constructions were often based on examples of modern-style, tall and large structures. The poor status of local technology capabilities is reflected in a number of unfinished buildings, a poor physical state of the finished ones. The building construction processes are characterized by their labor intensity.

The general government policy answers to these bottlenecks included an increase of

a. state participation in construction and the establishment of large state owned construction corporations. (b). state owned building materials industries, (c). import controls on materials and equipment, (d). labor policies, (e). registration systems for public construction companies with preferential position in tendering procedures. , (f). support of the establishment of joint ventures with foreign firms to facilitate technology transfers.

A lack of continuity is mentioned to be the major hindrance for any success of these measures.

P*ossible policy solutions mentioned in literature* indicate that the role of the government is to guide the changes in the construction industry to attain more efficiency and effectivity in the building construction projects.

1. a major point of attention should be to *enhance structural change* in the construction sector. This means an adequate responsibility structure to effect optimal use of available resources. The traditional structure with established renumeration systems for services and production activities is a real constraint.
2. Next to the structural aspect of the construction industry the government could have an important role to play in *standardization and setting the norms* for the basic construction details in order to achieve (1) higher product qualities, (2) lower costs through the possibility of standardized manufacturing of components.
3. the *provision of financial incentives* for most promising elements of the construction industry, like generous advance payments, risk guarantees for private banks lending to contractors or small scale building material producers
4. *enhancement of the possibilities for speculative building* by contractors, pre-fabrication of building (components), turn-key projects, package deals, serial contracts, management contracts, improvement of the technology infrastructure: effective integration of the various parties involved in the construction process.
5. Possible solutions that are found for the structural changes in the construction industry in the industrialized countries are: *negotiation contracts and package deals*. Package deals have some advantages for developing countries to re-structure the industry s infrastructure.

Appendix II

Data on Tanzania

I research design | II tanzania | III costa rica | IV conclusions

Contents

APPENDIX II-1

Empirical aspects of the Technology Mapping studies in Tanzania

Table II-1 Data collection methods applied during the field studies

Method	Type of data and comments
Literature studies	1. general background information 2. necessary data from studies which were performed before on the international, national and sectoral setting and on the same type of subject. 3. additional data on the product- and process technologies 4. more detailed data on the backgrounds of the participating parties in the dwelling construction projects for the lower income households The data were useful to compare the outcome of the field studies which were carried out in Dar Es Salaam, in Tanzania
Unstructured interviews with key-persons	To gather (additional) information which was not available from written sources and to gain more insight in the general outlook of the construction industry in the countries of investigation Contractors were interviewed to give their viewpoints on a. The all over performance of the construction industry b. The prices of building materials and components charged by contractors.
Structured interviews By means of both a questionnaire and personal interviews	Data on a. Project setting , b. Product technologies, c. Process technologies, d. Production inputs In general the mailed questionnaires had very poor response, this is why structured personal interviews were held additionally. Advantages of these personal interviews were that cases of illiteracy (sometimes encountered in Tanzania) could be overcome. Moreover this gave the opportunity to ask additional clearifying questions, to omit mis-interpretations of the questions. In some cases in Tanzania it was necessary to make use of an interpreter who was familiar with the construction industry. To properly estimate the costs of the houses the prices of building materials sold in shops were collected through structured interviews with shop owners and compared with the building materials costs lists available at the National Construction Council. The shops which have been interviewed were in principle the same as those where the house-owners bought their materials.
Expert opinions	To check the validity of the found data
Non-participant observations	To cross check the data during the whole period of the research project at the time that site visits were made to the countries of investigation
Visits to (pre)-fabrication sites of building materials	To investigate the particularities of the utilized building materials the data of pre-fabrication and 'production -on-site' By means of structured interviews and observation. Many building materials are produced on the construction site, some are produced on small-scale by a separate enterprise. In the larger towns like Dar es Salaam many building materials are imported and sold in shops

Table 1.2 sampling procedure

1. area sampling	to determine areas where construction projects had been carried out for (and by) the lower income households within the time-span of 1990 up to 1996.
2.selection of projects	Based upon criteria: (a) The target group of the dwelling construction project which should be the lower income household. (b) The execution of the construction project in the private sector by the so-called petty contractors, (c) The major basic features of the dwelling (d) the sites should be known as common residential districts. This implied that the center district of Dar Es Salaam was excluded (e) ease of accessibility of the project sites
3. further sampling	Random 'the first opportunity'. and recommendation of key-persons (in most cases the owner of the house)

Table 1.3 Sample

Number	42 dwelling construction projects for the lower income households
Type	The construction of one single storey dwelling only
Locations	Dar es Salaam Urban Areas: 1. Temeke, 2. .Vingunguti, 3. Buguruni, 4. Mabibo, 5. Tandika, 6. Changombe, 7. Tabata, 8. Sinsa, 9. Ubungo, 10. Kiwalani, 11. Mbezi, 12. *Gongo* la Mboto. 13. Mzimbasi, 14. Mbagala.

Appendix II-2

Data on housing in Tanzania

Table 2.1 Housing types in different areas Source: Mpuya, et all 1990

	Coastal & Lake areas	Central plateau area	Upland areas
1	Warm & humid High temperatures 26-33 C High relative humidity 70-95% Annual rainfall 600-2900mm Winds north-east & south-east monsoon; sea-side breeze during the night (cooling effect)	Hot & dry Temperatures 27-31 C hot during the day, cool during the night humidity : moderate 40-50% rainfall: 250-1650mm winds: light breezes no dominant direction, dusty dry	Temperate, cloudy mornings, rather cool nights temperature: 18-25 C humidity: 40-69% rainfall 750-1500 mm winds: moderate no dominant direction
2.	0m - 600m above sealevel	450-1200m above sea level	> 1200m above sea level
3.	Rich in forestry and vegetation	covered with forests, bush and lands	grasslands, woodlands, mountain rain forests
4.	Sand, clay, coral stones, lime, Gypsum, pozzolana , mica	limestone, large amount of clay soils, sand, stones & chips; wood fuel gypsum, pumic & volcanic ashes, pozzolana	timber, clay soils, limestone, gypsum, sand, chippings; not enough wood fuel for wide application of burnt bricks
5.	Strong traditions; Privacy of domestic spaces Outdoor food preparation, washing, drying, guest entertainment	heat : rest during the hot hours food preparation, etc in shaded spaces	low temperatures: gathering around fireplaces often relatively more space indoors for accomodation of (outside) activities
6.	Zaramo & Swahili Rectangular Enclosed court yard Central passage Front verandah	many forms and shapes (Hehe, Gogo), circular, rectangular, courtyards extended family houses	circular , cone-shaped in higher altitudes: (Chagga houses) comforatbale to heat and steep roofs for rain protection rectangular in warmer and less forestress areas.
7.	Zaramo: Poles, sticks, grass, Palm leaves Swahili: coral stone, mud & poles and Now-a-days: corrugated iron sheets, sand-cement blocks	soil, grass, poles, mud block walls, mud&poles with thatched roofs. Burnt bricks, iron roofing sheets	timber and sticks, leaves and grasses mud& poles, soil blocks for rectangular houses now-a-days: corrugated iron sheets
8	Quality non permanent < 7 yrs Organic materials: good insulation value New materials:climatologic not suitablewith current technical details but better Durability (with proper foundation and constr details!) 30 yrs.	Heavy to medium weight structures, compact, earth materials and tatched roofs Good insulation. Attacked by termites: non permanent quality	quality non permanent < 7 yrs organic materials: good insulation value new materials:climatologic not suitablewith current technical details but better durability and waterproofness (with proper foundation and constr details!) 30 yrs.

Legenda: 1. Climate; 2. Altitude ; 3.Vegetation; 4. Soils; 5. Population &. Living pattern; 6. Housetype 7. Construction system & Materialization, 8. Physique technical quality

Table 2.2 : Household income and expenditure in major Tanzanian cities
Sources: Fereira, World Bank 1995, Arundhati, I. 1994.

	Average.Household. Income (Tshs.)	Av. Household Expenditure (Tshs.)	Ratio Income/Expenditure.
Tanzania	64,378	61,560	1,05
Dar es Salaam	147,894	112,896	1,31
Arusha	89,970	88,037	1.02
Moshi	52,533	159,530	0.33
Tanga	31,931	73,416	0.43
Iringa	13,954	91,656	0.15
Morogoro	49,945	108,331	0.46

Table 2.3: Household expendit/ expend group,(% of total monthly expend)
Source: Arundhati, I. 1994.

	Rent	Building Mainten.	Water	School fees	Sanitation /sewerage	Garbage collection	Medical bills	Food	Energy/ electricity
Arusha	4%	10%	2.5%	10%	2%	3%	10%	43%	12%
Moshi	3%	23%	2%	20%	3%	3%	6%	24%	10%
Tanga	6%	9%	1%	15%	4%	1%	7%	37%	8%
Iringa	6%	11%	1.5%	12%	4%	4%	9%	32%	10%
Morogoro	3.5%	9%	0.5%	15%	4%	2%	6%	30%	9%
Average	4.5%	12.4%	1.5%	14.4%	3.4%	2.6%	7.6%	33.2%	9.8%

Table 2.4 Estimated housing deficit in the year 2000 in urban areas.
Source: Kyessi, c.s.Dar es Salaam, '95

Income group	Estimated housing deficit in 2000 in urban areas (demand)
Lower income	1,081,671
Middle to higher income	721,114

Table 2.5 The public sector housing delivery system in Tanzania
Source: Hoek-Smit WB 1990, Kyessi, c.s. Ardhi Institute, CHStudies, Dar es Salaam, '95.

Governmnt houses	Houses directly owned by the government or rented from the NHC. After 1967 no new government houses. Large majority of governmt housing units (2480 units) is located in Dar Es Salaam (approx 1.5% of the housing stock). Houses are rented to civil servants allocated by the government. Rent : 3% (1995) of the salary of the occupant.
National Housing Corporation (NHC)	Established in 1962. Responsible for the bulk of the public sector housing activities. Has not been able to fulfill the urban housing demand. 1964-1969: 6,000 units realized versus a target of 100,000 units. Stock: 26,685 rental units, incl. a number of government houses. The first housing programs did not reach the target group (low-income households) and reduce densities. 1985-1990 only 222 units were built by the NHC (Kyessi, 1995). Most of the existing NHC units are in a poor state. The 1984 Rent Restriction Act has, until recently, prevented the NHC from increasing the rents. No funds for maintenance and repair consequently. Result: a poor state of t existing stock
Registrar of Buildings (RoB)	Established in 1971, based on the Building Acquisition Act. This enabled the government to nationalize buildings with a value of at least Tsh. 100,000 and which were not occupied by the owner. The RoB also constructed new housing units. In 1990 the RoB was abolished. All RoB units (13,250) were taken over by the NHC.
Parastatals	The only public sector organizations that still are building new houses for their employees. Housing stock: total number is not known but is considerably more than that of the government. Estimates of the parastatal housing stock in Dar Es Salaam: 15% of the total stock. [Hoek-Smit 1990]. The houses are rented out during the occupants employment and need to be left when ending the employer's service. Rents are similar to the government and NHC rents and cannot exceed 3% of the salary.

Table 2.6 Financing systems for housing in Tanzania

Tanzania Housing Bank (THB) Loan programmes	1972 established after nationalization of the First Permanent Housing Finance Company. Objectives: (1)mobilization of local savings and external sources for housing development,(2) provision of technical and financial assistance for owner occupied housing, (3) provision of financing for the development of commercial and industrial facilities. THB was the only long term mortgage provider in the country. Types of loans: (a) un-subsidized mortgages from general funds; (b) subsidized from the Workers´and Farmers´Housing development Fund. Sources of the funds mainly : (a) share capital - Tsh 800 million , 52% Ministry of Finance, 24% National Insurance Company, 24% National Provident Fund - but paid-up capital was never more than Tsh 220 million; (b) deposits. Interest rates: set by Bank of Tanzania (for both lending and deposits); rather high lending rates for regular non-subsid. residential mortgages (for approx 20 years - 31%). Mortgage amounts: limited to Tsh 500,000 (was increased from Tsh 35,000 in 1973). Largest institutional client for mortgage funds: Tanzanian Housing Corporation. Since 1973 little more than 14,000 mortgages issued; last decade this became steadily less due to high interest rates relative to incomes and relative low mortgage amounts for those able to afford an expensive loan. In 1995 the THB has gone bancrupt.
Workers´ & Farmers´ Housing Development Fund	A fund for residential mortgages administered through the THB, against rather low (subsidized) interest rates for workers and farmers (9%). Major sources for the fund : from a 2% levy on the wage bills of the employers with more than 10 employees. No new contribution have been made since 1985. At present the fund is operating like a revolving fund. Conditions for allocation of a mortgage: (a) the employer should have contributed to the fund, (b) repayment should not exceed one third of the borrowers income, (c) a deposit should be made of 5% of the loan amount, (d) the loan term was capped by the age of the borrower (repayment period should not exceed his 55th year). The average loan amount was Tsh 50,000 during the last decade. A little more than 25,000 mortgages have been issued since 1973, about 8000 of the outstanding mortgage borrowers is in trouble.
Housing allowances system	A rather complex system meant for eligible and entitled public employees, which includes both a rental allowance (40% of the salary which equals an amount between Tsh 500 and Tsh 700/month) to rent a house privately and a house-maintenance allowance for the maintenance of an owner occupied house or for those who are living in a government house and who have given up their own house for rent by the Government . Not only the national government but also private (foreign) employers have established similar systems of housing allowances for their employees. Approx. 20% of the owners in Dar Es Salaam receive a maintenance allowance and 25% of all households renting a house received a rental allowance, which are tax free. (WB1995)
Rent Controls for private and Public Housing	1984 Rent Controls for private and Public Housing act (adjusted 1962 Act). *Objectives*: keep control over rents. All existing and new rental properties were affected by the act The act avoids that the annual rents exceed 14% of the (replacement value of the property, valued by a governm evaluator. Rental Tribunal (under the rent restriction act) sets all the rents also of the NHC and RoB properties, (remained unchanged between 1971-1985) 1985 rent increase to economic levels were allowed. Still rents are rather low relative to building costs, thus rents do not cover the maintenance costs of the rental stock. The rent was set as a proportion of the income for employees of government and parastatal organizations who live in a government or institutional dwelling , which may not exceed 3% of the salary (amount was changed in 1990 from 10% to 35 , to be more in balance with the decreased real wage-income level)

Table 2.7 GENERAL POLICIES on land use and buildings (1962-1971)

Land Ordinance cap. 113, (1962)	• nationalization of all land • land without infra- or super structure has no official value & cannot be charged or taxed (unimproved land is not included in the present valuation of lands in urban areas) • land tenure on urban land is issued by the governm by means of the Right of Occupancy (RoO). RoO is given for a period of one year, 33 years or for periods longer than 33 years (the latter counts in case of commercial or industrial development) • One year RoO can be issued without formal survey of the plot. • The plot needs to be surveyed officially in case of a 33 or longer period RoO • Survey time and registration processes take 4 to 5 years on average, starting from the date the offical offer is given to the allotee. • An official title is given to the survey, which is necessary to apply for a mortgage at the only mortgage lender in Tanzania: the Tanzanian Housing Bank • Land allocation is controlled by the Government. • Land has no official value, so no costs are charged for the land, but costs are charged for the surveys. • Prices can only be offically charged & recorded for transfers of privately owned land by previous occupants to the next occupants for the land improvements. • No formal RoO issued in case of informal tenure; to a certain extent secured and governmnet sanctioned, by means of a land- tenure security allocated through a community leader • Due to a limited supply of formally allocated plots and a high demand for urban land a rather active informal market has devevloped for the allocation and payment for land. Informally people thus pay high and un recorded charges for land to private land holders. • Private surveyors are hired increasingly to meet the survey-requirements to acquire a formal title for land obtained at the informal market. *Result* of the Land ordinance: a dualistic system of a formal and an informal land market.
Acquisition of Buildings Act(1971)	• 1971: all privately owned buildings, both the residential and the commercial buildings, which were rented and not occupied by the owners, worth more than Tsh 100,000 (Tsh6 = US$ 1 in 1971) were nationalized • 1985: This act was abandonned to stimulte further private investments in rental housing. • 1990: the National Housing Corporation Act repealed the 1971 Act. Civil servants with a certain rank and income level (above Tsh 1600/month) were not allowed to won a house in urban areas. ***Result* of land- and house-ownership policies** in combination with Rent Restriction Act and lack of long-term financing: impossible to develope a rental investment housing sector

Table 2.8 Policies on urban development, housing and construction formulated in the National Development Plans Source: National Development Plans

Urban developm	The existing urban infrastructure and services have not kept pace with the rapid urbanization which Tanzania is currently experiencing. This has hindered urban development. The implications are unreliable water and energy supply, transport and waste management services. The government is formulating a Comprehensive Urban Development Policy Framework, which has to be a guidance in the attainment of the urban sector objectives. The main objectives include -to develop a sustainable urban infrastructure investment and maintenance program, -to alleviate urban poverty, -to improve the land delivery systems.
Rural developm	With respect to rural development significant improvements are needed in (among other fields) housing. These improvements have not taken place so far due to a lack of skills, ability, tools and finance among the people and organizations responsible for rural development. The main policy objectives of the government are (a.o.): -to increase incomes and alleviate poverty, -to promote the investment in economic and social infrastructures, -to prevent environmental degradation. One of the priority areas in government policy will be the formulation of integrated development programmes.
Housing	The main constraints currently facing the housing sector include -lack of building materials, - inadequate and high interest costs of housing credit finance, - shortage of surveyed plots with its implications for the squatter issue. The main objective of the government is 'to ensure that all Tanzanians have access to adequate and affordable shelter'. The National Housing Corporation (NHC) failed to cope with the demand for low-income housing. In 1972 the government formulated the sites and services and squatter upgrading approach. This approach was partly based on the fact that the majority of the housing was realized by private individuals. Since this harmonized with the national policy of socialism and self-reliance, the government supported this situation. The government's role would be a provider of a stimulating environment for private housing activities. The sites and services projects, however, did not reach its target group. In 1981 a National Housing Development Policy was formulated. The main features of this policy were (a) -integration of economic planning and human settlement planning in development decision making, (b) stimulating private housing initiatives. This policy did not work out properly due to a lack of effective strategies and of a realistic assessment of the housing needs. Its success was only marginal. Currently a new strategy is being formulated based on an 'enabling approach' and 'sustainable development'. This housing strategy will have to contribute to economic growth and employment.(NCC 1995)
Constr. Industry	One of the policy objectives of the government in is to achieve self-sufficiency in the production of local building materials. This will be realized (among other measures) by promoting the use of suitable naturally occurring materials and to considerably increase their local production. Building materials take 60% of the total building costs and form an important part of the construction industry. Tanzania is facing a lot of problems in this field. The supply of materials has not kept pace with the demand for it. This is due to limited local production capacity and a lack of foreign exchange for the necessary imports.

Table 2.9 Basic regulations for residential buildings (TBR 1985)

Plot and land use	Plot should be of sufficient size and with access roads for users and also for emergency vehicles. Land use should be not more than 60% of the plot
Dwelling	Every dwelling shall be provided with reasonable spaces for living, sleeping, dining, studying, cooking and personal hygiene
Living room	in every dwelling, floor area 10 m2, height 2.40m
Bedroom	10m2, bedroom for 2 pers (at least one) ; 7 m2. Bedroom for 1 person; Height 2.10
Living/ dining/bedr	15m2 (Combined in one room)
Kitchen	5 m2 Every dwelling should have cooking facilities, food preparation., storing-room
Lavatory	2 m2
Shower/bath	2,5 m2
Toilet & bathr.	3,5 m2 (combined functions) Every dwelling to be provided with necessary facilities
Store	3,5 m2. Sufficient for clothes and household equipment
Garage	16 m2

Appendix II-3

Data on the technological capabilities

Technology stock

Table 3.1 Type of houses in Tanzania Source: BRU, WR 68 – 1990

Shape	Occurrence % all houses 1990	No of rooms and basic lay-out
1. rectuangular hipped roof entrance: long side	40-45% of all houses (1990) *Location*: all regions	one-room wide width: range 2.6 - 3.8m; median: 3.2m length: range 3m - 40m,; median 6m 25% < 5m; 25%> 7.5m
2. rectangular gable roof entrance: long side	20% of all houses ('90) *Location*: all regions	two room wide (with central corridor) width: range 3.6m - 6.6m; median: 6.4m length: range 7.0 - 9.5m
3. rectangular flat soil roof (Tembe)	10%; *Location*: hot & dry + temperate climate areas	indoor area :major range: 4m2 - 80m2
4. Swahili rectangular hipped roof entrance: short side	10%; *Location*: coastal regions + Morogoro region	median: 23m2; 25% < 14m2; 25%>35m2 nr of rooms: range. 1- 42
5. long rectangular vaulted roof covered with grass and soil	1-2%; *Location*: Iringa region	median: 4-5 rooms/house; 25%< 3 rms; 25%> 6rms
6. round con- cylindrical	5-8%; *Location*: northern part + Morogoro + Mbeya region	1 room house: 2.8-21.7m2; median: 10m2 l range 2-6m, median 3-4m
7. pointed beehive	< 1% ; *Location*: northern part, West of Lake Victoria + near Kenyan border	2-rooms house: 6-25m2;l 4-6m 3 rooms house:16- 35m2; l 5-7m
8. small round beehive	Neglectable *Location*: Wtanzania Kigoma	round + square room in the middle: 28-75m2; l 6-7m round +round central room: 28-75m2 ;l 6-10m height external wall: range: 1-3m; median: 2m; 25%< 1.8m; 25% > 2.3m
9. oval Masai	< 0.5%; *Location*: northern part	Low height < 1.8m

Table 3.2 Construction systems of houses of lower income households in Tanzania
Source: Edvardsen, 1972; HBS 1978; Mpuya, 1990; Mtui, 1990

Foundations	1. firm soil foundations (91%): a. pole foundation (65%) b. mud / soil blocks (26%) 2. stone foundations (4%) 3. burnt brick foundations (3%) 4. concrete mix foundations (2%)
Floors	1. tamped soil (91%) 2. sand-cement floors (7%) 3. concrete floor (0.5%) 4. burnt bricks with cement screed (0.5%) 5. stone floor (1%)

Table 3.2 continued next page/...

.../Table 3.2 continued

Walls	1. mud & poles (50%) 2. mud blocks & mud insitu (26) 3. Poles, grasses & plants (16%) 4. Burnt bricks (3.5%) 5. sand-cement blocks (2.5%) 6. stone (2%)
Roof structure	1. round timber poles (93%) 2. sawn timber (7%) 7% trusses: 4% round poles trusses 2% round purlines- 2% sawn purlins 3% totally sawn timber trusses
Roof finishing	1. grasses and leaves (71%) 2. flat or vaulted soil (12%) 3. metal roofing sheets (17%)

Table 3.2 b On the construction product technology systems in Tanzania

The most common type of **wall systems** in many regions in the country are the traditional mud-and-poles system (50%) and the mud wall system (26%). Next come the walls of organic materials -poles, grasses and plants(16%). In urban areas the sand cement blocks are being applied increasingly since the last decades (2.5%). In Dar es Salaam this percentage is higher: 66% for all houses and 60% for the houses in the un-planned private sector. (Hoek-Smit, WB 1990). The burnt bricks masonry system was introduced by the Catholic fathers to substitute the traditionally applied sun-dried mud bricks to improve the quality of the houses. The diffusion of this technology has taken place only rather slowly. A Constraints are the costs and high energy utilization for the production of the burnt bricks.
Quality: With exception of the sand-cement blocks and burnt bricks wall construction system, the rest of the wall construction systems are liable to rapid deterioration caused by termites and other insects and the washing out of the mud during the rainy season. The walls are easily attacked by fungus and the risk of fire is also rather high especially for the houses built with the organic materials only.

The major type of **foundation system** (91%) is the mud wall without footing directly put on the firm soil. Or - in case the main structure is carried out as a mud-and-poles structure- the foundations are separate (stone filled) small holes excavated for each vertical pole of the main structure. Other types of foundations that are applied in minority are those carried out with footings of stones or burnt bricks, or those carried out as concrete strip foundations.
Quality: The non-existence of real foundations make the houses vulnerable for mechanical and climatological forces (wind, rain, flooding).

The **floor systems** include the (a) simple tamped soil floors, (b) sometimes covered with a cement screed layer, (c) sand-cement floors, (d) stone floors and very few (e) burnt bricks floors. But the floors are too often just a continuation of the outside ground. Almost all houses have a tamped soil floor (92%) which is in only 7% of the cases covered with is cement screed layer.
Quality: Since floor finishing is only applied in few cases the floors are difficult to clean, often dusty, are attacked by insects and liable to flooding during heavy rains.

The **roofing system** generally is made on site and consists of a structure of either sawn or round timber(93%), and timber trusses (7%) that are traditionally and most times covered with grass and leaves (71%) in the country. Metal roofing sheets are used in 17%. In Dar es Salaam 66% of the houses have corrugated iron sheets as roof finishing. Also other roof structures like steel structures are known, although these fall beyond the affordability of the target households, like the clay and concrete roofing tiles as roof finishing materials.
Quality: the roofs have no high quality since a major part still is carried out entirely with organic materials. The roofs are even more vulnerable to rapid deterioration than the walls, which is too often reflected in leakage and a collapse of the whole roof. During rain the heavy palm leave and grass roofs absorb a lot of water, which increases its weight leading to often dangerous and fatal results of collapse. The quality of the timber and the engineering details applied for the roofing structure do not meet the physique technical requirements. (Iwaarden-EUT 1996, Tillie- EUT, 1995)

Table 3.3 Attributes of Housing stock in urban areas
Source:Urban housing Survey.Hoek-Smit/WB,90

Dwelling attributes In Tanzania	Govt / NHC DeS	Inst/ employer DeS	private/ formal DeS	Private / Unplanned DeS	Total			
Housetype	17%	15%	27%	41%	DeS	Iringa	Mwanz	Morog
Traditional	3	26	31	17	20	-	24	1
Unext Swahili	1	-	**51**	**60**	**38**	**40**	**32**	**36**
Ext Swahili	-	-	7	8	5	21	3	10
Core house	-	-	2	5	3	5	9	24
Detached house	-20	26	4	7	11	26	7	23
Semi-detached	20	26	4	7	3	3	4	3
Row house		13	1	2	5	2	1	2
Multi-storey	1	-	3	-	15	3	20	1
Wall materials								
Mud/wattle	-	1	**37**	**34**	**24**	**28**	**12**	**14**
Sun-dried mud	-	-	1	-	1	7	23	5
Burnt bricks	26	98	7	5	8	61	5	0
Cement blocks	**76**	-	**52**	**60**	**66**	**4**	**45**	**80**
Other	-		3	1	1	5	-	1
Roofing mater.								
Thatch	-	-	4	1	1	-	6	7
Tins	-	-	3	4	2	1	6	-
Corrugated iron	1	27	89	94	67	99	64	85
Asbestos	4	-	1	-	1		4	7
Tile	33	31	-	-	11		-	1
Other	62	42	3	1	18		20	-
Condition Bldg								
Bad	2	40	22	27	24	43	17	33
Poor	1	-	15	10	8	4	20	2
Fair	70	26	50	54	51	46	49	47
Good	28	34	13	9	17	7	14	18
No of rooms								
Mean	3.2	3.7	5.8	5.2	4.8	6.5	4.8	5.6
Mode	3.0	4.0	6.0	4.0	4.0	8.0	3.0	4.0
Size of dwelling (m2)								
Mean	112	113	158	122	128	186	193	-
Mode	126	93	144	96	120	68	120	84

Table 3.4 Utilization of tools in the dwelling construction projects Source: BRU, WR 68, 1990

Tape measures	8%	Pick axe	4%	Carpenters axe	30%
Square	2%	Axe	68%	Hammer	22%
Spirit level	10%	Knife	47%	file	1%
Rope	4%	Saw	19%	tray	20%
Local spit	27%	Bowl	1%	bucket	40%
Hoe	58%	Wheelbarrow	4%	busket	3%
Spade	16%	Wooden mould	1%	trowel	11%
Machete	86%	grass cutter	3%	suffrias/pots / levellers	

Table 3.5 Project management & labor input in dwelling construction projects
Source: BRU/WR 68/Mpuya '90

	hh head	fundi/ contractor	hh head + fundi	hh head + relatives/ friends	hh head + fundi + relatives /villagers	not known
Project management	27%	23%	36%	5%	9%	-
Project participation	21%	27%	28%	4%	17%	3%

Table 3.6 Construction units involved in dwelling construction for lower income (classified after Ofori 1990)

Type	Characteristics	Dwelling construct.
Internationally operating contractors (civil construction, infrastructure, hotels, offices)	Foreign owned, some foreign consultancy, imported materials and equipment, professional and management personnel	Not involved
Conventional large (offices, highways, factories, blocks, flats)	large local contractors, some imported material, plant & equipment, skilled personnel	Not involved
Conventional medium or small (modern technologies: schools,houses)	small local contractors, imported/local material, few skilled managerial and technical staff, skilled operatives	X
Self-help (formal co-operations building social communal facilities, roads, houses)	government technical aid, local/imported material/ voluntary labor by community	X
Monetary traditional and subsistence (informal operations: houses, shops, comm. facilities)	traditional materials. Traditional skills, Traditional informal labor, semi- and unskilled, owner and co-operaive labor.	X

Table 3.7 Classification of total technology system in dwelling construction projects in Tanzania

	Conventional (12%)	**Traditional** (88%)
Location of application	Mainly in urban areas, but also increasingly in rural areas. Continuous demand.	rural areas, un-authorized settlements around urban areas. mainly simple & basic housing units for lower income hholds, continuous overwhelming demand.
Production process technology	*Equipment*: mainly hand tools but mechanized to a little extent (e.g. use of a concrete mixer) *Labor*: local un-skilled and semi-skilled, trained on-the job *Information elements*: design and engineering documents locally made *Organizations*: medium-, small- and informal; no planning, no experience	*Equipment:* simple tools *Labor*: semi-skilled and un-skilled, illiterates, generally self-employed individuals, temporary. Workers, some coop. & and many family businesses in inf. sector. Labor intensive. Low wages. Lack of technical and administrative expertise *Information*: no documents., no standards and blg regulations or codes, costs registration *Organization*: ad hoc, no governm social security regul or labor regulations
Product technology	Production output to customer's demand locally determined terms of ref. For design and engineering imported components and elements, Building materials: imported to large extent	Traditional mud, thatch & un-finished timber constr., but also more cement blocks, corr. iron sheets, allum & asbestos, finished timber, glass. Geometric change from circular shape to rectangular enhanced by changes in culture and life styles. Many materials produced on site.

..../ table 3.7 continued

General	lack of finance, shortages of materials. delays in construction, time overruns,in-efficient plant and equipment use, low productivity, low levels of output, inability to meet construction demand Hindrance to overall development. Shortage of skilled labor. Inability of planning & management, shortage of spare parts.	inadequate. Investm; low level of reinvestment, ltd access to funds. credit facilities, fall outside the national tax regime. Poor qual. products, inadeq. marketing, ltd access to training in managemt & techn expertise, problems with supply of materials, poor access to governm. assist. schemes, infrastr & facilties (electricity, water, etc) Ltd access to information. Ltd relat. with formal sector. Lack of institut. support for selection & applic. Of techn.. Major contributor to shelter delivery . Marginal to economic development.

Human resources stock

Box 3.1 Tanzanian population distribution by sex, age group and area
Source: HBS 1991/1992

a. a high percentage of population in the younger ages, more than 40 percent of the population is below the age of 15.
b. more female than male population in Tanzania Mainland
c. the percentage of male population of age groups 60 years and over is higher in all areas(4.9 per cent) compared to that of the female population (3.4 per cent)
d. 25 percent of the population is urban, against 18 per cent in the population census of 1988 and 28 per cent for Sub-Saharan Africa.
e. the population with age of 65+ is relatively small, smaller in urban areas compared to rural areas.
f. the old age dependency is minimal compared to the child dependency.(the ratio of persons aged 0-14 and 65+ divided by the number of persons aged 15-64). The dependency ratio was 0.88 in 1991/1992, in the census of 1988 it was 1.01 and for Sub-Saharan Africa the figure is 0.94

Table 3.8 Laborforce in construction 1992
Source: Misanga in Uhandisi Journal, Dec 1993, p 122-129

Labourforce	employed	Vacancies	total required
Professionals	474	63	537
Technicians	1388	396	1784
Craftsmen	1378	341	1719
Total	3240	800	4040

Table 3.9 Occupational status in sectors

Occup. Status	Agr&f	M&Q	Manuf	E&G	**B&C**	Trade	Transp	Finan	C&P
Adm/managers	0	1	2	0	**0**	76	4	1	16
Professionals	0	0	10	4	**6**	17	8	14	41
Ass/profession.	2	0	3	0	**1**	2	3	3	85
Clerks	2	0	14	3	**2**	18	17	9	35
Service/shops	0	0	2	0	**0**	64	2	0	31
Agr on farms	100	0	0	0	**0**	0	0	0	0
Crafts wrks etc	0	25	32	1	**16**	5	3	1	17
Opers mach	3	1	44	3	**4**	6	27	1	12
Sales labours	10	1	7	0	**4**	58	5	1	14

Table 3.10 Education level 1992	total	self empl with employees	paid labor	unpaid	trad agric	self employ without employees
None	33	10	6	11	37	17
Primary not completed	21	14	13	29	22	20
Primary completed	43	59	58	50	40	58
Secondary and >	3	17	24	10	1	5

Table 3.11 Type of training 1992 Source NBS 1995

Training	total	with empl	paid empl	unpaid	trad agric
None	660394 (67%)	199434 (73%)	216825 (49%)	16038 (94%)	228097 (90%)
On the job	147504 (15%)	37767 (14%)	97382 (22%)	801 (4%)	11554 (4%)
Other	179778 (18%)	36140 (13%)	131182 (29%)	290 (2%)	12166 (6%)
Total	987676	273341 (28% of total)	445389 (45%)	17129 (2%)	251817 (25%)

Table 3.12 Literacy		TOTAL			URBAN			RURAL	
Source:NBS 1995	TOTAL	EMPLOY	UN-EMP	TOTAL	EMPLOY	UN-EMP	TOTAL	EMPLOY	UN-EMP
Total	100	96,4	3,6	100	89,4	10,6	100	97,8	2,2
Literate	67,4	64,6	2,8	84,5	74,9	9,6	63,9	62,5	1,4
Illiterate	32,6	31,8	0,8	15,5	14,5	1	36,1	35,3	0,7

Table 3.13 R&D Statistics of Tanzania, Costa Rica, The Netherlands
Source: UNESCO: Statistical Yearbook '95; For Tanzania: Mwala & Sheya 1990

R&D scientists & engin./ sector	production sector	higher education sector	general service	Total
Costa Rica 1992	74	1197	451	1722
Netherlands (1991)	17920	10390	11690	40000
Tanzania		no data available	no data available	In 1986: 2,893 scientists 4,036 engineers

Natural resources stock

Table 3.14 Major necessary resources for the construction Industry. Source: NCC 1995

Building materials & Construction elements	natural resource components	avail. in Tanzania	major charact. of current production & utilization
Plot	Land	x	lack of surveyed plots for construction
Cement Cement based products	Clay, lime and gypsum	x	local large scale production; import content in production 57%
Aggregates	Sand, rocks & gravel	x	no full scale exploitation, only small scale mining & quarrying
Lime products	Lime	x	no full scale exploitation, only small scale mining & quarrying
Gypsum products	Gypsum	x	imported Gypsum boards & blocks, and some local plaster of Paris; majority used in cement industry.
Clay & clay products	Kaolin	x	local small scale prod.
Ceramic products & Sanitary ware	Kaolin, salt, gypsum, lime	x	Imported
Iron and steel products	iron ores, coal, magnesite for lining of furnaces	x	intermediate materials imported, import content in production 90%
Alluminium products	bauxite	x	interm products imported
Wood and timber products Agro-based products (grasses, sisal, etc)	forestry resources agricultural resources	x	partly imported, in particular composed construction materials
Bamboo and bamboo prod.	bamboo resources	x	nearly not utilized
Thermoplastics	Crude oil, petro-chemicals like benzene, salt, caustic soda	x	Imported
Paints, Chemicals	(petro-)chemicals	x	interm products imported
Sheet glass	white quartz sand, limestone, soda	x	imported; factory not in use
Gasses for welding		x	imported
Rubber, resins, etc	agricultural resources	x	imported
Water	Water	x	local
Energy	crude oil, coal, wind, water, solar, biomass	x	not fully exploited

Table 3.15 Mineral resources
Source: Dorgan, C.A. Gale country &world rankings reporter, 1995

Non metallic minerals	type in 1000 m tons	1983	1985	1987	1989	1990	1991
	Gypsum	12	15	25	5	36	35
	Limestone, calcareous stone & natural phosphates (alum calcium phosph0	-	-	-	5	25	22
	Sand & gravel	-	-	-	-	-	-
	Clay	1	2	2	2	2	2
	Kaolin	1	2	2.	2	0.	0
	Salt unrefined	28	21	41	20	20	64
Metallic minerals	many different ores, like iron copper, zinc, lead, mangan, and sulfur, gold etc deposites	no concentrated extraction					

Table 3.16 Technology infrastructure characteristics Source: Maro et all 1991

Actor Nature of activity & objectives	Availability & source of capital	Relationship with contractors in sub-sector of residential bid for lower income hh	Problems and constraints reflected in construction performance
Client . assignm of project . Purchase materials . Project management	.lack of savings .lack of funds on continuous basis .difficult access to finaning organizations	. Collaboration during construction process	. Lack of knowledge . Lack of skills . Lack of time . Acceptance of lowest but un- realistic bid . Inadequate judgem of quality of materials & work . Delays in constr . Extra costs . Late payments
Consultants .Supply of doc. & inform, design .Supply of managemnt & organiz. Support	. Lack of investment cap. of the market	.in general no relation	. Lack of expertise . Lack of time . Lack of funds reflected in inadequate prepar of project, no design, no tender documents, wrong choices, delays, extra costs, no supervision on site (Msita 1993)
Materials suppliers *Equipment suppliers*	. Lack of investm capacity of .Suppliers themselves .Market	purchases from *informal sector in* majority	. lack of raw materials . *Lack of prod cap.* . Low quality material . insufficient transport . Reliance on imports. . Lack of foreign currency . Delays . Higher construction costs . Low quality of buildings

Table 3.16 continued next page/...

.../ table 3.16 continued

R&D institutes, libraries, doc centers	. Lack of funds in majority depending from public sources	practically no relation	. Lack of Information . Hardly any technology developments . No diffusion of knowledge & skills
Educational institutes	Lack of funds in majority depending from public sources	only at low level educ relations	Not adjusted to training needs and lack of qualified personnel . Reflected in wrong construction procedures application of wrong technologies, bad project management, costs overruns, delays
Financing organizations	.govrnm. controlled + many restrictions .Inflation .Devaluation	practically no relation	lack of funds
Government	. Lack of funds due to consequences and effects of economic liberalization measures; . Lack of forex due to a lack of foreign exchange-earning activities (e.g. export)	practically no relation	Lack of co-ordination in sectoral planning and a non-existence of inter-sectoral planning system Lack of suitable + consistent tender documents and procedures resulting in an automatic' use of foreign systems Inadequate + uncoordinated registration of contractors due to a lack of capacity in the registration institutes and a registration responsibility with different organisations Inadequate physical infrastructure --> difficult communication & transport
Branch organizations		no relation	-> lack of control tool for government ---> may hinder implementation of certain government measures
Labor organizations		no relation	Lack of incentives for workers -> lack motivation ---> low speed and quality of work---> comparatively long construction times + increased costs

Table 3.18 Product technology stock scoring keys

Class of system (0<C<10)	*Score*
Traditional	3
Conventional	6
Advanced	9
Quality (0<Q<10)	
Good >11yrs	2
Fair (6-11yrs)	1
Bad (<6yrs)	0
Production complexity	0<P<10
Affordability	0<Aff<10

Table 3.19 Processted stock scoring keys	
TECHNO Type (0<T<10) See part I chapter 1	
Hand tools: a. tools as direct reinforcement of human energy/ force; like stone, chisel, hammer b. tools with extra transmission part (hammer with handle) c. transmission part and actual tool combined: drill (man needs one hand to transmit power/energy and the other to guide/steer the process)	2
Tool with non-human energy source (electro motor)	3
Tool with non-human energy source & control mechanism	4
Totally mechanized tool (push-a-button tool)	5
Tool that can be programmed manually, in order to reach identical end-product	7
Tool that can be programmed automatically (CAM)	8
Integrated computer aided design and manufacturing production tools CAD/CAM tools	9
HUMAN *Type (0<L<1)*	**score**
Skilled labour	
Un-skilled labour	
Training (0<Tr<10)	
On the job	
Other	
Education (0<E<10)	
Secondary school and > (9)	9
Primary school (5)	5
Not finished primary school (1)	1
None (0)	0

INFOWARE	**SCORE**	**ORGAWARE**	**SCORE**
Availability	*0<Av<10*	*Type*	0<Type<10
Technical specifications		small informal	1
Planning and control		small formal	3
Material & equipment		medium scale	5
		large scale	7
Retrievability		Foreign	9
None	0	*Project management*	
Written	1	Household(o)	0
Computerized	2	Contractor (1)	1
		Project planning	0<PP<10
		Regulation & control	0<R&C<10
		Bussiness orientation	
		training	0<tr<10
		R&D	0<r&d<10

Appendix II-4

TECHNOLOGY STATUS

4.I. Project setting

1. Location			
Climate	Hot and humid		
Land & soils	See table 5.2		
Earthquakes	n.a.		
Wind forces	3.1 m/s		
Groundwater level	12m (static water level)		
2. accessibility	*Type of road*	number	%
	Road	4	9
	Footpath	9	22
	None	29	69
3. size	*no houses/project*	number	%
	Single unit	42	100
	Mass construction	0	0
4. age	*Year of construction*		
	< 1 year	4	9
	1 year	5	12
	2 years	5	12
	3 years	4	9
	4 years	8	19
	5 years	5	12
	6 years	2	5
	7 years	3	7
	12 years	2	5
	14 years	3	7
	15 years	1	3
5 client/principal	*Type of customer*	number	%
	Housing corporation	0	0
	Institutional investor	0	0
	Private investor/owner	42	100
	Private investor/cooperation	0	0
6. source of finance	Savings /own salary	37	88
	Family / friends	3	7
	Loan /employer	2	5
7. project management		number	%
formal sector	Project engineer	0	0
	Foreman	0	0
	Skilled labor	0	0
informal sector	Owner	34	81
	Contractor	4	9
	Owner and contractor	2	5
	House wife	2	5
8. legal status	Legalized	4	
	Expect legalization.	18	
	Illegal	20	

4.2. Productec

1. Type of house		number	%
	Traditional	6	
	Un-extended swahili	33	
	Extended swahili	3	
	Semi-detached	0	
	Row house	0	
	Multi-storey	0	
. plot size		Number	%
	< 100 m2	3	7
	101 - 300 m2	12	29
	301 - 500 m2	11	26
	> 500 m2	16	38
3. dwelling size			
	< 40 m2	9	22
	40 - 100 m2	10	24
	100 - 150 m2	8	19
	150 - 250 m2	7	16
	> 250 m2	8	19
3.b ratio house/plot size			
	< 30%	16	38
	30 - 60%	18	43
	> 60%	8	19
4. nr. of rooms	excl kitchen &sanitary serv.	number	%
	1 room	3	7
	2 room s	12	29
	3 room s	5	12
	4 rooms	7	16
	5 rooms	5	12
	6 rooms	5	12
	7 rooms	3	7
5. living pattern	>10 rooms	2	5
			%
use of house & plot	farming	27	65
	small business	3	6
	shop	1	2
6. facilities		number	%
Cooking facilities	inside	31	75
	outside	11	25
Bathing		number	%
	inside	8	19
	outside	34	81
Drainage			
	drainage available	4	9
	no drainage on plot	38	

Electricity	electricity available	8	19
	grid connection for all appliances	0	
	grid connection for light only	0	
	own generator	0	
	comb grid/own generator	0	
	Other	0	
	electr non-available	42	
Toilet facilities	flush toilet for excl use of hh	0	
	flush toilet for shared use	0	
	pit latrine for excl use of hh	41	97
	pit latrine for shared use	0	
	Communal toil. for many hh. in area	0	
	none – bush	1	3
Drinking water		number	%
	available	9	22
	piped inside the house	0	
	piped outside on the plot	0	
	communal standpipe	0	
	Borehole		
	shallow well	0	
	River	0	
	non-available	33	
Waste- & garbage facilities		n.a..	
7. Geometry		number	%
House size in m2	30-50m2	9	22
	51-80m2	4	9
	81-150m2	13	31
	> 150m2	16	38
Shape of house		number	%
	Rectangular	n.a.	
	Rectangular composed	42	100
	Circular	n.a.	
		number	
Shape of roof	Flat	n.a.	
	Gable	42	100
	Sloping	n.a.	
8. Construction system			
8.1sub-structure		number	%
Site preparations	removing top soil 0.2 m	17	40
	Type	number	%
8.2foundation	stone filled trench30-40 mm x 30 - 40mm	0	0
	stones in cement or lime mortar	0	0
	poles in stones with mortar	6	15
	soil blocks with mud-mortar	0	0
	sand cement blocks	36	85
	concrete footing /strip foundation	0	0
	sand-cement bl. on concr.footing	0	0
	s/c'blocks on burnt bricks/s/c bl. footing	0	0

Foundation depth		number	%
(should be at least 30-40mm)	< 0.3 m	2	5
	0.3< depth < 0.6m	40	95
	> 0,6m	0	0
Width (should be 30-40 mm)	> 30 mm	17	40
	< 30mm	25	60
Foundation line	Straight	36	85
	not in straight line	6	9
Reinforcement	Reinforcement	4	
	no reinforcement	38	
8.3 groundfloor		number	%
Level	150mm above plot level	24	58
	<150 mm above plot level	18	
Leveling groundfloor		38	90
Materialization	soil /tamped	15	35
	stones / gravel / hard core	27	65
	concrete	0	N.A.
	timber	0	N.A.
Finishing ground floor	mud-plaster	0	0
	screed 25-60mm	32	75
	none	10	25
8.4 main structure		number	%
Ext walls & mainframe	mud & poles	6	15
	soil walls	0	
	burnt bricks	0	
	timber	0	
	cement -aggregate blocks	36	85
	precast concrete elements	0	
	steel	0	
	other	0	
Reinforcement bars	in sand-cement block wallls	36	100
Nr and position	estimated by laborer	28	68
	calculation	4	9
	thaught by other fundi	4	9
	not known/ other	6	14
Wall finishing	cement sand plaster	37	88
	white wash	0	
	none	5	
Interior walls/ partitions	same as external walls		
8.5 Roof construction			
Roofing structure:			
Timber	Rafters fastened with iron strips	17	40
	Rafters nailed to bond beam	16	39
	rafters fastened w. bolts in wall	2	5
	no real attachment	7	16
Steel			n.a.
Concrete			n.a.
Other			n.a.

Roofing technical details		number	%
Roof overhang	< 200mm	20	47
Roof overhang > 600mm	201-400 mm	10	23
(BRU74-T14)	401-600 mm	7	18
	>601 mm	5	12
Roofing finishes			
	thatch organic mat. (grass, leaves)	1	2,5
	flattened tins	1	2,5
	corrugated iron sheets	40	95
	asbestos sheets	0	n.a.
	ceramic tiles	0	n.a.
	other	0	n.a
8.6 openings			
Windows, doors & casements	timber	42	100
	metal	0	
	alluminium	0	
	Plastic	0	
Casements attachment	horns & nails	39	92
	horns & iron rods	3	8
Windows	sheet glass	0	
	Shutters	0	
	wire blinds	0	
	None	0	
8.7physical conditions	*total building*	number	%
Durability, strength, stability	Bad	15	36
Maintainability	Poor	4	9
	Fair	19	46
	good	4	9
Sound proofness	N.A.		-
Ventilation	fair	42	100
Heat accumulation	poor	42	100
fire resistency	fair	41	98
Relative humidity	too high	42	100
8.8production complexity		**number**	**%**
	simple units to customer´s orders	42	100
	units composed of many different products & components, elements	42	100
	complex units comp. of many different prod.&comp & elements.	n.a.	
	refab components assembled differently.	n.a.	
	prefab components assembled similarly	n.a.	
9. Costs	construction costs	Tsh 1995	US $
	mud&pole system	400	640
	sand-cement masonry system	650	1040

4.3 PROCESTEC

4.3.1 Technoware

1.1Owner of tools & equipment	Type of equipment		
	Hand tools - non-electrical	powered /electr. tools equipm	. powered tools + control mechanism
A. household	x	0	0
B. contractor	x	0	0
C. laborer	x	0	0
D. hired	0	x	0

1.2Utilization of powered tools / worksection		
Work section	powered tools/equipment	% available & utilized
Foundations	soil compacting machine	not available
	concrete mixer	19%
	vibrating needle concrete	not available
floor beds	soil compacting machine	not available
	concrete mixer	19%
	vibrating needle concrete	not available
exterior walls	concrete mixer	19%
internal walls / partitions	electric saw	not available
Roofs	electric saw	not available
	electric drill	not available
frames and doors	electric saw	not available
	electric drill	not available
	sanding machine	not available

1.3 Actual utilization of tools & equipment / work sub-section	TYPE OF TOOL	DESCRIPTION
Foundation		
1. excavation		HANDTOOLS
2. backfill sand+hard core	T2	
3. compacting of soil	-	HANDTOOLS
4. preparation of cement	T2	hand saw, chopper, hacksaw, rammer, sieve hammer, shovel, bucket
5 preparation of reinforcem	T2	
6 placing of elements +reinf	-	
7. casting of concrete	T2	
8. vibrating concrete	T2	
Groundfloor		TOOLS+ EQUIPM
1 leveling and tamping	T2	Broom, shovel, hand saw, chisel, hammer, sieve bucket, pickaxe, trowel, rammer concrete mixer (19%)
2 preparation of cement	T2 + T3 19%	
3 casting of concrete	T2	
4. vibrating concrete		
Walls exterior		
CONCR BLOCKS WALL		
1. Preparation of cement blocks on site	T2 + T3 19%	EQUIPMENT: concr mixer 19%
(2. Placing of reinf. bars in blocks).		
3 Prepar of mortar (140kg/cm2)	T2 +T3 19%	HANDTOOLS

4.a **MASONRY WITH CONCR BLOCKS**	T2	hose, sieve, wheelbarrow
fixation of ringbeam 50x75 mm on top of wall	T2	hacksaw, trowel, bucket, hammer
4b MUD & POLES SYSTEM		
.Placing of poles	T2	HANDTOOLS
.weaving a wooden branches structure	T2	knife, bucket, manchete
filling & plastering with mud	2	
5 Fixation of ringbeam on top	T2	
6 preparation of cement mortar	T2	
7finishing walls with cement mortar	T2	
Walls interior		HANDTOOLS
Preparation + fixation of partitions		bucket, hammer, pumbline, triangle, hacksaw
Roofs		HANDTOOLS
1 preparation of timber roofing structure	T2	hand saw, hacksaw, stairs, measing tape, hammer
2. fixation of roofing structure	T2	
3. finishing of roof with sheets	T2	
Frames, doors & windows		HANDTOOLS
1 preparation of frames doors & windows	T2	plumb line, hand drill, spanner/wrench, screw driver, firmer chisel, measuring tape
2 fixation of frames, doors, windows	T2	

4.3.2. Humanware

2.1 Number manpower/ project	
Permanent project managers	0
Permanent foremen	1
Average per project	0,7
Average per house	
Permanent skilled laborers	3
Temporary skilled laborers	2
Permanent unskilled laborers	0
Average per project	4,6
Average per house	4,6

2.2 Experience *(in at least 2 former construction projects)*

Project managers n=42	16%
Foremen n=42	95%
skilled laborers n=112	93%
unskilled laborers n=71	3%

2.3 Source of skills

PM= project managers	SL=Skilled Labor	
FM= foreman	UL=Unskilled labor	
	n=42	n=114
	PM/FM	SL/UL
Self taught	2	0
Apprentice in ss enterprice	26	106
Apprentice in ls enterprise	3	0
Vocational schooling	11	8
Other	0	0

2.4 Education

project managers		
University	1	2%
Higher education	0	0
secondary education	0	0
primary school	22	53%
not completed primary school	17	40%
no formal education	2	5%
Foremen		
higher education	0	0
secondary education	0	0
primary school	38	90%
primary school not completed	2	5%
no formal education	2	5%
skilled laborers		
higher education	0	0
secondary education	4	2%
primary school	175	96%
no finished education	2	1%
no formal education	2	1%
unskilled laborers		
secondary education	0	0
primary school	11	100%

4.3.3 Infoware

3.1 Availability of information system			
technical documentation	DOC		computer.
construction specifications &procedures	4	10%	0%
norms and regulations	0	0%	0%
documents former projects	0	0%	0%
planning documentation			
time planning procedures	2		0%
progress control techniques	12	28%	0%
cost administration	23	54%	0%
machine documentation			
manuals of machines	0	0%	0%
specifications of machines	0	0%	0%
3.2 Type of information system	docum.		computer.
technical documentation			
construction specific & procedures	4	10%	0%
norms, regulations	0	0	0
documents former projects	0	0	0
planning documentation			
time planning procedures	2	4%	0%
progress administration	12	28%	0%
cost administration	23	54%	0%
documentation of machines			
manuals of machines	0	0%	0%
specifications of machines	0	0%	0%

3.3 Material & equipment database

material databases			
material information	11	0%	0%
material suppliers	0	0%	0%
equipment databases			
equipment information	0	0%	0%
equipment suppliers	0	0%	0%

3.4 Type of database for Material & Equipment

material databases			
material information	11	0%	0%
material suppliers	0	0%	0%
equipment databases			
equipment information	0	0%	0%
equipment suppliers	0	0%	0%

4.3.4. Orgaware

4.1 Location of organization	
1. country	Tanzania
2. province / department	Dar Es Salaam
3. region	Dar es Salaam
4. municipality	Dar es Salaam
4.2 Origin of the organization	
a. local	100%
b. foreign	N.A.
c. partly local, partly foreign	N.A.
4.3 Type of bussiness	
a. international, foreign owned, joint venture	0
b. conventional large scale private organization	0
c. parastatal	0
d. conventional local medium & small scale private organization	0
e. cooperations /self help organization	0
f. monetary traditional tradesman & fungi (informal sector)	42
g. subsistence , households & do-it-yourself owners of bldgs	0
4.4 Company size (permanent workers)	
less than 10 employees	100%
4.5 Specialization	
low-income housing	48%
low-, middle- & high class houses	52%
civil engineering work	0%

4.6 Experience with low income housing projects

< 4 projects	0%	< 1 year	0
5-14 projects	10%	1-3 years	4
15-19 projects	17%	4-5 years	7
20-39 projects	26%	6-10 years	11
40-75 projects	26%	11-20 years	11
> 75 projects	21%	>20 years	9

4.7 Business objectives		
a. stay ahead of competition	14	33
b. growth and expansion	26	62%
c. start new other sector buss..	2	5%
In case of working in the informal sector		
jective to be formalized	39	93%
no intention to be formalized	3	7%

4.8 Competition by other contractors					
NO	0	YES			42
Competition experienced on				*By which type of competitor*	
Price	*Quality*		*knowhow*		
n.a	n.a	n.a.		foreign	0
n.a	. n.a.	n.a		parastatal	0
.X	X	X		local private	13
X	X	X		informal sector	29

4.9 centralization		
Up-down directing procedures	yes	No
information before decisions are made	37	5
information after decisions have been made	40	2
employees express opinions upon request	41	1
employees express opinion un-asked	41	1

4.10 formalization					
Handling/directing on site	*A problems*	*A complaints*	*A information*	*written*	*Verbal*
	Verbal	verbal	operating instructions	4 9%	38 91%
	Verbal	verbal	job descriptions	0 0	42 100
	Verbal	verbal	working schedules	2 5%	40 95%
	Verbal	verbal	other	0 0	42 100

Employment selection procedures			
Project manager and foremen		*Skilled and unskilled laborers*	
standard application forms	0%	standard application forms	0%
school/study certificates	0%	school/study certificates	0%
personal recommendations	95%	personal recommendat.	87%
review social backgrounds	0%	review social backgrounds	0%
interview by superior	80%	interview by superior	7%
standardized tests	0%	standardized tests	0%
practice testing on the job	0%	practice testing on the job	64%

4.11 Regulation and control

Quality control materials		
visual on site	Simple instrum on site	complex instrument in lab
Prefab concrete elements, wood	No	No
at random: all materials:	No	No
All materials	No	No
wood, blocks, bamboo, cement	No	No
Prefab elements, sand, stones, cement	no	No
concr. blocks, in-situ concr, concrete elements	No	No

Final quality control		
A visual on site	simple instrum on site	complex instr in lab
ext. & int. walls, roofs, ext. & int. walls finishings	no	No
at random: external and internal walls	no	No
External and internal walls	no	no
all materials	no	no

Safety precautions			
Helmets	Safety shoes	eye protection	ear protection
No	No	welding	no
No	No	no	o
Site protection	Stealing of materials and equipment		
security guard	materials		equipment
	no exact data available		no exact data available
	often		often

4.12 Technology development orientation

Training facilities on the job	*Project manager and foremen*		*Skilled and unskilled laborers*	
	on the job	0%	on the job	0%
	else during work-time	0%	else during work-time	0%
	else in free-time paid	0%	else in free-time (paid)	0%
	else in free-time not paid	0%	else in free-time (not paid)	0%

Research activities	
full time	0 %
half time	0 %
at random	0 %
None	100%

4.13 External relations

Organizations	*informal contact*	*formal contact*	*no contact*
National Construction Council	40%	0%	60%
Trade association	0%	0%	100%
Chamber of commerce	0%	0%	100%
Employers organisation	0%	0%	100%
Management association	0%	0%	100%
Educational association	0%	0%	100%
Research association	0%	0%	100%
University or higher educ. inst.	0%	0%	100%
Government bureau	15%	0%	85%
Consultants	0%	0%	100%
Financing organizations	0%	0%	100

Reason to rent equipment	
less costs, uncertainty with regard to continuos use of equipment	19%
nothing rented	81%

4.14 Communication & administration equipment on site	
Telephone	no
mobile telephone	no
Calculator	No

4.4 Material Inputs

Raw materials	Manufactproducts	bldg components
(un-processed and semi processed)	Cement	wall elements
	hydrated lime	floor elements
agricultural products	timber products	windows, doors
sisal, grass	steel products	frames
	concrete products	trusses
forestry products.	plastic products	sanitary install.
timber , bamboo	paints	*electrical installations*
	glass	
mineral products	ceramic tiles	
sand, aggregates, lime, clay	roofing material	
natural stones	plumbing material	
	electr materials	
	explosives	

4.4.1Type of input/worksection	Raw materials			Manufactured. Products			
Foundation	*mineral prod.*	*forestry prod.*	*agric. prod*	*Manuf. Prod*	*Water*	*Electri*	*fuel (diesel)*
1. Excavation		-	-				
2. backfill sand+hard core	sand, aggreg 65%	-	-				
3. compacting of soil	-	-	-				
4. preparation of cement mortar	Sand10%	-	-	Cement	Water	Electr	fuel
5 preparation of reinforcem	-	-	-	Reinforc. Steel 9%			
6 placing of elements +reinf	-	timber poles 15%	-				
7. casting of concrete	-	-	-				
8. vibrating concrete	-	-	-				
Groundfloor							
1 leveling and tamping	Sand 75%						
2 preparation of cement mortar	sand, aggreg 75%	-	-	Cement 75%	water	Electr	fuel
3 casting of concrete	-	-	-	-	-	-	-
4. vibrating concrete	-	-	-	-	-		-
Walls exterior	*mineral products*	*Forestry prod.*	*agric. prod*	*Manuf. Prod*	*Water*	*Electri*	*Fuel (diesel)*
CONCR BLOCKS							
1. Prepar of cement blocks on site	Sand, soil			Cement	Water	Electr	Fuel
(2. Placing of reinf. bars in blocks)	-			Reinforcem steel			
3 Prepar of mortar (140kg/cm2)	Sand 85%	-	-	Cement 85%	Water 85%	Electr	
4. Masonry with concr blocks							
5. fixation of ringbeam 50x75 mm	-	Timber batten 4%		Nails 4%			

MUD & POLES SYSTEM							
1. Placing of poles		Timber poles 15%					
2. weaving timber branches structure	-	Branches 15%					
3. filling & plastering with mud	Soil 15%			Cement, (lime) 10%	Water		
3. Fixation of ringbeam on top				Timber & steel prod			
preparation of cement mortar	Sand 15%			Cement	Water		
5. finishing with cement mortar							
alls interior / partitions							
Preparation + fixation of partitions	Soil 15%	timber poles & branches 15%		Cement (lime) 15%	Water		
Roofs							
1 prep. of timber roofing structure				Timber 100%			
2. fixation of roofing structure				Steel 40%			
3. finishing of roof	-	Leaves 2%	Grasses 2%	Steel 98%			
Frames,doors & windows							
1 prep of frames doors & windows				Timber 100%			
2. fixation of frames, doors, windows				Timber & steel 100%			

Table 4.4.2 availability of all inputs		%
Building materials	7	16
Equipment & tools	28	66
Knowledge and skills	5	12
Capital	32	76
Water	13	31
Electricity	5	12
Access roads	35	83

Table 4.4.3. Type, availability and quality of material inputs in the construction projects

Material	Type	Availability	Quality
soil & clay	raw material	Good 80% direct at sites	Reasonable depends on granulation
sand & aggregates (pebbles, rocks, stone)	raw material	Good in many regions available, extracted and bought from traders; 60% direct at site	Reasonable
Lime,gypsum & other binders	Intermediate product	small scale extraction in many regions; seldom used; gypsum prod. Imported	Reasonable
Cement	Intermediate product	Reasonable, locally produced (3 factories)	Good
Concrete products blocks, tiles	bld material produced on site 80%	blocks predominantly made on site;	Poor - reasonable
Timber	Interm. product bld material	Reasonable but decreases due to deforestation ;	Poor
timber products	building component 18% prefab	Poor Imports	local products poor
grasses,bamboo & leaves	raw material	abundantly available in all regions	Reasonable - good
steel	building materials & components	reasonable local production with imported inputs: bars, pipes & fittings	Reasonable
metal roofing sheets	building component	reasonable - good locally produced imported inputs	Reasonable-good
plastic products	building components PVC pipes, conduits, sewage	reasonable produced locally with imported inputs	Reasonable

Price indices (%) for different kinds of materials over the years. (1986 = 100), based on market prices in Tanzanian Shillings in current prices.
Sources: NCC 1992: 16-18;NCC 1995: price list; Muhegi, 1994:26)

	1982	1984	1986	1988	1989	1991	1993	1995
Sand	17	83	100	117	146	-	-	163
Cement	33	43	100	180	330	650	-	1235
Steel	36	45	100	54	306	400	-	795
Corrugated iron sheets	83	92	100	292	375	457	-	756
Lime	50	63	100	138	175	214	-	457
Timber	-	-	100	200	256	343	-	412
Cement/ aggr. blocks	-	-	100	278	528	750	1154	2473
Plastic Products	-	-	100	164	586	586	-	4053

5 Directly imported/locally purchased materials on the construction sites (%)

Purchased locally	100	Imported	0

Appendix II-5

The technological production performance

Table 5.1 Product technological scores of the production output		%
Functionality availability of facilities	water	22
	electricity	16
	toilet	97
multiple usability	farming, shop, workshop	87
Site	1. clearing and removal of top soil	40
	2. levelling	90
	3 drainage	10
	4 ratio house size/ plot size max 60%	81
	5. access roads for users and for emergency vehicles.	30
Foundation	1. Availability of footing (BRU techn guidelines 1990)	40
	2. Straightness of foundation trenches	85
	3. Durability of material foundation wall & 150mm + ground level.	86
	4. Poles (mud-and-pole structure) positioned in between stones.	14
Floors	1. a foil (plastic) between soil and groundfloor.	0
	2. hard & smooth surface, easy to clean + soil/cement screed finishing	24
	3. the floor level at least 150mm above the outside groundlevel.	57
Walls	1. withstand their own weight & all applied loads without harmfull deformations	86
	2. rain-proof (resist penetration of rainwater)	86
	3. no water and vapour should raise from the ground through the walls	0
	4. permanent construction. >25 years, with reasonable maintenance.	86
	5. low thermal storage capacity preferably + reflective, light coloured coating.	0
Roofs	1.rain and water proof.	95
	2.light weight material,	100
	3.reflective or with high insulation values.	5
	4.preferably with slopes	100
	5. withstand its own weight without harmfull deformations .	100
	6.wind proof ,(properly anchored)	46
	7.sustain a point load of 100 kg (maintenance).	95
	8. overhang of at least 500 - 600 mm.	12
	9. the space under the roof shall be well ventilated	95
Openings	proper number and positioning	95

Table 5.2 Process technological characteristics scores

Technology component			Score
Tools & equipment (see scoring table 6.#)	Simple hand tools in all phases of the construction process neglectable % of cases hired mechanical and electrical equipment		3
Labourforce	nr./project av. 4,6 (semi-) skilled labour un-skilled labour	4,6 60% 40%	-
Experience	Projectmanager contractor/foremen skilled labour un-skilled labour	16% 95% 93% 3%	5,2
Education scores: 0-10 university 9 second. Sch 6 prim school3 not-compl2 no form educ0	Projectmanager university prim school not comp. prim school no formal educ.	2% 53% 40% 5%	2.84
	contractor/foremen primary school not compl prim school no formal educ	90% 5% 5%	
	skilled labour secondary educ. primary school not compl prim school no formal educ	2% 96% 1% 1%	
	un-skilled labour prim school	100%	
Info & docum.			Score
Availability. (% of proj)	Technical doc constr.specific. standards & regul- doc former proj -	10% 0 0	1.48
	Planning & control doc. time planning progress control financial admin	4% 28% 54%	
	Materials data base inform & doc equipment database inform & doc	26% 0	
Type of info carrier/ ease of retrievability	a. Written doc 100% (if any) b. Computerized		
organization			score
classif.scores: small informal 1 small formal 3 medium scale 6 large scale 9	Configuration Informal sector sole / household mode no fixed workshop on average 3,6 perm.. empl.	100%	1
Scores for avail. standard. Systems 0-10	Formalization neglectable standardization, negl. planning & control	28,6%	2.86

Scores: highly central. 1 partially inform differ. Of taks 3 partly formal tasks diff 6 total formal task 9	Centralization highly central Work upon direct order by foremen Directcommunic: master –employees informal on all occasions Nearly no written information Hardly apprentices	100%	1
Experience score % units with > 3 proj. experience	Specialization / experience existence 6-20yrs, primarily dwelling constr and small buildings. sub-contracting	100%	10
buss.orientation scores (% of constr.units) planning for expans. cap. Investments/yr training R&D	Bussiness orientation planning & strategies cap. Investments (av. investm./yr 0-999 Tsh curr. Working cap 40,000-59,999 Tsh 1995) training No R&D	0 0 0 0	0
External relations	Customers/yr 3,7 mat suppl 80% purchased from inf. Sector equipment simple tools informally acquired financing 97% from client competition from other informal contractors Government no formal relation R&D inst no formal relation Educ inst no formal relation Branch org. no formal registration Labour org no formal relation	+ - - - + - - - - - - - - - -	-

Table 5.3 Summarized process technological scores

Process technology components	assessment criteria	Scores
Technoware 3	Major features of the tools and equipment: 1. Handtools 2. Tool with non-human energy source (electro motor) 3. Tool with non-human energy source & control mechan.	3
Humanware 4.34	Major features of the labourforce 1. Education level 2. Experience	2.84 5.85
Infoware 1.48	Major features of the information and documentation 1. Availability 2. Type of information carrier/retrievability	1.48 Verbal + some written documents
Orgaware 1.62	Major features of the organizational framework a.Configuration b.Centralization c.Formalization d.Specialization e.Bussiness orientation, no planning, training or R&D f.External relations	a. 1 b. 1 c. 2.86 d. Ss bldgs e. 0 f. - -

Table 5.4 Materials input scores

	raw materials	*bld materials*	*Components*	*elements*	*Building*
Nature	sand cement aggregates timber	cement blocks reinforcem rods	frames/ windows/ doors	-	
	Score 0 .2 92% >0.18	Score 0.4 5% > 0.015	Score . 6 3% > 0.05	Score .8 0	Score 10 0
Availability	general low availability 17% of the projects not enough purchased by client 21% of the projects				
Quality	bad 21% of the projects not sufficient 74% of the projects reasonable 6% of the projects				

APPENDIX II-6

The construction industry in Tanzania

Table 6.1 Informal sector operations :advantages and disadvantages
Source: Treffers/TUE 1996

Advantages	(a) the low-capital intensity and thus more appropriate in a situation of very limited financial resources; (b) the provision of essential goods and services at prices which are affordable for a larger section of the population than those produced by the formal sector; (c) the labor intensity and thus contribution to employment where the formal sector appears to be un-able to absorb the large surplus of labor that exist in most large cities and (d) the simple and traditional technologies which are applied which thus put less pressure on the education and training system in the country.
Disadvantages	(a) the unfair competition with the formal sector; (b) the low rate of efficiency, (c) low rate of effectivity in terms of meeting the quality standards in particular to be able to compete at international level, (d) the prohibition of enhanced and accelerated technology development, industrialization and modernization.

fig 6.1 registered contractors by no/class
source NBAQSBC 1990-95

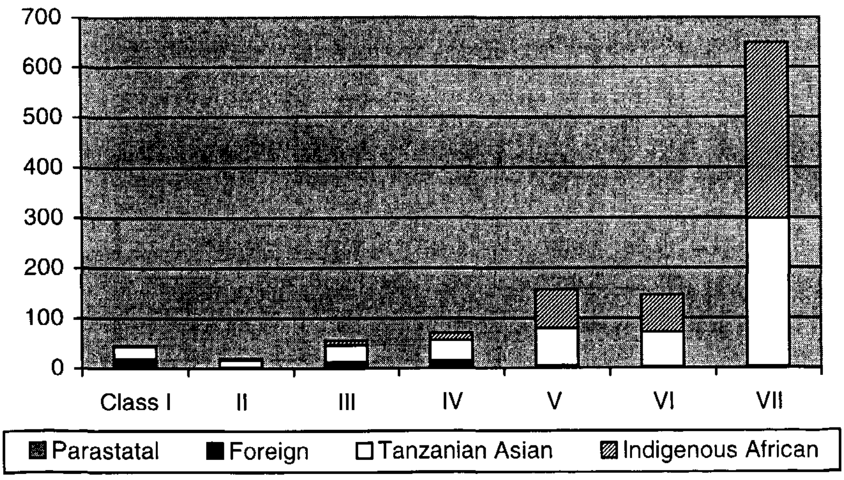


Figure 6.2 Nr of registered contractors , 1974-1995
Source NBAQS&BC. Dar es Salaam, 95

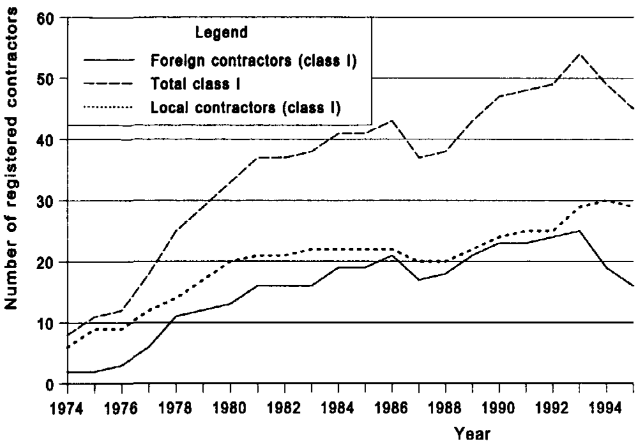


Table 6.2 Classification of contractors in Tanzania
Sources: NBAQS&BC List 1990, 1995, NCC Report on the construction industry (Barker & Burton)

Ownership	Class I	II	III	IV	V	VI	VII	Total
Parastatal number % of class total	1 2,3%	- -	4 7.1%	2 2.9%	- -	- -	- -	7 0.6%
Foreign number % of class total	18 40.9%	2 0.1%	8 14.3%	12 17.1%	5 3.2%	2 1.4%	3 0.5%	50 4.4%
Tanzanian Asian number % of class total	24 54.5%	15 75%	34 60.7%	42 60%	74 47.1%	70 47.9%	295 45.4%	554 48.5%
Indigenous African number % of class total	1 2.3%	3 15%	10 17.9%	14 20%	78 49.7%	74 50.7%	352 54.1%	532 46.5%
Class total 1990	44	20	56	70	157	146	650	1143 100%
Class total 1995	45	20	48	70	109	72	706	1070

Table 6.3 Formal sector contractors: major characteristics.
Source: NBAQS&BC 1993, Rijkenberg/TUE 96

public sector	PARASTATALS (2% of registered contractors) Late sixties : public sector given a crucial role by the government 1970: first parastatal contracting company: the Mwananchi Engineering and Contracting Company (MECCO). Target: a central role in the development of the local construction industry, as well as in the execution of government construction contracts Late seventies: MECCO one of the largest contractors in the country. Currently :MECCO suffers from a variety of problems.(as is the case with many parastatal companies) FORCE ACCOUNT BRIGADES: (a government-owned construction unit, not managerially and financially autonomous). in-house resources under direct control of the Ministry of Works (MOW) to realize the construction requirements of the government. Most direct way in which the government acts as a contractor. Conclusion: Role of the public sector as a contractor is and always has been rather limited, despite the government's intentions: public construction activities fall far behind those of the private sector, even before the economic reforms of the late eighties in terms of contribution to GDP (ref. Rijkenberg/TUE 1996)
Local private sector contractors	94% of registered contractors. Since 1974 the number of local class I contractors is increasing faster compared to the number of foreign contractors. Performance of the local contractors per construction project : low. Due to (a) internal factors of the contractors themselves (b) their immediate partners in the construction process: the client and consultant.(Maro et al., 1991). (c) also the macro-economic situation leaves its marks on the performance of the local contractors.
Foreign contractors	Most of all dominant on large and technically complex projects, which usually are civil work projects (Ministry of Works, 1991). Reasons: (1) a lack of capacity and expertise among local contractors; (2) conditions of bilateral donors concerning the use of a contractor from their country of origin. 1974-1995. no major increase in the amount of these contractors after the economic liberalization. Period before liberalization strongest increase in foreign contracting capacity . After 1986: a decreasing number of foreign contr. since 1992. More foreign contractors than local contractors disappeared from the records may be the result from the preferential treatment which the government and multilateral donors are giving to local contractors since the beginning of the nineties. (Based on an interview with Mr. Malyi of the Central Tender Board, Dar es Salaam, August 1995). NB. In first instance the sudden decrease in the number of contractors in 1986 seems to indicate a negative influence of the economic reforms. However, considering the growth after 1987 the decrease may very well be a result of another >clearing' of the records of the NBAQS&BC.

Table 6.4 : Different types of small scale and informal construction units
Source: Mwaiselage CHS 1991

1. a contractor who moves with his gang	In this system the contractor is able to undertake a number of operations on a construction site like block making, trench digging, masonry work etc. In these operations he can have one or more skilled permanent laborers (fundis). These can each have their own helper (kibarua) or unskilled laborers are hired by the contractor himself, most of the time on a casual basis. The contractor with his gang usually works on one site and mostly on one project at a time in this system. The entire house can be completed by the contractor and his gang, and it is also very well possible that the contractor takes care of the purchase of all needed materials.
2. a contractor who is hired for a certain skill	In this system the contractor is contracted by the client for a specific skill required for a certain job. If the contractor needs help with his job, he will hire another worker. The payment of this worker is then the responsibility of the contractor. In urban areas clients ask the help of such a contractor beneath the use of self-help, for instance in squatter settlements or when resources are too poor to hire more than one fundi at a time.
3. a contractor for specialised jobs like concrete pouring	In the case of this system the contractor, when having been awarded a certain job, collects his own gang of unskilled laborers, mostly from his own neighbourhood, to do the job within one to three days. He is contracted by the entrpreneur or the client to provide the labor power which is required in large numbers during concrete mixing and pouring. As it is rather expensive to hire machines required for these operations, it is necessary that the work will be done as quickly as possible. This type of informal contractor often appears in cases where a larger (formal) contractor is going to subcontract certain tasks.

Table 6.5 The major actors in the actor network of the construction industry
Sources: NCC 1995, Rijkenberg/TUE 1996, Esmeijer/TUE 1997

Clients	*Public non-residential investment projects* Formal sector construction projects: dominated by government. 90% of the building projects in the country 100% of the road projects. (Chief engineer MOW 1996) Reason: (a). most construction works involve huge costs, which cannot be afforded by many private actors, especially not in a developing country like Tanzania. (b). some construction works have a community character (like roads), which makes the government the right 'person' to act as initiator. Implication: contractors depend on government investments. Recently the overall priority is given by the Tanzanian government to private sector activities which might also give a more prominent role to the private sector on the construction market in the near future.

Table 6.5 to be continued next page/....

..../ Table 6.5 continued

Clients	*Public investment projects financed by foreign donors* (a). road projects (the Integrated Roads Project) ; (b). building projects (e.g. DANIDA) multilateral funds: African Development Bank, European Community, UNDP bilateral funds: Norad, DANIDA, FINNIDA, USAid.(Interview with mr. Mamiro of the National Construction Council, Dar es Salaam) Foreign funds are often channelled through one of the ministries of the Tanzanian government. *Public investments in residential buildings* in the recent years are nearly neglectible. Government only has invested in 5% of the dwelling constructions during the last years. (MLHUD 1995) *Private investments in residential buildings.* (95%) 75% of projects for lower income households through involvement of the informal sector. (MLHUD 1995).
Consul-tants	A low capacity of local consultants Large and complex projects are designed by foreign consultants. *Problems*: absence of adequate local regulations and standards. > *result* in specifications which differ every time depending on the country of origin of consultants. > *result* in a non-uniformity in design, non specification of the use of local materials, delays in project execution and cost escalation due to delay or inability to import the products. NB Informal sector practically does not make use of consultants
R&D institutes	. high degree of inadequacy (NCC 1995). .an inadequate dissemination and utilization of available research information, . accessibility and retrievability of information is low. .coordination of funding of R&D is in-adequate. Currently the national science and technology policy has redressed this situation by committing an allocation of 20% of the Tanzanian R&D budget to the industry including the construction industry. The percentage of public expenditure for R&D has increased: in 1985/86 This was 1.5% of GDP. The intention is that it should rise to 3.5% by the year of 2000. Government has also the intention to provide fiscal incentives for R&D by private individuals, enterprises and public institutions. The informal sector practically has no formal contacts with these institutes
Educa tional institutes	. Too few institutes . Limited output not meeting demand for human resources (quality& quantity). . Follow-up practical training seldom exist . Coordination is lacking and facilities are not adequate although various institutions have undertaken the training of technicians at present.
Building materials suppliers	. the total demand has increased - the supply remained too low . limited capacity of production. .operational problems like machine breaks, short of inputs like water and energy cause an under-utilization of the existing plants. .little efforts on research and exploitation of the locally available naturally available materials . competition of imported materials. Materials input count for 60% of the total costs of structure in Tanzania. Informal sector purchases materials often in informal sector or produces the materials themselves.

table 6.5 to be continued next page/....

.../ Table 6.5 continued

Equipmnt suppliers	.in-sufficient availability of foreign exchange to purchase the equipment and spares for the maintenance .little or no standardization of tools and equipment, which makes repair and maintenance difficult. .local production of tools and equipment is limited. .existing equipment hire facilities have to deal with broken down material and lack of spare parts.
Financing organiz.	.lack of funds were due to the inability for contractors to acquire working capital which causes project execution delays and escalation of costs. .loan conditions are often hard to meet, interest rates too high (40%). .inadequate and un-coordinated commitments were made of funds to serve the construction industry.
Branch organiz.	like the NBAQS&BC work at very low level due to lack of manpower, funds and authority.
Labor organiz.	have a rather big influence in the country , which became noticeable during the last few years by the considerable increase of the minimum wage level

Table 6.6 Relation between GDP and construction 1983-1993 (constant 1976 prices)
Source Bureau of Statistics. National accounts of Tanzania 1976-1993. 1994, p. 9/10.

	1983	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
Av. annual GDP growth (%)	-2.4	3.4	2.6	3.3	5.1	4.2	4.0	4.8	3.9	3.5	3.7
Share of construction in GDP(%)	2.4	2.8	2.5	2.8	4.0	4.3	3.3	5.4	4.4	4.6	4.0
Growth inconstruction GDP (%)	- 41.	20.2	-8.9	17.3	49.2	11.9	-19.2	69.8	-14.1	9.4	-10.3
Contribution of construction toGDP growth (%)	-1.0	0.6	-0.2	0.5	2.0	0.5	-0.6	3.8	-0.6	0.4	-0.4

Notes The contribution of construction to GDP has been calculated as growth of construction (%) x share of construction sector in GDP growth

Table 6.7 Share of different type of construction activities in GFCF / growth rate of *construction activities and total GFCF*, 1983-1993 (constant 1976 prices)
Source Bureau of Statistics. Selected Statistical Series 1951-1991. 1994, p. 35;. Statistical Abstract 1993. 1995.

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Growth in total GFCF (%)	-33.2	45.7	22.6	-3.0	29.7	2.3	-5.1	-6.5	32.0	-11.0	-5.4
Growth in GFCF 'buildings' (%)	-32.2	17.2	-3.2	10.1	-13.1	19.4	-21.4	29.5	49.7	33.3	-16.6
Growth in GFCF 'other works' (%)	-17.0	14.1	-6.5	27.6	98.3	1.3	-25.3	136.2	-32.1	9.1	12.3
% of 'buildings' in GFCF (%)	19.9	16.0	12.7	14.4	9.7	11.3	9.3	12.9	14.5	16.9	13.7
% other works in GFCF (%)	18.3	14.3	10.9	14.4	22.0	21.8	17.2	43.4	22.2	27.2	30.0
% bldgs in annual GFCF growth	-6.5	2.8	-0.4	1.5	-1.3	2.2	-2.0	3.8	7.2	0.6	-2.3
% other works in annual GFCF growth	-3.1	2.0	-0.7	4.0	21.6	0.3	-4.4	59.1	-7.1	2.5	3.7

Table 6.8 Employment in the Construction Industry
Source: Statistical Abstract 1991, p.65; Preliminary report on Constr, Trade, Transport NBS/WB 1995

	Construction	Trade	Transport
1991 Stat. Abstract 1991	91,649	691,388	109,062
1995 Source NBS/WB	222,223	43,608	14,539

Table 6.9 Employment in the formal and informal construction industry in Tanzania
Sources: Statistical Abstract 1991, Labor Force Survey 1990/1991, Informal sector Survey 1991, Survey of construction, trade & transport 1995

	informal sector	formal sector	total
nr of people employed (x 1000)	160,000 (TIS 1991)	91,649 (LFS 91) 22,113 (WB 94)	251,649 182,113
% of total employed in construction	64	36	100
Annual gross output	14577 million Tsh 1991	14416 mill Tsh 91 88554 mill Tsh 94	28993
Annual value added	10864 million Tsh 1991	4324 mill Tsh 91 26420 mill Tsh 94	15188

Table 6.10 Expenditures for the purpose of intermediate consumption for construction works, 1994.
Source:NBS / WB Report on the survey of construction, trade and transport, Tanzania 1995.

Expenditure item	total expend (mill. Tshs.)	share in total expenditures	Share in total expenditure by company size (number of employees)			
			5-9	10-49	50-99	100+
Fuel	6106	10%	(*)	14%	18%	68%
Cement	5491	9%	1%	25%	16%	58%
Bricks & cement blocks	1771	3%	(*)	16%	9%	75%
Reinforcement steel	3167	5%	0,5%	23%	15%	61,5%
Steel frames (doors etc.)	1077	2%	(*)	17%	8%	75%
Roofing iron	778	1%	(*)	35%	10%	55%
Timber	1867	3%	3%	22%	11%	64%
Plastic pipe	799	1%	1%	26%	16%	57%
Bitumen	1747	3%	(*)	2%	72%	26%
Electric wire	917	1%	(*)	10%	54%	36%
Electrical fittings	962	1,5%	(*)	23%	26%	51%
Other building materials	17999	29%	2%	10%	24%	64%
Subcontracting	4918	8%	(*)	23%	19%	58%
Vehicle & business licences	296	0,5%	4%	34%	24%	38%
all other expenses (**)	14239	23%	1%	12%	36%	51%
TOTAL	62134	100%	1%	15%	25%	59%

(*)Incl under >other building mat' class 5-9.(**) Excl interest payments and depreciation allowances

Table6.11: Criteria for registration of building contractors: the equipment component.
Source: NBAQS&BC, 1993 Dar es Salaam, Tanzania.

Equipment item/ Class	Class I	II	III	IV	V	VI	VII
Tower crane	1	1	-	-	-	-	-
Concrete mixers	3	2	1	1	1	-	-
Block making mixers	2	1	1	1	-	-	-
Steel bending machines (set)	1 set	1 set	1 set	-	-	-	-
Water pumps	2	1	1	-	-	-	-
Concrete dumpers	2	2	-	-	-	-	-
Heavy duty motor vehicles	3	2	1	-	-	-	-
Compactors	2	1	-	-	-	-	-
Compressors	1	1	-	-	-	-	-
Concrete vibrators	2	1	1	-	-	-	-
Total no of reg.contractors 1990	45	20	56	70	157	146	650

Table 6.12 Magnitude of the informal sector Sources: Planning commission and MLYD, 1991

	Dar es Salaam	other urbam	Rural	total
total employment (nr persons)	22,327	28,785	112,326	163,438
Employment in dwelling construction	4.416	1,366	12,568	18,350
employment in masonry	10,596	24,209	88,061	122,866
employment other trades	7,315	3,210	11,697	22,222
no of enterprises	10,762	18,136	87,598	116,496
total capital (million Tsh)	763		553	1,316

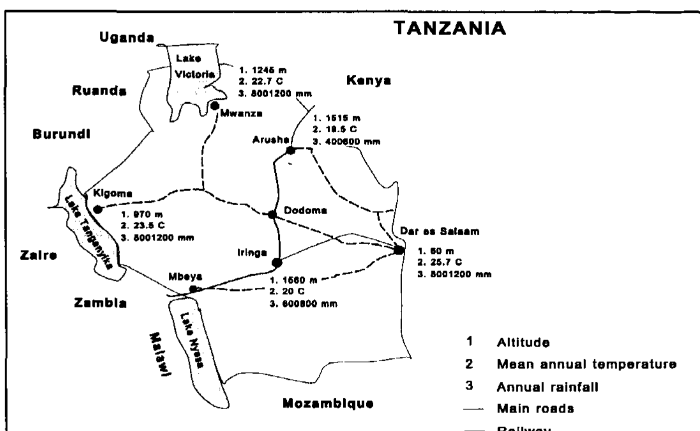
Table 6.13 National policies on the construction industry in retrospect 1977-1996
Source: National development plans 1977-1995/1996

1977-1981	1977 survey on the construction sector in Tanzania revealed considerable shortfalls in the performance of the sector: more policy attention
1981/82-1985/86	Objective: Increase the abilities of the construction sector
1986 –1988	Objective: improved availability of building equipment and building materials leading to improvement of building activities.
85/86-90/91	new objectives compared to previous plan: increase and wider spread of technology. Increase of production and availability of building materials and equipment.
1990 - 1993	integral strategy for the entire construction sector : National Construction Industry Development Strategy Objective: to assure a consistent way of policy making and implementation by all ministries, parastatals and other institutions involved in the construction sector. Emphasis on importance of the utilization of local resources and to minimize the dependence on foreign inputs. Most attention to civil works, specifically to road works.
1993/94-1995/96	Plan 1993/94 – 1995/96 was under implementation during this research project. No significant changes expected.

Appendix II-7

Data on the national technology setting in Tanzania

Table .1. Geography		
1.1 location	East Africa	
Latitude	600 S Latitude	
Longitude	35 00E West Longitude	
Borderlines km	Burundi 451 km, Kenya 769 km, Malawi 475 km, Mozambique 756 km, Rwanda 217 km, Uganda 396 km, Zambia 338 km.	
Coastline km	1,424 km	
1.2altitudes	Location	m above sealevel
major cities	Coastal area: plains Central plateau Highlands	from sealevel - 900 m between 914 to 1524m above sealevel. >1524 m
Highest point	Highest point of African continent	Kilimanjaro 5,895 m



	location	type
a. hot & dry	inland plateaus, n-w Tanzania, Ruvuma, South Morogoro	av temp av. yr 25 C; warmest month (jan) 29 C coldest month(jul) 22 C rainfall: av/year 880mm; rainy season (jan) 190mm; dry season (jul)
b. warm & humid:	around lakes (500m above sea-level), Coastal plateaus in eastern part	av temp: av/yr 30 C; warmest (jan) 32 C; coldest (aug) 29 C rainfall: av/yr 1100 mm; dry season (jul) 21 mm; rainy season (jan) 260 mm
c. temperate	S- and N-highlands, over 1000 and 2500m above sea-level	av temp: 20 °C daily , max temp 24.9 C, min temp 16.3 C rainfall: av/yr 400-600mm /yr

1.4 natural disasters	Occurence
Earthquakes	Seldom
Volcanoes	n.a.
Hurricanes	n.a.
Flooding	Low lands in coastal areas during heavy rains

Table.2. History.

Colonalization	1884-1961	Countries: Germany, U.K.
Independence date	1961	

2.1 Major historic events in chronology

1884	Tanzania mainland became the German colony : Tanganyica, a country dominated by subsistence agriculture, livestock herding, little trade. Start of commercial agriculture.
1890	The Sultanate of Zanzibar became a British protectorate
1918	End of World war I. Tanganyica became a British mandate. Agriculture remains major source of income. Majority of a agricult. prod. unprocessed exported. Later on few industries established in urban areas to produce simple consumer goods for small elite in towns. Increase of gap between urban and rural areas.
1961	Tanganyica independent. British left a poorly developed Tanganyica. Majority of population lives on subsistence level in rural areas. Very small industrial sector contributin g 3.5 % to GDP (1961), employing 9% of labour force (1963) Major industr.c production is in agroprocessing industries sisal production. Situation remains until 1967.
1962	Nyerere president of Tanganyica, leading the country with his strong philosophies of African socialism in attempts towards Tanzanian development.
1963	Zanzibar independent
1964	Zanzibar signes union with Tanganyica and form together Tanzania.
1967	Arusha declaration: socialism, self.reliance and political democracy. Top priority to rural and agricultural developm. Nationalization of privately owned enterprises.
1973	Establishment of Small Ind. dev. Org. SIDO to promote import substitution production . Result: production structure capital intensive, import intensive, large sized.
1977	One party state. Both Mainland and Zanzibari parties for the CCM (Revolutionary party of Tanzania
1980	succeeding economic crisis resulting from both internal and external factors. First steps to liberalization of politics under increasing pressure of donor community and development banks.
1985	Nyerere resigns as president. Former vice-president Mwinyi, is succesor and starts liberalisation move of Nyerere's strongly socialistically oriented policies.
1990	Mwinyi succesor of Nyerere as chairman of CCM, after resignment Nyerere as chairman that year
1992	Other political parties allowed.

Table 3. government and politics

3.1 General data on government and policies

Official country name	United Republic of Tanzania (Mainland Tanzania capital : Dar es Salaam and Zanzibar)
Constitution	25 April 1977; major revisions October 1984
Executive branch	*Chiefs of state: 1. President of Mainland (Mkapa 1995) and 2. President of Zanzibar; elected for a five-year term by popular vote; last election: November 1995; next: October 2000*
Political parties	CCM or Revolutionary Party (Ali Hassan MWINYI); Civic United Front (CUF); National Convention for Construction and Reform (NCCR); Union for Multiparty Democracy (UMD); Chama Cha Demokrasia na Maendeleo (CHADEMA); Democratic Party (unregistered); United Democratic Party (UDP)
Legal system:	based on English common law; judicial review of legislative acts limited to matters of interpretation; has not accepted compulsory ICJ jurisdiction Judicial branch: Court of Appeal; High Court
3.2 adminstr. divisions	**Regions (25)**
	Arusha, Dar es Salaam, Dodoma, Iringa, Kigoma, Kilimanjaro, Lindi, Mara, Mbeya, Morogoro, Mtwara, Mwanza, Pemba North, Pemba South, Pwani, Rukwa, Ruvuma, Shinyanga, Singida, Tabora, Tanga, Zanzibar Central/South, Zanzibar North, Zanzibar Urban/West, Ziwa Magharibi
3.3 political orientation	**Political orientation after independence (1961 - present)**
1967 'Declaration of Arusha'	a one-party socialist state, with a centrally planned economic system orientation: 'self-reliance' and >socialism= towards national development . Fundamental ideas: (1) major means of production should be publicly owned , (2) the country should rely on its own resources to avoid impoverishment caused by the strong and developed nations.
1977 New constitution the only political party in Mainland TANU and the Afro-Shirazi Party, on Zanzibar, joined to become the Chama Cha Mapinduzi (CCM).	based on principles of socialism and self-reliance. Political ideology : (1) an introvert economic policy, (2) sceptism toward export as a motivational power in economic development (3) Government itself, influenced by systems in the Soviet Union and China, was to be the motivational power. (4)centrally planned agricultural development the prime mover for development on selfreliant basis Strategies: (1) establishment of a rather extensive number of parastatals, (2) creatrion of rural development programmes (3) high import taxes Effects: (1) a high increase in population, (2) an increased rate of urbanization, (3) hardly any economic development , (4) increasing foreign debt.
1985 Economy at point of collapse	Economic Recovery Programs: consequent political economic changes versus a more liberalized economy, Political reforms stayed behind--> Nyerere's resignation -->. Presidency of Ali Hassan Mwinyi
1992	Monopoly of the CCM was abandoned by law, followed by the registration of several political parties a year later. At present the United Republic of Tanzania has a multi party political system.

3.4 political stability

Changes in political orient.	1977, 1985, 1992
Coups	n.a.

Table.4. Economic setting Source World Bank World tables 1995

4.1 Basic economic data	1991	1992	1993	1994	1995
GDP at market prices (current million US$)	3183.5	2745.5		-	8557.9
Av GDP growth 1985-1994 (1976 prices)	4.2%				
GDP/cap current US$	126	105	104	103	-

	1980-1986	1987-1990	1991-1993
Inflation (%)	32%	27%	3.5%
min. wage increase (%)	8.6%	64.5% Based on min wage set by nat govern	

Annual conversion factor Tsh./US$, 1985-1993.	1985	1986	1987	1988	1989	1990	1991	1992	1993
	17,5	33	24	99	-	195	219	297	407

4.2 production structure	1970 % GDP	1976	1982	1986	1992
Agriculture, forestry+fishing	48.4	41.8	50.3	59.7	61.4
Mining + quarrying	1.3	1.0	0.5	0.3	1.6
Manufacturing	10.1	13.0	8.3	6.1	4.6
Electricity + Water	1.0	1.0	0.8	1.1	1.6
Construction	4.9	4.1	3.5	2.2	4.3
Trade, Hotels, etc.	12.7	13.1	13.0	13.8	14.1
Transport + communication	8.7	7.8	6.5	5.5	7.1
Financial services	3.0	9.4	9.3	5.8	4.7
Public administration	11.2	10.8	10.4	7.3	5.5
Imputed bank service charges	-1.3	-2.0	-2.4	-1.8	-4.9
GDP (Tsh million)	8,215	21,652	52,546	140,866	698,024

4.3 Employment /sector	%
Agriculture	84,2
Bussiness and other services	4,2
Finance and real estate	0,2
Transport	1,0
Commerce	6,3
Construction	0,8
Electricity	0,1
Manufacturing	2,2
Mining	0,9

4.4 International trade (in millions of current US$) Source: World Tables 1990

	1980	1985	1990	% of total
Exports (FOB)	527.7	337.0	389.3	
Non fuel primary products	427.7			81,4%
Fuels	24.9			2,9%
Manufactures	75.1			15,7%
Imports (CIF)	1,211.4	945.9	1,346.0	
Non fuel primary products	194.7	143.9	204.8	10,5%
Fuels	254.0	175.9	250.3	13,4%
Manufactures	762.7	626.1	890.9	76,2%
Trade balance	683.7	608.9	956.7	
% GDP	12.5 %	8.8 %	37%	

4.5 External debt (mill.US$)	1971	1981	1985	1990	1993
Long term Debt	258.2	2,622.1	3,752.0	129.4	-
Short term debt	0.0	301.2	354.8	379.6	-

4.6a Income distribution and expenditires by spatial distribution Source: Fereira, WB, 1995

Income class	Annual expend./adult equivalent (mean Tsh				Annual expendit / capita (mean Tsh)			
Quintile	Tanzan	rural	urban	DSM	Tanzan	rural	Urban	DSM
Poorest	61,145	60,959	62,666	n.a.	38,011	37,709	40,479	n.a
2	95,367	94,975	97,081	101,230	60,963	60,162	64,535	66,520
3	129,270	129,053	129,574	133,895	83,012	81,745	86,452	87,621
4	180,099	178,945	181,484	182,273	118,583	117,002	121,145	124,380
5 richest	381,674	319,842	398,062	500,299	267,355	216,258	287,607	351,266
Ratio 5/1	6.24	5.25	6,35	4,94	7,03	5,73	7,10	5,28
All at hh level	183,162	146,297	230,667	416,387	123,352	95,328	161,773	290,631
All US$	370	296	466	841	249	193	327	587

4.6b Household expenditures by % of households 1991/1992(Tsh) Source Bureau of Statistics 1994 p 11	Tanzania %	Dar Es Salaam %
0- 11,999	23.07	10.39
12,000- 23,999	36.78	39.99
24,000 - 47,999	28.92	39.23
48,000 - 71,999	6.36	7.12
72,000 - 95,999	1.82	1.49
96,000 - 119,999	0.93	0.94
120,000- 299,999	1.33	0.66
300,000- 479,999	0.18	0.09
480,000 >	0.61	0.09
TOTAL	100	100

Table .5 Basic data on education Source: Unesco's statistics on education 1995 on www

Illiteracy	32.2% of tot. pop	20.6% male pop	43.2% female pop
nr of stud/100,000 pop	21		
Public exp on educ	5.0% of GDP		
Enrollment 1995	Source: Unesco's statistics on education 1995 on www		
	1993	1994	Increase
Primary school	668559	674670	0.9 %
Secondary school	93647	99155	5.5 %
Universities	4001	4289	6.7 %
Gross enrollment in prim. & sec. Educ. % of tot.age group		44% (1994)	

Table 6 Health indicators Sources: Bureau of statistics Tanzania 1995, World Tables 1997

Life expectancy	Total population: 42.34 years; male: 40.95 years ; female: 43.78 years (1996 est.)
birth rate	41.31 births/1,000 population (1996 est.)
mortality rate	19.47 deaths/1,000 population (1996 est.)
infant mortality / 1000 life births	105.9 (1996 est.)
fertility rate (no children/women)	5.67 children born/woman (1996 est.)
population /physician	24970
Food prod/cap 1988-1990 (1979-1980=100)	88

Table 7. Land & natural resources

7.1 land — Source; Dorgan , Gale contry & world rankings reporter

1995

Land area km2	886,040 km2

Landuse	Arable	Meadows	perm crops	forests	other
% total landarea	5%	40 %	1%	47%	7 %

7.2 Natural Resources

Source. UNDP Human Development Report 1992	Tanzania	1	2	3	4
Internal renewable water resources /cap (1,000 m3/year 1990)	2,8	6,7	10,6	9,4	6,9
Forest area % total land area 1990	47	28	31	..	30
Arable land	5				37
Other	48				33
Annual rate of deforestation % '80-90	0,3	1,1	0,6	-	-
Annual % change of prod. Of fuel wood	4,2	2,3	3,0	-	-
Commerc. energy consump /cap(kg oil equivalent) 1965 - 1989	37-37	201 505	44 63	3380 4930	1069 1331
Annual % of change energy consump. % 1980-1989	2,3	4,9	3,8	1,2	4,2
Commerc. energy consumed in kg of oil equival per $100 GDP 1965 - 1989	55 40	157 72	38 28	169 29	167 36
Annual rate of change energy consump. % 1965-1989	- 1,3	- 3.3	-1,1	-7,3	-6,6
Green House index (carbon heating equival. in metric tons/cap 1988-89	0,3	0,9	0.9	3,5	1,5

Legenda: 1. All developing countries; 2.Least devel. Countries; 3.Industrial countries;

Table 8. Physical Infrastructure

8.1 Transport network in Tanzania — Source: Dorgan, C.A.

1995

Roadnetwork in Tanzania	Highways	Roads	Total
	81,900 km	85,500 km	35560

Railroad 3,555 km

Major sea harbor : Dar es Salaam

8.2 Electricity infrastructure — Source: TANESCO; Bureau of statistics 1995

% dwellings with electricity	Electricity prod in mill kW / yr	electr.consumption 1993
	Installed capacity 1993: 486 million kW 1994: 505 million kW	11.4 million tons of oil equivalent (toe) or 24.5 gigajoules/cap

8.3 Water distribution

% of all households supplied with piped water

8.4 Telephone communication system — Source:Bureau of statistics 1995

No of subscriptions/lines in use	public phones/area	Publ phones/1000pop
1993: 85 000 1994: 88 000	urban - rural -	-

8.5 other communication channels — Source: — Source edweb@www.educ.unesco.org 98

Television sets no/1000inhab	Radio channels	Journals in no	Magazines in no
2	-	8	-

Table 9. Population

9.1 Major demographic data Source: Nat Bureau of statistics (NBS) 1994

Total population. (July 1996 est.)	Pop. Growth (000)	Pop. growth %	Urban / rural pop (1995)	Av. Pop.density hab/km^2
29,058,470	1988: 23,127 1994: 27,471	1,15% (1996 est.)	Urban: 19% Rural: 81%	30 (Tanzania) 1,153 (Dar es S)

9.2 Agestructure s Source: Nat bureau of statistics 1994

Age groups	< 15 yrs	15 < age < 65	> 65 yrs
% of total population	> 40% (1994)	57%	<3 % (1994 est)

9.3 ethnic/cultural homogenity Source: National Bureau of Stat. 1994

Ethnic groups	Mainland: native African (95% Bantu, consisting of well over 100 tribes) 99%, Asian, European, and Arab 1% ; Zanzibar: Arab, mixed Arab and native African, native African
Religions	Mainland: Christian 45%, Muslim 35%, indig. beliefs 20% Zanzibar: Muslim > 99%
Language	Kiswahili English (official prim. language of commerce, admin & higher educ), local languages

9.4 Average household size 5.91 persons Source: Fereira, WB, 1995

Nr of persons /hh	1-3 pers	4 pers	5-6 pers	7-9 pers	10 or more
% of total households	14.7%	16.8%	31.7 %	24.2 %	12.6 %

9.5 Household composition/ region Source: National Bureau of Stat. 1994

	Rural	Urban	Dar es Salaam
a. no.of hh	2,993,821	737,898	281,170
b. persons	18 4 41 941	4 043 684	1 360 ,865
c. average hh size	6.16	5.48	4.84
d. hh composition			
1 adult, no children	1.6	3.2	6.2
1 adult, 1-2 children	1.2	1.8	3.1
1 adult, 3-4 children	0.9	1.1	1.3
1 adult, >5 children	0.5	0.4	0
2 adults, no children	4.6	6.7	8.7
2 adults, 1-2 children	14.6	15.6	23.8
2 adults, 3-4 children	15.5	11.1	16.9
2 adults, > 5 children	6.0	2.7	1.9
> 3 adults, no children	4.7	8.8	5.3
> 3 adults, 1-2 children	17.3	17.5	14.5
> 3 adults, 3-4 children	18.6	22.6	4.2
> 3 adults, > 5 children	14.7	8.7	2.0
Total	100	100	100

9.6 Hh characteristics by income Source: Bureau of statistics 1994.

	All Tanzania	Poorest 20%	Richest 20%
no of household members	5.91	7.05	4.89
Dependency ratio (nr dep. <15and >64yr	1.15	1.31	0.94
Average of household head (yrs)	43.7	45.8	41.4
Female headed households (% of total)	12.2	10.9	15.3
Average no of children < 15 yrs/hh	2.80	3.50	2.10
Average no of adults > 65/hh	0.15	0.20	0.14

9.7 No lowest income households Source: Fereira, WB, 1995	% Hh under poverty line	23.07%

Table 10 Urban growth in Tanzania (%)	1978-1988	1989-1991	1991-1995
Source: UNDP 1994	10.9	18.0	20.7

Fig 7.2 Education system in Tanzania
Source Ministry of Industry. *Local construction industry study.* 1977, p.226; Dam, A. van. *Onderwijs in Tanzania.* 1990, p.14/15.; Rijkenberg,S. TUE 1996

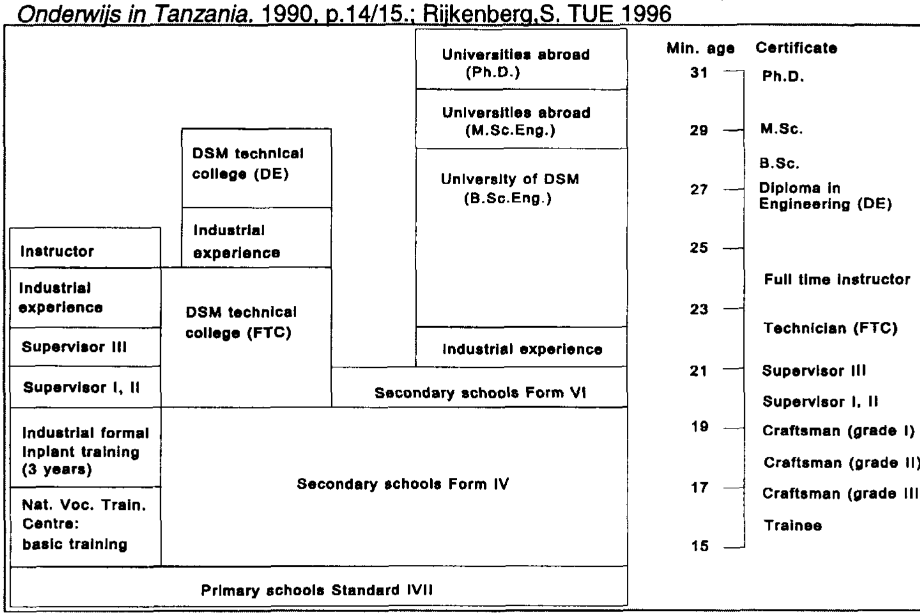
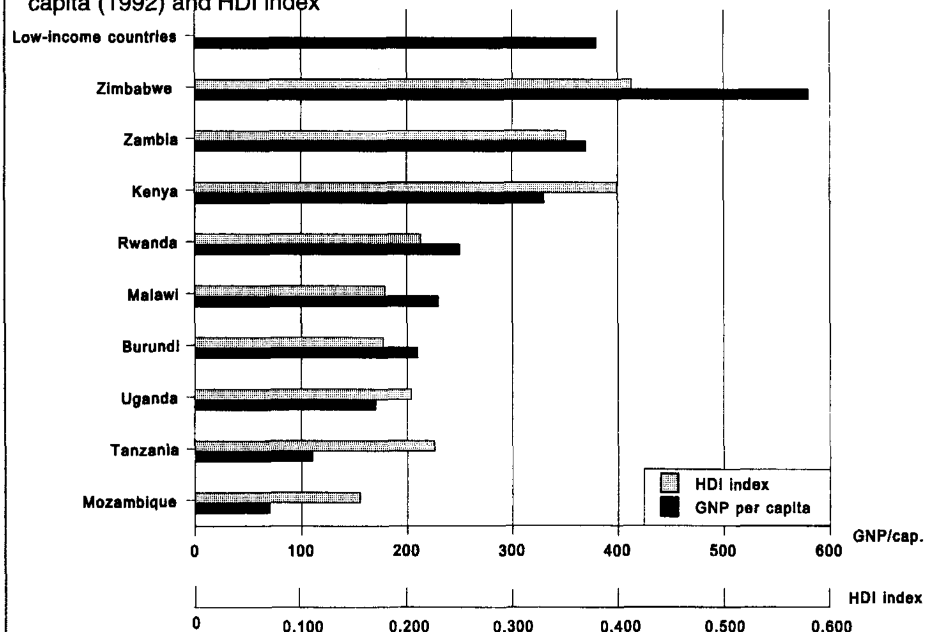


Figure 7.3 Ranking of Tanzania and neighbouring countries on the basis of GNP per capita (1992) and HDI index



APPENDIX II-8

Strengths and weaknesses of the technological capabilities and technology status in the dwelling construction sector

Table 8/1 Promoting and constraining features of the technological capabilities

National stock	Promoting feature	Constraining feature
Technologies	* large range of dwelling types * multiple usability	* high import content * low level of facilities * low durability construction systems * high production complexity * too high costs for target group * illegal status
		* in-sufficient and non-adequate tools & equipmt
	* low capital intensity of process technologies * low cost labor * flexible organization * informal * direct	* high import content of tools & equipmt * in-sufficient technical skills and knowledge * in- sufficient management skills * too low education level * in-sufficient info & doc * in-efficient organizational framework
Human resources	* large size young population	* low literacy * low enrollment rates in education sys * lack of trained labor force * lack of skilled crafts men * lack of trained managemt staff * lack of supervision & control staff * low number of R&D staff * low number of consultancy staff
Natural resources	* large potential of mineral resources * extensive availability of land	* low level of mining * lack of infrastructural facilities * lack of knowledge on usability of resources * high rate of deforestation * in-sufficient energy sources
Technology infrastructure	-	* weak network of relations * weak performance of actors * lack of financial means * lack of consultancy capacities * lack of education & training capacities * lack of information & docum capacities * lack of R&D capacities * lack of manufacturing capacities for material & equipmt * in-adequate policies & strategies * low standardization * low income level customers

Table 8.2Strengths and weaknesses of the *product technological features* of the output

	Weakness	Strengths
Type	-	Matches the Tanzanian urban lifestyle.
Geometry	-	100% easy extension of the house 75% roof shape reduces change for leakages
Functionality	low access to facilities 82%	100 % multiple usability
Materials & construction systems	* too high requirem. skills & knowledge 86 % * not durable main structure 14% * non treated timber 95% * inefficient material utilization * high import content 86% * non durable earth floors 50% * high costs	86 % relative high durability main structure 14% traditionally known technology
Phys-technical quality	Bad physique technical status. 60%	-
Production complexity	* no economies of scale * long construction duration	-
Costs	* relatively un-affordable costs of durable buildings for target group	

Table 8.3 Strengths and weaknesses of the *process technology* features

	Weaknesses	Strengths
Tools & equipment simple hand tools	* high import content * no standard output * no guaranteed quality of output * high time consumption	low costs
Labor force	*Project management* * low experience * lack of time, lack of knowledge & skills, * low capacity to judge the quality of materials and work *laborers* * lack of knowledge & skills, low capacity to judge the quality of materials and work *un-skilled labor*, low experience	low costs flexible relatively high experience: contractor/foremen skilled labor
Information	* too limited technical doc * limited planning & control sys * limited material & equipm data * low level of info carrier	
Organization	* informal sector: less protection * no fixed workshop: less retrievable * lack of capital: low investment level * low wages; No R&D; No planning * no training; no access to financing * informal & ad hoc relation to suppliers of materials & equipment * no formal relation to other actors	* existence 6-20yrs * high market demand * flexible * direct action * informal direct communication

Box 8.1 Development of skills and Knowledge on building construction

In the traditional (rural) communities the skills needed for building construction have developed at a very steady pace. The knowledge and skills on the application of the traditional construction systems are widely spread. This was also enhanced by the fact that most dwellings were not permanent, but only lasted a couple of years. Building construction therefor took and still takes place on continuous basis in (rural) communities and many people -household members, relatives and friends- participate on-going in the building processes helping eachother. The skills are still being taught from father to son.
Literature indicates that in rural areas in Tanzania it is very common that houses are built with only relatives and other community members. Due to the fact that many urban dwellers migrated from the rural areas to Dar es Salaam, where they left their family and friends, the traditional (kinship) relations are not existing or not as common in the urban areas as they are in rural areas.
An implication of this is that the network of relatives and friends who could help in the construction process of a dwelling is far less extended than it used to be and one is forced to rely on hiring more or less specialized construction workers. Moreover the new materials and construction systems have been adopted in a high speed, enhanced by the fact that many people regard western style construction superior to the indigenous technologies.
The skill-up grading did not keep up with the rapid changes in the building process. The result of this is visible now. In some cases contractors and fundis do not have proper equipment to use the materials in the way they should be used, or sometimes their knowledge is lacking on how to reach an optimum strength and durability with the used materials.
Another reason for the lack of skills are the very limited formal opportunities to become experienced in building construction. And once skilled and experienced, the laborforce is leaking away to better pays and better prospects (Mwaiselage). This limits the pool of skilled laborforce for the informal and small scale contractors. They donot have the financial means to compete with larger contractors in obtaining the best laborers.
What thus can be seen is that the original system of education and training in the traditional (rural) communities was and still is heavily interelated with the basic kinship structure. In other words the knowledge and skills system was and is more or less integrated in the family and relatives system. In the modern (urban) communities the boundaries between the various social institutions have become more strict. Moreover the fast pace in which this took place did not leave room for the development of a seperate well working technology infrastructure with a strong linkage between organizations, institutes and individuals.

Box 8.2Former attempts to improve the financial situation

Since 1980 loans were provided to building contractors, especially to small scale contractors, via the National Bank of Commerce . This bank had by far the largest branch network. Further more it was the only institution with previous experience in supply of credits to small scale enterprises. It was not surprising that this system did not improve the situation very much, as only 1 % of the total credit of the main financial institutions went to the building sector, and then specifically to the larger contractors, while the building sector contributed 4 % to the GDP. Smaller contractors appeared to receive three and a half times less credit than larger contractors, and only in the form of short term loans. Contractors outside Dar es Salaam on their turn received only half as much as the contractors in Dar es Salaam. Since the interest rates were still quite high, the loans became extremely expensive for most contractors in particular in case of delays in the building process. The government decided that the system had to be revised. So far nothing has been done yet.

Table 8.4Strength and weaknesses of the materials input

	Weaknesses	Strengths
Type	Majority of raw materials no prefab	Low cost
Availability	hampering supply	-
Import content	relatively high 86%	-
Quality	relatively low	-

Table 8.5: Promoting and constraining project setting factors

Factors	Promoting	Constraining
Climate	* many activities can be carried out outside	* heavy rains cause delays * high relative humidity cause a vulnerability for fungus and rot
Landform and soiltypes	* moderate good drainage * relatively simple foundations * availability of materials	* hazardous lands
Natural disasters	* low occurance earthquakes & hurricanes	* lower lands vulnerable for flooding during rains
Infrastructure	-	* bad accessibility of construction sites * in-sufficient water and electricity supply
project size		* no economies of scale
Financing	-	* lack of financing may cause delays
Legal status	-	* high percentage non-legalized plots * in-sufficient serviced plots * expensive plots
proj managem.		* too often non-skilled and non-experienced
Informal sector project execution	* low cost * flexible	* many different non-registered actors. * no warranty for quality of the output. * no access to formal information and document.

Table 8.6promoting and constraining factors of the national technology setting

	Promoting	Constraining
economic setting	* increased economic growth	* relatively low GDP/cap * low income distribution * high inflation * high interest * un favorable trade balance * low exchange rate * high dependence on foreign aid * in-balanced production structure * low industrialization rate
political setting	* relatively political stable * peaceful no internat. disputes * liberal policies, relatively less state intervention	* low social services budget * in adequate and vague policies * in-adequate legislative and regulatory environment
Educational setting	-	* high illiteracy * low enroll mnt rates * lack of educational means * low level of in-company training
Land & natural resources	* in abundance available	
Infrastructural setting		* rather bad accessibility * low communication facilities
demographic setting	* peaceful multi cultural population * large potential laborforce	* relatively high rate of growth * large percentage young population * large percentage of poverty * large percentage un-employment * high urbanization rate * high influx of refugees

Appendix III

Data on Costa Rica

I research design

II tanzania

III costa rica

IV conclusions

Contents

APPENDIX III-2

Housing in Costa Rica

2.1 Housing affordability index

	Real family income index	Housing costs index	Housing affordability index
1980	100	100	100
1981	86	98	62
1982	73	68	70
1983	76	83	52
1984	80	110	47
1985	80	106	49
1986	89	104	65
1987	82	103	54
1988	81	115	49
1989	80	117	44
1990	80	112	47
1991	82	109	44
1992	85	115	47
1993	86	138	43
1994	90	135	40

2.2 Poverty figures

	Urban			Rural		
	1993	1994	1995	1993	1994	1995
Population	1,323,069	1,348,602	1,365,673	1,679,318	1,716,557	1,765,311
No poverty	67.1%	73.4%	75.5%	55.6%	62.9%	63.8%
Basic poverty	4.1%	4.2%	3.7%	11.0%	11.1%	10.0%
Extreme poverty	2.7%	2.2%	2.3%	11.1%	10.8%	10.5%
No income	1.5%	1.5%	1.2%	2.2%	1.4%	1.7%
Unknown	24.6%	18.7%	17.3%	20.1%	13.8%	14.0%

2.3 Basic building regulations

Functional space	Minimum width (m)	Minimal surface (m2)
Bathroom	1.05	2.00
Kitchen	1.60	4.00
Kitchen sink (outside)	1.00	1.50
Multi purpose room	2.50	12.50
Master bedroom	2.50	7.50
Additional bedroom	2.00	6.00
Family room	2.50	7.50
Dining room	2.50	6.50
Room/dining room	2.50	12.50
Kitchen / dining room	2.50	9.00
Room/kitchen/dining room	2.50	13.00

Table 2.3 continued next page/....

.../table 2.3 continued

<table>
<tr><td>Net minimum surface:</td><td colspan="2">. the minimum size of a dwelling (with 2 bedrooms) : 30 m2
. each additional bedroom should have a size of at least 10 m2.
. the minimum sanitation nucleus: 7m2
. the minimum sanitation nucleus for multiple use: 20m2</td></tr>
<tr><td>Materialization and finishing</td><td colspan="2">. All structural elements such as foundations, walls and roof should be constructed in compliance with the Costa Rican seismic regulations (Codigo Sismico).
. Walls should be made of a combustible- , non-combustible material or a combination of the two. When combustible materials are utilized then the houses must be separately situated with a minimum distance between the building and the plot line of 1.50meter.
. Floors can be built outof stabilzied cement, concrete or each other similar material with a comparatively durability. Floors have to be levelled and free of dust in order that they can be used by its inhabitants daily
. The houses may be constructed without a ceiling when a ventilation above the bond beam can be guaranteed.
. The minimum floor height is 2.20 meter measured between the floor and the top of the bond beam.
. Each room should be provided with an opening to guarantee enough ventilation and day light.A maximum 50% of these wall openings should be permanently closed. The rest can be opened for ventilation purposes, for instance by means of ventilation blocks, wire blinds, shutters, casements, balance windows.</td></tr>
<tr><td>Min. requirements size of wall openings in % of in-side floor space</td><td>Climatological area

a. moderate or cold areas
b. hot and humid areas
c. hot and dry areas</td><td>wall openings in % of inside floorspace
10%
20%
15%</td></tr>
<tr><td>Flexibility and opportunities for the construction of annexes to the dwellings</td><td colspan="2">The design of the dwelling's sanitary nucleus should allow the construction of annexes to the dwelling by the houseowner himself in future.
The complete manual , the detailed works drawings and the drawings of possible annexes to the dwelling should be given to the houseowner in order to guarantee a certain standard of adequacy of these future annexes. This regulation is also meant to avoid the construction of not-foreseen annexes which can lead to sanitation problems, damage to the direct dwelling environment and a loss of time and money on account of the house owners.</td></tr>
<tr><td>Property limits and alignment:</td><td colspan="2">When more than one building is constructed on a plot for more than one family , the construction norm V 3.5 should be taken into account. This norm determines the limits of the property, party fences and regulations with regard to the allowed distance of the dwelling to the alignment and the location of windows and wall openings relative to the party fences. A wall without wall openings can be situated on a minimum distance of one fourth of the height of the adjacent building, however never less than 3.00 meters from that building.</td></tr>
</table>

2.4 Projections of increasing housing deficit related to income levels (1985-2000)
Source: Project report PNB 1985

Year	Lowest	low	Middle-higher	total deficit
1985	77.500	47.000	13.900	138.400
1990	89.300	54.000	16.000	159.500
1995	101.100	61.400	18.100	180.600
2000	112.900	68.600	20.100	201.600

2.5Estimate of the deficit of houses in Costa Rica (1984-2000)
Source: Ministerio de Vivienda y Asentamientos Humanos (1994)

Year	effective demand for houses (total ascertaine d need)	Existing stock of houses	Stock of adequate houses	Stock of houses at sub-standard level	Houses in-adequate for habitation and non-repairable	nomina l lack of houses	Actual deficit of houses
1984	558,739	508,979	275,339	170,409	63,231	49,760	112,991
1985	580,921	523,857	287,168	171,432	65,657	57,264	122,321
1986	603,983	533,223	300,184	172,336	66,703	64,760	131,463
1987	628,452	557,749	316,150	173,228	68,371	70,703	139,074
1988	652,921	575,204	331,030	174,094	70,080	77,717	147,797
1989	677,390	599,169	352,373	174,964	71,832	78,221	150,053
1990	701,859	623,081	373,614	175,839	73,628	78,778	152,406
1991	723,577	644,859	392,673	176,718	75,468	78,718	154,186
1992	745,966	669,446	414,489	177,602	77,355	76,520	153,875
1993	769,049	695,596	437,817	178,490	79,289	73,453	152,742
1994	792,845	716,068	455,414	179,383	81,271	76,777	158,048
1995	817,378	736,540	472,958	180,279	83,303	80,838	168,141
1996	839,400	757,012	490,446	181,181	85,385	82,388	167,773
1997	862,015	777,484	507,877	182,087	87,520	84,531	172,051
1998	885,240	797,956	525,251	182,997	89,708	87,284	176,992
1999	909,090	818,428	542,565	183,912	91,951	90,662	182,613
2000	933,583	838,900	559,818	184,832	94,250	94,683	188,933

2.6: Share of houses in the output of the construction industry (1989-1993)
Source: CCCC, 1995

Year	Stores & office (m^2)	Industrial (m^2)	Others (m^2)	Houses (m^2)	Total (m^2)	% houses
1989	240,482	138,236	92,832	1,491,277	1,962,827	75.98 %
1990	275,741	146,184	60,321	1,131,078	1,613,324	70.11 %
1991	177,486	90,306	38,291	1,219,654	1,525,737	79.94 %
1992	233,263	143,426	57,611	1,027,445	1,461,745	70.29 %
1993	435,206	134,552	72,699	1,303,721	1,946,178	%

2.7 Number of houses constructed per year in Costa Rica (1963-1993
Source:Ministerio de Vivienda y Asenmientos Humanos (1994)

Year	Houses	Year	Houses	Year	Houses
1963	9,880	1974	14,970	1985	15,909
1964	9,091	1975	13,932	1986	16,110
1965	9,284	1976	14,854	1987	18,526
1966	8,900	1977	16,872	1988	17,455
1967	9,161	1978	17,917	1989	23,965
1968	9,972	1979	17,939	1990	23,912
1969	9,698	1980	18,149	1991	21,798
1970	10,394	1981	15,438	1992	24,587
1971	11,981	1982	13,459	1993	26,150
1972	15,350	1983	11,892	1994	
1973	14,453	1984	16,311	1995	

2.8 Percentage of houses constructed beyond or within the SFNV (may1994-april 1995)
Source: MIVAH: informe anual de labores 1994-1995, april 1995

Beyond the SFNV	30.3 %
With subsidies	52.1 %
Without subsidies	14.3 %
With own resources	.2 %

2.9Construction within the SFNV by type of project financing ,jan.1994 - april 1995
Source: MIVAH: informe anual de labores 1994-1995, abril 1995

	Amount of financing in mill current Colones	Nr of projects	% of projects
Construction of a house	16.723	13.337	55.9 %
Purchase of an existing house	14.283	6.610	27.7 %
Extension and reparation	2.049	2.476	10.4 %
Purchase of a plot	1.862	1.415	5.9 %
Total	34.917	123.838	100 %

Box2.2 Sistema Financiero Nacional de vivienda (SFNV) objectives

1. *to promote savings, national and foreign investments* for the purpose of collecting the financial resources to obtain a solution for the existing housing problem in the country (law 7052) this is the major objective to establish such a mechanism in order that the housing problem can be adequately solved.
2. to integrate into a single system all institutions private and public, who traditionally finance housing, some of which will form part of the System through the application of the law (Mutual Associations and Public Institutions) and others may act freely as authorized entities of the same (private banks, cooperations and others).
3. to establish a housing mortgage bank (BANHVI) as a public rather than a State organization with legal jurisdiction, private resources and administrative autonomy as the ruling entity of the system, with power to dictate general policies, safeguard, censure, orient and sanction authorized entities

2.10 Government interventions in the housing situation in the period from 1904 to 1994 in chronology

1904	regulations on chinchorros and neighborhood houses (April 1904)
1914	Authorization for the government to obtain foreign loans for dwelling construction by the State or families of middle and higher income classes
1922	Authorization for the Executive Power to contract loans for the construction of housing for lower income households (October 1922)
1939	Creation of a National Housing Board (Junta Nacional de Habitacion) initially linked to the government and later converted into an independent institution (1939-1942) : to create legal and institutional instruments to address the housing problems at the end of the 1930s.
1940-1948.	Establishm of the Cooperative for Low-cost Housing ("La Familia"). During the 1940s the Communists party in Crica, promoted a progr. named "Inexpensive houses"from the Caja Costarricense de Seguro Social (CCSS) . Housing for lower income groups was seen as a problem of social interest and became a constitutional precept. The Nat. Housing Board & La Familia was incorporated in the CCSS : the official agency in charge for housing for the housing for low income population when the department of housing was created by accreditation of the Habitation Law (1945) [Pujol,et all 1984:pp-4]
1948	Establishm of the National Institute of Insurance and nationalization of the Banking system to form the channels through which the housing programmes were financed.
1954	Establishm of the national institute of housing and urbanization (Instituto Nacional de Vivienda Y Urbanismo INVU) Tasks: integral approach of housing and urbanization issues "based on a better knowledge from its reality". Operate as independent autonomous institution with its own financial, administrative, legal and technical resources. Major activities (early 1950s) : slum clearance in attempts to up-grade the living standards for the poor and dwelling construction for lower middle class population. Financial resources: During the first four years (1954-1958) by the state through an allocation of the national budget for its operations. Later: rely on foreign financing to carry out its programmes and on private economic resources for its basic expenses. When the finan. resources from the State were withdrawn INVU´s capacity for action decreased. Result: construction of only 900 houses/yr (1958 and 1973) Many of these beyond the affordability of the poor. INVU has not been free from critical notes since then.
1969	Creation by law the National system for Savings and Loans to combine local efforts of both the public and private sectors in their activities of housing provision(1969). Private non-profit financing institutions could be established from then on named Mutual Savings and Loan Associations (Associaciones Mutuales de Ahorro y Prestamo). Imported role in alleviating the housing problems of in particular the middle income population during the last two decades. The State kept on having a grip on the mutuales through the control of their actual policies and actions executed by the Agricultural Credit bank of Cartago (banco de Credito Agricola de Cartago) an Institution of the State Banking System, through the Central Department of Savings and Loans (Departemento Central de Ahorro y Prestamo DECAP). Resources: generated through savings and other financial sources (foreign and national). Resources used to construct dwellings and to improve an d repair existing ones. Conditions mainly based on the income of the households and their ability to save and pay-back.
1971	Established in 1971 by law :public sector institution the IMAS, Mixed Institute of social Assistance (Instituto Mixto the Ayuda Social) in charge for the provision of the housing facilities for the lowest income groups. Financial resourcs: State income from import duties and taxes, a percentage of the national lottery income and a percentage of the family allotment Fund. IMAS carried out a number of housing programmes (construction of tenement housing facilities, shelter for homeless, programmes for do-it-yourself dwelling construction and community *enterprises etc.)*
1979	Establishment of the Ministry of Housing and Human Assessment "Plan Habitacional del Gobierno": the foundation of the Housing and Human settlements sector ; objective: to unite all institutions involved in dwelling construction or supplementary programmes. Final objective: alleviate the further deteriorating situation in the housing sector in Costa Rica. The housing deficit was considered to be one of the principal social problems which had to be solved in particular for the lowest income group which consisted of 56% of the population with an income of less than US$ 60.00 per month (8000 colon)

Table 3.10 continued next page

table 3.10 continued...

1982 –1986	Decision of administration of 1982-1986 : Ministry of Housing and Human Settlements (Ministerio de Vivienda Y Habitacion MIVAH) unnecessary . Better to strengthen the existing bodies like INVU, then increase the size of the public sector in Costa Rica. However lack of financial resources, adequate legal and institutional instruments further enhanced the deterioration of the housing situation in particular for the lower income groups. The existing bodies both public and private sector organizations seemed to be working in a scattered way and without proper coordination which was noticeable in different credit policies, financing facilities, pay-back period of loans, interest rates, conditional requirements, which made a effective solutions for the housing situation problematic. Examples : IMAS allocated the financial resources for dwelling construction, which is not their major target nor primary activity. INVU: too limited abilities to address the housing problem effectively due to a lack of a guiding policy framework and lack of financial resources. The Sistema Nacional de Ahorro y Prestamo SNAP directed its activities only to those who are able to save and thus exclude a large part of the population. [Zomer 1982:pp129-136].
1984	1984 decision : former housing plans were to be adjusted for the period 1986-1990. "Plan Nacional de Vivienda Popular" (National Housing Programme) 1986 : Government compromised with a yearly financing for the construction of 80,000 houses for the lowest income groups in rural and urban areas (income level below C 15.000 monthly). Radical approach needed (a) release the financial resources and human potential, (b) establish the necessary restructuring and reorganization of the ineffectively working existing housing provision sector.

APPENDIX III-3

Technological Capabilities

Technology stock

Box 3.1 Historiographic overview of dwelling construction systems in Costa Rica (1900-1950)
Source: Altezer, 1986

The construction technologies that were applied in the **nineteenth century** in Costa Rica were inherited from the Spanish colonialists and the indigenous population who used traditional local materials and construction systems. **Adobe** was generally used for the structural elements, the roofs were thatched in case of the simple dwellings and covered with ceramic roofing tiles in case of the more important buildings. The **brickwork masonry** was actually only applied for religious and governmental building constructions, due to the skill requirements and labor intensiveness of these type of construction.
The construction industry started growing at the **end of the nineteenth century**, co-inciding with population growth and increased economic developments. The production of ceramic building materials like bricks , floor-tiles and roofing tiles increased at the same time. The basic materials for these products, like lime, sand and clay easily could be derived from nearby locale resources.
At the **end of the nineteenth century new building materials** were introduced like metals, such as steel and zinc and timber to be used in new construction technologies. Steel was going to be utilized as structural element, roof covering material, and as reinforcement for decorative vertical elements. Corrugated sheets soon substituted the traditional roofing tiles, these sheets are light-weight and have a good resistance against seismic forces. Moreover the metal sheets formed a good solution for the severe humidity problems in Costa Rica. From the end of the nineteenth century up to the fifties during this century timber has taken a predominant place as construction material, accepted by the various social classes and preferred by the lower income groups for its relatively low-costs and easy availability in the country. The many forests in the country and the extensive range of different species enhanced the timber utilization in construction. The local market could provide for the total demand for timber. The increased exploitation of the forests for the exports of timber however resulted in frequent periods of shortage of timber to meet the local market demand. This situation even was seen as one of the causes of the increased housing problems up to the eighties. During the first decades of the 20th century Costa Rica has started the production of composed building materials like **concrete blocks, floor tiles, etc. based on imported cement.** Also during this period the **reinforced concrete technologies** were introduced in Costa Rica as a material which should be distinctly proper to resist the natural forces of earthquakes, hurricanes, fire , humidity and the biological attacks of insects and fungus. However caused by **a lack of professional knowledge and skills for the application of the reinforced concrete technologies** and the problems in the provision of the necessary (imported) materials this technology was not extensively applied until the fifties. At the time that the **reinforced concrete** was introduced no production of the basic materials, cement and steel took place in Costa Rica. The increased local cement consumption and the difficulties of the cement provision in the country in particular during the crisis in the cement producing countries like Europe during war time, contributed to frequent shortages of the material. In the sixties cement production started in Costa Rica for the first time. This made the construction industry less dependent from foreign sources. But the other materials like reinforcement steel and the corrugated iron roofing sheets still have to be imported. During the eighties research started on alternative construction materials which can be produced locally to substitute the imports

3.1 overview of construction systems for houses in Costa Rica

constr system	Basic description	product technical properties
CB masonry	Foundation: re-inf. Concrete slab underneath walls; Size: cross section min. 20-30cm, anchors no 2 , 20 cm c.t.c. Walls: CB masonry; min. 10 cm (solid blocks) and 12cm (hollow blocks). Re-inf. Important: iron rods no3 & no4 max. 80cm c.t.c. vertically & 60cm horizontally. (Codigo Sismico, Bldg reg.) Special reinforcement in (a) Load bearing columns of hollow blocks filled with concrete and re-inf. to bear vertical loads, (b) intersections between walls, (c) door- & window openings. Concr. bond beam connect walls at the top. Alternative system: Re-inforced concr. skeleton + CB infill walls (no extra reinf in CB necessary)	Functionality: all possibilities to adapt size and sub-division of space as required. Geometry: Particular recognizable appearance when walls are not finished with plaster Durability against seismic forces limited Height of walls: limited to 2.5m; Max. width wall-elements: 3.5m. (without ortogonal connection to other wall element) Door- & window operings with width >2.5 m not recommended [Codigo Sismico de CR] Durability w.r.t. humidity in rainy (> 3,000mm/yr) & humid areas: 1.a mortar finishing of the walls; 2.a protecting roof overhang [UCR/CONOCIT, 1989] Construction complexity: very flexible system , but needs adequate supervision & knowledge and skills on masonry and concrete reinforcem. Construction of windows- & door frames needs skilled carpenters to properly fix connections between walls, door - and windowframes.
Timber	Foundation: reinf concr found. beam underneath walls: min. 120 x 250mm with horizontal refinf (no3) +anchors (no 2) 20cm c.t.c. & vert. rods (no 3) 90cm c.t.c. to anchor the timber system. Alternative: Standard timber panels (1.80 m width) 2 anchors fixed 45cm from board ends. NB Foundation is too extensive. A foundation on cast in situ concrete dies will do. Walls: timber structure of beams and columns nailed with laths.	Functionality: all possibilities to adapt the size and sub-division of space as required. Geometry: Particular recognizable appearance Durability: Timber needs special treatment against biological influences (fungus, moth, termites, etc). Timber should not stay in contact with the soil or not be easy accessible through any cracks in the building and should be provided with metal slab placed on top of foundation Construction complexity: very flexible system ; Needs supervision & knowledge and skills of carpenters mainly
Zocalo	Combination of CB brick masonry and timber systems Foundation reinf concr found beam underneath the walls min.200 x 300 mm + reinforcem Walls: Lowest part of building: 5 layers of CBlocks, reinforced (no 3) 90cm c.t.c. vertic. & (no 2) horiz. every 2 layers. Timber construction system on top of masonry. .	Functionality: all possibilities to adapt the size and sub-division of space as required. Geometry: Particular recognizable appearance due to combination of masonry and timber structure. Durability: see foregoing constr systems Production complexity: : see foregoing constr systems

Table 3.2 continued next page/...

Concre-bam	prefab bamboo strips reinforced concrete panels: 60x500 x 2600mm Foundation: not reinf concrete slab underneath the walls min. 300x350mm First layer of concrete 300x200 mm poured into foundation trench; Walls: Guiding rail on top of foundation for the concrebam panels: steel profile of 50x100 mm finished with 150 mm concrete after placing of panels. Corner connection of wall panels: with iron rods (no 2) 52cm c.t.t. fixed with wire at the corner. Bondbeam on top wall panels: steel profile.	Functionality: all possibilities to adapt the size and sub-division of space as required. Durability: vulnerable to humidity. Adherence bamboo-concrete severely influenced by changing humidity. Bending strength: bamboo reinf establish increase of 38% of strength of concrete under • normal• circumstances. reduced to practically zero in processes of severe dehydratation -> a collapse of the structure in ultimate stages [UCR/CONOCIT, 1989] Solutions (not very satisfying sofar): (a) Reduction of permeability of concr. (b) Impregnation of bambu Other product technical properties: good
Prefa PC	modular system; prefab columns & horizontally placed wall panels Foundation:cast in situ concr. or CBlocks die (300x300x800mm) underneath colums. Walls: reinf concr colums (130x130mm) placed max 2m c.t.c. Concr. Panels (40x500mm) placed in trenches (55x55mm) in columns. The length of panels: variable upon order Cement mortar is used to bond the panels and colums together. Iron rods fixed on top of columns serve as anchors for the timber bond beam. Water & electr pipes are cast in the colums.	*Functionality: all possibilities* to adapt the size and sub-division of space as required. Geometry: a specific outlook column-structure stays visible at outside of house Durability rather good. [UCR/CONOCIT, 1989] Windloads and seismic forces on horiz. Panels passed to columns and foundation. Bond beam prevents column movemnt in horizontal direction (otherwise may cause cracks in the panels). Compressive strength panels: 270kg/cm2 guaranteed by the entrepreneur; 241 kg/cm2 in tests but does not imply any significant deficiences of structural security. *Constr complexity*: very flexible system can be placed manually. Placing of columns and panels require adequate supervision. Constr of windows- & door frames rather difficult, due to problematic connections between wall-elements, door cases and windowframes.
Bambu	Modular system; industr. prefab panels.; frame of either bambu or timber and a "lining" of cane (Cana Brava) or bambu-strips of the bambu specimen Gudua Angustifolia. Panels are later finished with three layers of cement plaster finishing. The wall panels are connected with 6mm bolts. The foundation exists of a slab of reinforced concrete cast in situ in a trench of 150x250 mm. On top of this concrete slab two layers of concrete blocks filled with concrete are placed. Iron rods cast in the hollow concrete blocks at a distance of at least 45cm centre-to-centre serve as an anchor to fasten the bambu panels on top of a timber batten of 50x50mm fixed on the upper layer of concrete blocks.. [CIVCO, 1993, PROY.NAC.DE BAMBU]	Functionality: all possibilities to adapt the size and sub-division of space as required, (several sized panels provided upon request). Number of panels with *different sizes is limited.* Geometry: outlook does not differ from the traditional concrete blocks construction system (plaster finishing of the walls). *Durability* against (A) mechanic and physical forces windloads and seismic forces): extremely good. (B) *biological influences* (fungus, termites, insects, etc).: problem, requires carefull preservation reasonable protection by concrete plastering *Construction complexity*: very flexible;can be placed manually; construction of *window-frames & door cases* is *included in* this system which facilitates their connections with the wall-elements

3.2 Construction systems applied for dwelling constructions of approx 50m2 and more
Source: CONSTRUDATA of DME (1994)

Year	Concrete blocks masonry	other construction systems
1987	92%	%
1988	98%	2%
1989	98%	2%
1990	99%	1%
1991	99%	1%

3.3 Equipment and labour requirements for the various construction systems

Constr system	Equipment requirements	Labour requirements
Concrete Blocks masonry	Traditional: bucket, shovel, leadline, plumb line, trog Advanced: cement mixer	Skilled masons with knowledge of the construction system.
Timber	Trad: Foundation: bucket, shovel, leadline, plumb line, trog; Timber structure: hammer, saw, pair of tongs, screw driver Adv: cement mixer, mechanized hammer and electric srewdriver	Generally all work can be carried out by a carpenter with skills and knowledge of timber constructions.
Zocalo	Trad: Foundation: bucket, shovel, leadline, plumb line, trog; Timber structure: hammer, saw, pair of tongs, screw driver Adv: cement mixer, mechanized hammer and electric srewdriver	Bricklayer and carpenter with skills and knowledge of bricklaying and timber constructions.
Concre-bam	Trad: Foundation: bucket, shovel, leadline, plumb line, trog; Timber finishings: hammer, saw, pair of tongs, screw driver Adv: cement mixer;leveling,excavation and trench making machines.	Labourer with knowledge of the construction system and carpenter with skills and knowledge of timber constructions for the finishings.
Prefa PC	No specific equipment except the traditional ones is required thanks to the relatively light weight and handy sizes..	The PREFA PC construction system can be placed manually Knowledge and skills are required for the exact placing of the colums, panels, bond beamd and roofing structure. Professionals and engineers generally carry out the inspection on the construction process with PREFA-PC.
Bambu	No specific equipment except the traditional ones is required, thanks to its relatively light weight and handy sizes.	The Bambu Construction system can be placed manually. Semi-skilled labourforce will be able to carry out the job. The finishing requires plastering skills. Basic instructions are given by the producer of the construction system.

Human resources stock

3.4 Registrated allumini

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Civil engineers UCR	100	93,4	86,8	80,2	73,6	67	66	65	64	63	74
Architects UCR	37	38,4	39,8	41,2	42,6	44	45,25	46,5	47,75	49	57
Building engineers ITCR	18	16,6	15,2	13,8	12,4	11	10,5	10	9,5	9	12

3.5 nr of INA graduates

1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
286	279	514	897	1206	1179	857	861	865	877	994	1121	1459	1461	1901

Fig 3.1 The registration of architects in the Colegio de Ingenieros
Source: Thielemans, J/TUE 1997

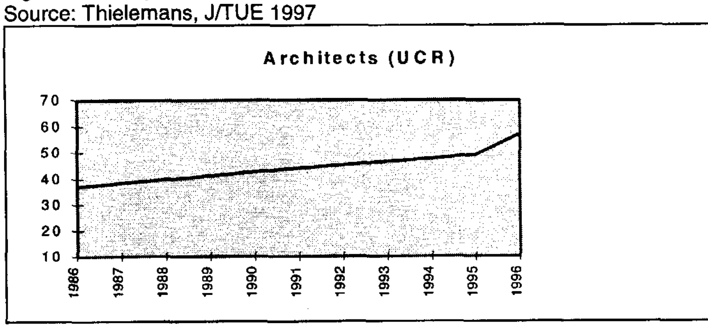


Fig 3.2 The registration of civil engineers in the Colegio de Ingenieros

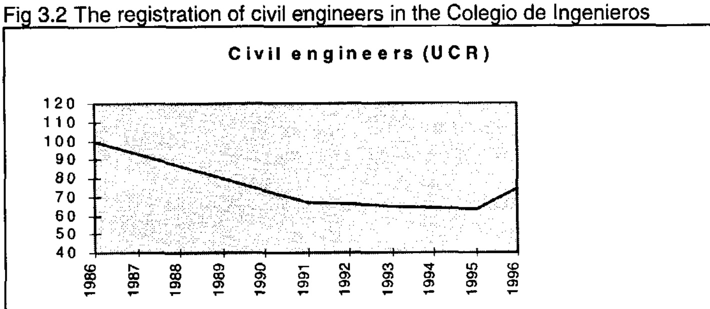


Fig 3.3 The regiatration of building engineers in the Colegio de Ingenieros

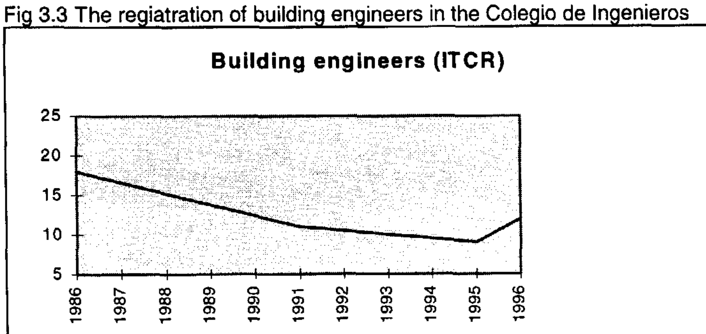
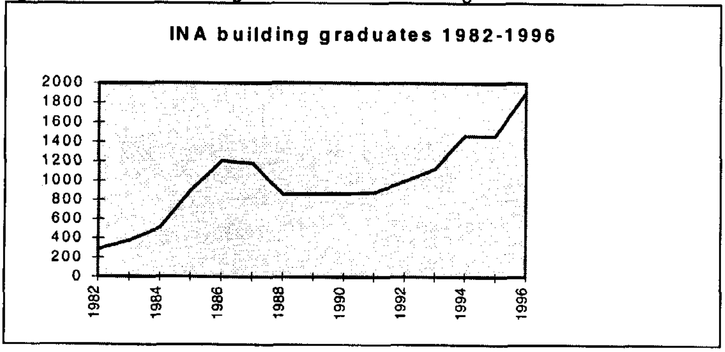


fig 3.4 Number of graduates of INA building courses 1982-1996



Natural resources stock

3.6 Natural resources stock relevant for the construction industry in Costa Rica

Non-metallic minerals Source:Dorgan, C.A. Gale country &world rankings reporter. 1995
= a marked break in the series; data prior to sign not comparable

Limestone flux and calcareous stone (thousand metric tons) Limestone flux and limestone and calcereous rocks commonly used for the manufacture of lime or cement, excl. building or monumental stone. Those materials in powdered form for soil improvement are included. Dolomite and chalk are excluded.

1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
110	100	100	#1000	1000	1015	#2300	1600	--	--
Sand and gravel (thousand cubic metres) (Commercially extracted sand used in building, in glass industry, for cleaning materials etc.)									
280	250	80	100	400	1400	1020	--	--	--
Clay (total production) (thousand metric tons) (estimated figures) All natural crude clayey substances consisting of earth or rocks of sedimentation origin with basis of aluminium silicates, such as kaolin, bentonite, andalusite etc. Expanded clays are excluded									
1 Kaolin only	1	1	#200	200	200	200	200	200	--
Kaolin (thousand metric tons) (Kaolin, a high grade, white or nearly white plastic clay used in the porcelain and paper making industries. Kaolin-bearing sands are excluded)									
1	1	1	-	-	-	-	-	-	-
Salt unrefined (thousand metric tons) Sodium chloride or common salt (NaCl), irrespective of the source from which it is obtained and the degree of purity or concentration. Refined salt, salt liquors and sea water are excluded) * estimated figures									
109 (sea salt)	109	#30	30	13	27	30	40	40	--
Abrasives, natural (pozzolan, pumice etc.) (thousand metric tons)(Data refer to production of natural abrasives, such as pozzolan, pumice and volcanic ... Unless otherwise stated, production of other abrasives, including emery, natural corundum, tripoli and garnet is not included. Precious or semi-precious stone dust or powder are also excluded.)									
1.8*	1.8	1.8	1.5	6.0	6.0	6.4	6.5	--	--

* estimated figures

NB Non-metallic minerals: # = a marked break in the series; data prior to sign not comparable.

- *Limestone* flux and limestone and calcereous rocks commonly used for the manufacture of lime or cement, excl. building or monumental stone. Those materials in powdered form for soil improvement are included. Dolomite and chalk are excluded
- *Sand and gravel* Commercially extracted sand used in building, in glass industry, for cleaning materials etc.
- *Clay* (total prod estim fig) All natural crude clayey substances consisting of earth or rocks of

sedimentation origin with basis of aluminium silicates, such as kaolin, bentonite, andalusite etc. Expanded clays are excluded

- *Kaolin*, a high grade, white or nearly white plastic clay used in the porcelain and paper making industries. Kaolin-bearing sands are excluded
- *Salt* unrefined Sodium chloride or common salt (NaCl), irrespective of the source from which it is obtained and the degree of purity or concentration. Refined salt, salt liquors and sea water are excluded
- *Aggregates, natural pozzolan, pumice* etc.Data refer to prod of natural abrasives, such as pozzolan, pumice and volcanic Unless otherwise stated, prod of other abrasives, incl emery, natural corundum, tripoli and garnet is not included. Precious or semi-precious stone dust or powder are also excluded.

Technology infrastructure

3.7 Major actors in actor network

National and regional governments	A minor role in the actual execution of construction projects, Mainly involved in the provision of building permits, inspection of building sites and infrastructure and basic services.
Professionals engaged in consultancy	Architects: responsible for the design of the house; structural engineers: elaboration of the engineering details; and in case the house has a size of more than 110m2 an electrical engineer needs to be involved in the preparation of the electr. Desing and engineering plans in Costa Rica. All Costa Rican architects and construction engineers need to be registered with the CFIA to safeguard the quality of their work. The CFIA is the authority which establishes and controls the contract regulations and tariffs for consultancy in the construction sector in Costa Rica.
Building materials suppliers	Provide predominantly the materials like cement, concrete blocks, timber, iron reinforcement bars and corrugated iron roofing sheets and electrical and sanitary equipment.for dwelling construction for the lower income households. Most imported but cement, concrete, metal and plastic products are produced by Costa Rican plants
Equipment and tools suppliers	The majority of the equipment and tools supplied and utilized in the construction industry is imported. Only the simple hand tools are locally produced, although still the import content of these products is relatively high due to the necessary imports of raw materials and intermediary products.
Educational institutes	The educational institutes seemingly are not successful to supply the constr industry with the required quantity and quality of labor.(CIVCO 1992) Education for the staff of design and engineering companies and for project management is quite well organized. Education for labor force on site: formal education is scarce and is typically carried out as learning -by- doing through informal on the job training. There is seemingly no education to fill the apparent gap between the lower and higher level. Result: a lack of qualified skilled labor like carpenters and masons (CIVCO 1992).
R&D institutes	Majority of R&D activities carried out by public organizations. Problem: dependence on governm limited budgetary allocations. The nat. sc. & techn system is more or less determined by the demand from it by the production sectors. Result: pattern of technology adoption is based on foreign technol. Solutions, thus rather dependent on foreign sources. One of the major obstacles for the dev of a local techn system in the country: very slow developmnt of standards, norms and legalization; result: constraints to the application of new technologies in the constr. projects in the country. (CIVCO 1995)

Table 3.7 continued next page

.../ table 3.7 continued

Branch organization	Camara Costaricense de la Construcion (CCC) establ in 1966 Objective: represent & defend the interests of the affiliates of constr industry and the enterpr with direct relationship with the activities of the contractors in the country. Activities: a. distributor of information and documentation on both economic and technological developments in the sector. b. organizing seminars and conferences c. carry out research w.r.t. the operations in the constr industry to determine problems, constraints and possible solutions for these. d. strong relations with educational and R&D institutes, with the Federation of Architects and Engineers (CFIA) other Chamber of Commerce and the Public sector. e. at international level in Central America and beyond, the CCC has a number of strong relations with similar organizations and institutes. Performance: CCC organization is seemingly well organized. Not all contractors are affiliated to the CCC.
Financing organization	Thanks to a rather well developed financing system for housing in Costa Rica a part of the lower income households in Costa Rica can be provided with adequate houses with involved of the sub-sector of dwelling construction. The system however is rather vulnerable to economic and political development patterns in the country. The political and economic situation after 1994 has not been very beneficial for the national housing financing system nor for all other social services in the country. This implied that the demand for decent houses still exceeds by far the actual supply of these in aprticular for the lowest income households.

3.8 Classification of initiating actors and investors in dwelling construction in Costa Rica

Public sector	
National government & its agencies, like Instituto Nacional de Vivienda y Urbanismo (INVU) & the Instituto Mixto de Sayunda Social (IMAS).	The agencies take the project management role. Through a formal bidding procedure the construction company with the best bid is selected for the project execution.
Private sector	
Non-governmental organizations, like FUPROVI and Fundacion de Bambu	NGO acts as intermediate investor and project manager. Projects involve in general series of houses in a certain area
private organizations, real estate organization s and contractors	built houses in series like the above mentioned organizations. In most cases the houses are to be sold on the housing market.
private households	Construct their own house, which is common in Costa Rica. The financing of these projects can take place with subsidies from the national housing financing system (SFNV), with mortgages from the mutuales (cooperative mortgage banks) or with private funds.

APPENDIX III-4

TECHNOLOGY STATUS

4.I. Project setting

1. Location				
	Sites	Central Valley, prov.of San José, Alajuela, Cartago,HerediaGuanacaste, Limón		
	Climate	Temperate, humid		
	Landform	30% of the construction sites on a slope		
	land & soils	80% clay, mixed with sand, lime, gravel, rocks		
	Earthquackes	Often		
	windforces	Hurricanes		
2. accessibility	**type of road**		**no of projects**	**%**
mass constuction projects	Asphalt road good condition		4	24
	Asphalt road reasonable cond.		6	35
	Laterite /unpaved road		7	41
	None		0	0
Individual house constr	Laterite/ unpaved last 100m		19	100
3. size of project			no of projects	No of houses
Mass construction projects			4	2-50
			3	51-100
			5	101-200
			3	201-322
Individual dwelling constr projects			19	1
4. age	**yr of project execution**			**No of proj**
Mass construction projects		1989		1
		1991		1
		1993		2
		1994		2
		1995		4
		1996		7
Individual constr projects	1993			3
	1994			16
5. client/principal	**type of customer**		**No of proj**	**%**
Mass constr projects	Government		6	35%
	Institutional investor		2	12%
	Association		4	24%
	Private investor/household		5	29%
Indiv dwelling constr proj	private households		19	100%
6. source of finance	**financing agent**			**no of proj**
Mass constr projects	MUCAP 1993/94/95			5
	INVU 1995/1996			2
	Viviendacoop 1995			1
	CCSS +BCAC + banks 1995/96			2
	Mutual Metropl. 1997			1
	BANHVI 1991			1
	FUPROVI 1995			1
	Banco popular 1997			1
	Mutual Alajuela 1989/1994			1
	CEV 1993			1
	PNB 1996			1
Individual dwelling constr projects	MUCAP			19

7. project management	Type	No proj
Mass construction projects	contractor projects	15
	organization(FUPROVI/PNB)	2
Individual projects	owner	10
	contractor	6
	owner + engineering consultant	3
Type of contract indiv proj.	Total project execution	2
	time spending on proj.activities	11
	proj. managem. & time for proj.activities.	2
	other (like labor, part of activit)	4
8. legal status	status	No proj.
Mass constr. & individual projects	Legalized	36

II. Productec

1. Type of house	type	No of proj	%
	Semi-standard single storey	36	100%
2. plot size	**size**	**No of proj**	**%**
Mass production houses	< 100 m2	1	
	100 - 129 m2	7	
	130 - 159 m2	4	
	160 - 199 m2	4	
	> 200 m2	1	
Indiv dwelling construction	100-129 m2	6	
	130-159 m2	9	
	160-199m2	4	

3. dwelling size	size	mass constr proj	Indiv proj
	30-39 m2	2	1
	40-49 m2	9	2
	50-59 m2	3	1
	60-69	2	3
	70-79	1	5
	> 80 m2	0	7

4. no. of rooms (excl.kitchen&sanitary serv)		%
	<4 rooms	67
	4 rooms	22
	> 4 rooms	11

5. living pattern	Possibility / type	Number	%
multiple use of house & plot	Farming	0	0
	Small bussiness	0	0
	Shop	0	0
6. facilities	**Availability/type**	Number	%
Cooking facilties	Inside	36	100
Bathing	Inside	36	100
Drainage	Drainage available	36	100
Electricity	grid connection	36	100
Toilet facilities	Flush toilet for excl use of hh	35	
	Pit latrine for excl use of hh	1	
Drinking water	Piped inside the house	36	100
7.Geometry	Type	Number	%
Shape of house	Rectangular	36	100
Shape of roof	Flat	0	0
	Gable	36	100
8. Construction system		number	%
8.1 Site preparations	Removing top soil 0.2 m	36	100
8.2 foundation	Type	number	%
	r.c.strip found. 150-200x 300-400mm	18	50%
	Poles in concr filled holes300x300x800mm	14	39%
	Concr foundation strip 200x300 mm	1	3%
	r.c.strip 300x225mm at 500mm depth	1	3%
	Stone filled trench	2	5%
Foundation depth	Depth	number	%
	< 0.3 m	0	0
	0.3< depth < 0.6m	36	100
	> 0,6m	0	0
Foundation line	Correct straightness	number	%
	in straight line	36	100
8.3 groundfloor		number	%
Level	150mm above plot level	30	83
	>150 mm above plot level	6	17
Leveling groundfloor	36	100	
Type (materialization)	Soil /tamped	0	0
	Stones / gravel / hard core	0	0
	Concrete	36	100
	Timber	0	
Finishing	Screed 25-60mm	36	100
	None	0	0
8.4 main structure	**Type of ext walls & mainframe**	**number**	%
mass production projects	Cblocks	4	24
	Prefa PC	9	53
	Zitro	1	6
	Bamboo	1	6
	Other or mixed	2	11
single unit constr projects	Cblocks	14	74
	Prefa PC	5	26
	Zitro	0	0
	Bamboo	0	0

reinforcement bars	In sand-cement block walls	36	100
no and position reinforcem. Bars	estimated by laborer	0	0
	calculation / or indicated in drawing	36	100
	indicated by general foreman	0	0
	not known	0	0
Exterior wall finishing	**Type**	**No**	**%**
	Cement sand plaster	28	78
	white wash	6	17
	None	2	5
Interior walls/ partitions		**No**	**%**
	concr blocks	9	25
	prefab timber	5	14
	in situ timber partitions	14	39
	prefab bambu partitions	1	3
	none or only for bathroom c blocks	7	19
8.5 Roof construction			
roofing structure	**Type**	**no**	**%**
Timber	rafters & purlins or trusses fixed with iron strips	36	100
Other			n.a.
	Roofing technical details	**no**	**%**
Roof overhang	< 200mm	7	19
	201-400 mm	15	42
	401-600 mm	9	25
	>601 mm	5	14
Roofing finishes	**Type**	**no**	**%**
	thatch organic mat. (grass, leaves)	0	n.a.
	flattened tins	0	na.
	corrugated iron sheets.	36	100
	asbestos sheets	0	n.a.
	ceramic tiles		n.a.
	Other	0	n.a
8.6. openings			
Windows, doors & casements	Timber produced in situ	33	92
	Timber prefab	3	8
	metal	0	0
	Alluminium	0	0
	Plastic	0	0
Casements attachment	Anchored in a regular manner (%)		30
	Incorporated in prefab system (%)		70
Windows (Type)	sheet glass	0	0
	Shutters	0	0
	venetian blinds	18	50
	no glasing	4	11
	wire blinds	14	39
Number of windows	3windows	3	8
	4windows	15	42
	5 windows	6	17
	6windows	3	8
	7windows	9	5
8.7 Physique technical condition (Total building)		**no**	**%**
security against windforces	Good	29	81
	Fair	5	13
	Bad	2	6

security against earthquakes	Good	1	3
	Fair	34	94
	Bad	1	3
fire resistency	Good		0
	Fair	36	100
	Bad		0
Ventilation	Through doors	3	7
	Windows +venetians blinds	30	86
	Windows that can be opened	3	7
	Openings between walls & roof	28	n.a
	no ventilation between walls and roof	6	n.a
	no ceilings		16
rainwater resistency	good	26	72
	fair	10	28
	bad	0	
	reasonable	11	
	no problem	5	
Sound proofness	N.A.		
8.8 production complexity			
simple units to customer´s orders		9	25
units composed of many different products & components ,elements		4	10
complex units comp. of many different prod.&comp & elements.			n.a.
prefab components assembled differently.			n.a.
prefab components assembled similarly		23	65

4.2 PROCESTEC

4.2.1.Technoware

1.1 Owner of tools & equipment	**Type of equipment**		
	Non-electrical hand tools	Powered /electr. tools equipment	Powered tools + control mechan
. household	7%	n.a.	0
contractor	74.5%	56%	0
laborer	18%	29% (incl subcontr & fam)	0
hired	0.5 %	15%	0

1.2Utilization of powered tools / worksection		
Work section	**Powered tools/equipment**	**% available & utilized**
Foundations	Soil compacting machine	33%
	Concrete mixer	93%
	Vibrating needle concrete	27%
Floor beds	Soil compacting machine	100%
	Concrete mixer	100%
	Vibrating needle concrete	40%
Ext. walls	Concrete mixer	73%
Int. walls	Electric saw	27%
Roofs	electric saw	73%
	electric drill	33%
Frames and doors	electric saw	60%
	electric drill	53%
	sanding machine	73%

1.3 Actual utilization of tools & equipment / worksection

Worksection	*Type*	*Description*
Foundation		
1. excavation	T2	concrete mixer 93%
2. backfill sand+hard core	T2	soil compacting machine 33%
3. compacting of soil	T2 + T3 93%	vibrating needle concr 27%
4. preparation of cement	T2 + T3 33%	HANDTOOLS
5 preparation of reinforcem	T2	> 40% triangle, hand saw, chopper, hacksaw, pliers,
6 placing of elements +reinf	T2	hook to bend or tie up steel bar, rammer, sieve
7. casting of concrete	T2	> 60% measuring tape, levelling instrument, hammer, shovel
8. vibrating concrete	T2 + T3 27%	> 80% hose, pickaxe, trowel, wheelbarrow, bucket
Groundfloor		
1 leveling and tamping	T2 +T3 67%	concrete mixer 100%
2 preparation of cement	T3 100%	soil compacting machine 67%
3 casting of concrete	T2	vibrating needle concrete 40%
4. vibrating concrete	T2 + T3 40%	HAND TOOLS
		> 40% broom, shovel, hand saw chisel, stairs hook to bend or tie up steel bars
		> 60% sledgehammer, hammer, sieve
		> 80%meas. tape, pickaxe,trowel,
		levelling instrument, hose, rammer wheelbarrow, bucket
Walls exterior		
PREFA PC		**description**
1 placing of prefab elements	T2	
(length 50-75-...175-200 cm		EQUIPMENT
Width 4cm heighth 50cm)		Concrete mixer 73%
in grooves of prefab reinf concr		
Columns 130x130x3250mm		
2. placing of a timber bondbeam	T2	
3 preparation of cement mortar	T2 +T3 %	
4. filling of the vertical joints between	T2	HANDTOOLS
& horiz. elements with cement mortar		>. 40% hose, sieve, stairs
5 fixation of ringbeam on top of wall	T2	wheelbarrow,
ZITRO		
1. Placing &assembl prefab concr panels	T2	> 80% meas tape, levelling instrument,
2. prepar of cement mortar (210 kg/cm2)	T2 +T3 %	
3. filling the trench with concrete	T2	
4. fixation of ringbeam on top of the wall	T2	
CONCR BLOCKS		
1. Placing of reinf. bars in hollow blocks.	T2	
2. Prepar of mortar (140kg/cm2)	T2 +T3	
3. Casting of cement in hollow blocks	T2	
4. Masonoy with concr blocks	T2	
5. fixation of ringbeam on top of wall	T2	
BAMBU		
1. Placing & assembl prefab bambu frames	T2	
2. Fixation of ringbeam on top 50x75 cm	T2	
3. preparation of cement mortar	T3	
4. finishing walls with cement mortar	T2	

Walls interior(partitions)	Type	Description
Preparation + fixation of partitions	T2 +T3	electric saw 27%
		HANDTOOLS
		bucket, stairs plumb line, triangle, hacksaw measuring tape levelling instrument, hammer

Roofs

1 preparation of timber roofing structure	T2 + T3	electric saw 73%
2. fixation of roofing structure	T2 + T3	electric drill 33%
3. finishing of roof with sheets	T2	HANDTOOLS plumb line, triangle, levelling instr, stairs, meas.tape, hammer, hacksaw
Frames,doors & windows		
1 prepar of frames doors & windows	T2 + T3	electric saw 60%
2. fixation of frames, doors, windows	T2 + T3	electric drill 53%,
3. finishing of frames doors & windows	T2 + T3	sanding machine 73%
		HANDTOOLS
		plumbline, handdrill, spanner/ wrench, screwdriver, firmer chisel, meas.tape levelling instrument, hammer, hacksaw, carpenters brush

4.2.2. Humanware

2.1 Number	X	PC -a	PC..b	CBI.a	CBI.b	Zitro	Bamb	Fupr	IndCB	Ind PC
		n=4	n=4	n=1	n=2	n=1	n=1	n=1	n=7	n=4
Perman proj managers	1.28	7	4	1	2	2	1	1	0	2
Permanent foremen	2.5	8	11	1	11	2	1	1	7	4
Average per project		3.75	3.75	2	6.5	4	2	2		
Average per house		0.04	0.03	0.01	0.04	0.06	0.05	0.01		
Permanent skilled labor	5.29	9	65	0	0	0	-	-		
Temporary skilled labor	16.29	53	23	25	112	15	-	-		
Permanent unskilled labor	7.5	24	81	0	0	0	-	-		
Temporary unskilled labor	26.79	105	85	45	110	30	-	-		
Average per project		47.75	63.5	70	111	45	-	-		
Average per house		0.45	0.47	0.23	0.61	0.65	-	-		

2.2 Experience	X	PC a	PC b	CBI a	CBI b	Zitro	Bam	Fupr	Ind CB	Ind PC
		n=4	n=4	n=1	n=2	n=1	n=1	n=1	n=7	n=4
Project managers	93%	86%	95%	100%	100%	100%	100%	100%		
Foremen	80%	100%	93%	100%	55%	100%	80%	100%		
Skilled laborers	83%	71%	82%	100%	55%	100%	-	-		
Unskilled laborers	4%	41%	33%	100%	27%	70%	-	-		

.3 Education	X	PC a	PC b	CBI a	CBI b	Ziltro	Bam	Fupr	Ind CB	Ind PC
		n=4	n=4	n=1	n=2	n=1	n=1	n=1	n=7	n=4
Project managers										
University	72%	71%	75%	100%	50%	50%	100 %	100%	n.a.	n.a.
Higher education	10%	0%	20%	0%	0%	50%	0%	0%		
Secondary education	18%	29%	5%	0%	50%	0%	0%	0%		
Foremen										
Higher education	20%	38%	0%	0%	0%	100%	100 %	100%		
Secondary education	51%	62%	100%	100%	10%	0%	0%	0%		
Primary school	29%	0%	0%	0%	90%	0%	0%	0%		
Skilled laborers										
Higher education	3%	0%	0%	0%	0%	70%	-	-		
Secondary education	28%	23%	60%	50%	0%	30%	-	-		
Primary school	69%	77%	40%	50%	100%	0%	-	-		
Unskilled laborers										
Secondary education	6%	13%	0%	10%	0%	20%	-	-		
Primary school	71%	56%	58%	90%	100%	80%	-	-		
no finished education	23%	31%	42%	0%	0%	0%	-	-		

GENERAL LABOR CHARACTERISTICS

PM=project manager ; GF = General Forman

SL= Skilled Labor ; UL = Unskilled Labor

	PM	GF	SL	UL
% of total employed labor force	2%	4%	36%	58%
permanent employees	94%	66%	26%	22%
temporary employees	6%	34%	74%	78%
no education	0%	0%	0%	28%
primary education	0%	31%	68%	65%
secondary education	17%	47%	29%	7%
higher education	12%	22%	3%	0%
University	71%	0%	0%	0%
with experience	94%	81%	71%	44%
without experience	6%	19%	29%	56%
understand blueprints	100%	100%	41%	8%

2.5 Problems with skilled & unskilledlabor force	SL	UL
insufficient employees	46%	31%
insufficient skills and knowledge	23%	38%
motivation problems	31%	31%
absent caused by alcohol	69%	69%
absent caused by drug abuse	0	31%

4.2.3 INFOWARE

3.1 Availability of info system		PC a	PC bC	CB a	CB b	Ziltro	Bamb	Fupro
	x	n=4	n=5	n=1	n=2	n=1	n=1	n=1
technical documentation								
construction specifications &procedures	87%	4	4	1	1	1	1	1
norms and regulations	80%	4	4	1	1	1	1	0
documents former projects	60%	3	4	1	0	1	0	0
Planning documentation								
time planning procedures	60%	4	2	0	1	1	1	0
Progress control techniques	87%	4	5	0	1	1	1	1
Machine documentation								
Manuals of machines	73%	3	4	1	1	1	1	0
Specifications of machines	67%	3	3	1	1	1	1	0

.2 Type of info system	doc	com	d&c	none
technical documentation				
construction specific & procedures	55%	15%	15%	15%
norms, regulations	15%	70%	0%	15%
documents former projects	8%	15%	46%	31%
planning documentation				
time planning procedures	15%	23%	23%	39%
progress control techniques	0%	47%	38%	15%
documentation of machines				
manuals of machines	8%	46%	15%	31%
specifications of machines	8%	62%	0%	30%

3 Mater. & equipm database		PC a	PC b	CB a	CB b	Ztro	Bam	Fupr
	x	n=4	n=5	n=1	n=2	n=1	n=1	n=1
material databases								
material information	87%	4	4	1	1	1	1	1
material suppliers	93%	4	5	1	1	1	1	1
equipment databases								
equipment information	87%	4	4	1	1	1	1	1
equipment suppliers	80%	4	3	1	1	1	1	1

.4 Type of database for M&E	doc	com	d&c	none
material databases				
material information	7%	43%	36%	14%
material suppliers	22%	50%	21%	7%
equipment databases				
equipment information	14%	50%	22%	14%
equipment suppliers	21%	43%	14%	22%

4.2.4.ORGAWARE

4.1 Location of organization	
1. country	Costa Rica
2. province / department	San Jose , Cartago
3. *region*	Central Valley

4.2 Origin of the organization	
a. local	15
b. foreign	0
c. partly local, partly foreign	0

4.3 Type of business	
a. international, foreign owned, joint venture	0
b. conventional large scale private organization	0
c. parastatal	0
d. conventional local medium & small scale private organization	15
e. cooperations /self help organization	0
f. monetary traditional tradesman & fungi (informal sector)	0
g. subsistence ; households & do-it-yourself owners of bldgs	0

4.4 **Company size** (permanent workers)

		Prefa	CB	Zitro	Bam	Fuprovi
< 10 employees	33%	2	0	1	1	1
10<employees<15	20%	1	1	0	1	0
15< employees < 25	7%	0	1	0	0	0
25< employees < 35	7 %	0	1	0	0	0
35< em;oyees < 50	13 %	1	0	0	0	0
> 50 employees	20 %	0	2	0	0	0
4.5 Company specialization		PC	CB	Zitro	Bam	Fupr
Low-income housing	27%	1	1	0	0	0
Low-, middle- & high class	7%	0	1	0	0	0
Civil engin work	20%	1	0	0	2	0
All round	47%	2	3	1	0	1
4.6 Experience		PC	CB	Zitro	Bam	Fupr
with low income housing projects		n=4	n=4	n=2	n=1	n=1
no experience	0%	0	0	0	0	0
< 10 projects	64%	3	3	0	1	1
10< no. projects < 20	21%	1	0	2	0	0
> 20 projects	14%	0	1	0	0	0

4.7 Business objectives	
a. expansion	10%
b. stay ahead of competition	2%
c. create employment	14%
d. make profit	20%
e. improve quality	24%
f. contribute to national development	30%

4.8 Competition by other contractors	
0 yes	15
0 no	0

Competition experienced on			Type of competitor	
Price	quality	knowhow/ experience		
21%	47%.	42%.	Large scale	35%
42%	38%.	35%.	Medium scale	39%
37%	15%	23%	Small scale	26%

4.9 centralization (up-down directing procedures information after decisions)

		PC	CB	Zitro	Bam	Fupr
verbal	93%	4	4	1	1	1
notice board	7%	1	0	0	0	0
personnel letter	13%	1	1	0	0	0

4.10 formalization

Handling/directing on site	problems	complaints	information	written	Verbal
	verbal	verbal	operating instructions	80%	20%
	written/verbal	verbal	job descriptions	95%	5%
	verbal	verbal	working schedules	95%	5%
	verbal	verbal	other	100%	0

EMPLOYMENT SELECTION		PC	CB	Zitro	Bam	Fupr
Project manager and foremen						
standard application forms	14%	1	0	0	1	0
school/study certificates	64%	3	2	1	1	1
personnel	71%	3	3	1	1	1
review social backgrounds	7%	1	0	0	0	0
interview by superior	50%	2	2	1	1	0
standardised tests	14%	1	0	0	0	1
practice testing on the job	57%	3	4	1	0	0
Skilled and unskilled laborers						
standard application forms	0%	0	0	0	0	0
school/study certificates	0%	0	0	0	0	0
personnel	57%	4	3	0	1	0
review social backgrounds	7%	1	0	0	0	0
interview by superior	7%	0	1	0	0	0
Standardised tests	0%	0	0	0	0	0
practice testing on the job	64%	4	3	1	1	0

4.11 Regulation and control

Quality control materials

Visual on site	simple instrum on site	complex instr in lab
Prefab concrete elements, wood	20%	20%
All materials	No	no
Timber, blocks, bamboo cement, tubes	10%	10%
Sand, stones	No	no
Concr. Blocks, in-situ concr, concr elements	20%	60%
Final quality control		
visual on site	simple instrum on site	complex instr in lab
ext. & int. walls, roofs, ext. & int. walls finishings	17%	no
Frames, windows, doors	8%	no
Floorbeds, foundations	50%	no
all materials	No	no

Safety precautions	Helmets	Safety shoes	Eye protection	Ear protection
No	59%	65%	23%	71%
During concrete casting	12%	12%		
During welding & drilling	n.a.	5%	65%	29%
During carpentry	n.a.	0	12%	
In general	29%	18%		

Site protection	***Stealing of materials and equipment***	
security guard 88%	materials	Equipment
	no 23%	58%
	Often , more than once 77%	often more than once 42%

4:12 Technology development orientation

Training facilities	Project manager and foremen		Skilled and unskilled laborers	
	on the job	40%	on the job	53%
	Else during work-time	27%	else during work-time	13%
	Else in free-time paid	13%	else in free-time (paid)	0%
	Else in free-time not paid	13%	else in free-time (not paid)	0%

Research activities	
full time	13 %
half time	13 %
at random	20 %
None	53%

4.13 External relations	informal	formal	none
Camera Costarr de	25%	50%	25%
Trade association	12%	35%	53%
Chamber of commerce	8%	23%	69%
Employer's organisation	0%	8%	92%
Management association	15%	15%	70%
Educational association	15%	8%	77%
Research association	15%	8%	77%
University or higher educ.	23%	23%	54%
Government	19%	42%	39%
Technical consultants	15%	39%	46%

Reason to rent equipment	
less costs, uncertainty with regard to continuous use of equipment	78%
nothing rented	22%

Subcontracting		reasons subcontracting	
jobs subcontractors		insufficient knowledge	18%
roof	6%	production capacity	25%
ext wall finishings	6%	financial profits	52%
int walls , partitions	12%	none	25%
windows, doors & frames	6%		
foundations, civil engin.	24%		

4.14 Communication & administration equipment on site	
Telephone	88%
Computer	23%

Material Inputs

Mass construction projects	Prefa PC		Zitro	Concrete blocks		Bamboo
	A n=4	B n=5	n=1	A n=1	B n=2	n=1
Foundations	4 cast in-situ	5 cast in-situ	cast in-situ	cast in-situ	2 cast in-situ	cast in-situ
Floor beds	4 cast in-situ	5 cast in-situ	cast in-situ	cast in-situ	2 cast in-situ	cast in-situ
External walls	4 prefab elements	5 prefab elements	prefab elements	in-situ blockwork masonoy	2 in-situ blockwork masonoy	in situ blocks + prefab bamboo
Internal walls	3. in-situ timber	5 in-situ timber	prefab elements	in-situ blockwork masonoy	2 in-situ blockwork masonry	prefab bamboo
	1 concrete blocks			in-situ timber	2 in-situ timber	in-situ timber
Roofs	3 in-situ timber	5 in-situ timber	5 in-situ timber	in-situ timber	2 in-situ timber	in-situ timber
	1 in-situ steel					
Frames and doors	4 prefab timber	5 in-situ timber	prefab timber			

Inputs/no houses	prefa A: 421	prefa B: 706	Zitro: 66	CB-A : 300	CB-B: 366	Bambu: 40
Foundations	100% II	100% II	100% II	100% II		100% II
Floor beds	100% II	100% II	100% II	100% II	100% II	100% II
External walls	100% III	100% III	100% III	100% II	100% II	20% II + 80% III
Internal walls	100% II	100% II	100% III	100% II	100% II	100% III
Roofs	100% II	100% II	100% II	100% II	100% II	100% II
Frames and doors	100% III	100% II	100% II	100% II	100% II	100% II

Single dwelling construction projects	Prefa PC (n=4)		Concrete blocks N=7	
Foundations	4 cast in situ concrete II		7 cast in situ	100% insitu
Floor beds	4 cast in situ concrete II		7 cast in situ concrete	100% insitu
External walls	4 prefa PC III		7 concrete blocks	64% insitu
Internal walls	2 in situ timber II		7 concrete blocks	100% insitu
	2 concrete blocks II			100% in situ
Roofs	4 in situ timber II		7 in situ timber	
Frames and doors	4 in situ timber II		7 in situ timber	100% insitu
Single unit constr proj	6% prefab		94% in situ	
Mass prod projects	per 1899 houses		per project	
Foundations	100% insitu		100% in situ	
Floor beds	100% in situ		100% in situ	
External walls	35% insitu	65% prefab	21% insitu	79% prefab
Internal walls	94% insitu	6% prefab	14%insitu	86%prefab
Roofs	100% insitu			
Frames and doors	78% insitu	22% prefab	72% insitu	28% prefab

2. availability and quality of material inputs

availability	low 40%	normal 60%	high 0
quality	low 53%	reasonable 40%	high 7%

APPENDIX III-5

Technological production performance

5.1 Product technological features of the production output

Functionality	availability of facilities	water	100
		electricity	100
		toilet	100
	multiple usability	farming, shop, workshop	0
Site preparation	clearing and removal of top soil		100
	levelling		100
	drainage		100
	access roads for users and for emergency vehicles.		60
Foundation	Foundation trenches straight		90
	Foundation wall durable material 150mm above ground level.		100
	Poles (prefa PC & Zitro) positioned straight .		100
Floor	hard and smooth surface, easy to clean		100
	the floor level at least 150mm above the outside groundlevel.		100
Walls	withstand their own weight and all applied loads without harmfull deformations		4
	rain-proof (resist penetration of rainwater)		90
	no water and vapour should raise from the ground through the walls		95
	permanent construction/ >25 years, with reasonable maintenance.		100
	low thermal storage capacity preferably coated with reflective, light coloured coating.		100
Roofs	rain and water proof.		100
	Light weight material,		100
	reflective or with high insulation values.		0
	preferably with slopes		100
	withstand its own weight without harmfull deformations .		100
	wind proof ,(properly anchored)		100
	sustain a point load of 100 kg (maintenance).		100
	overhang of at least 500 - 600 mm.		90
	the space under the roof shall be well ventilated		90
Opening	proper number and positioning		100

5.2 Process tech components	assessment criteria		Score
Technoware Major features of the tools and equipment	1. Handtools 75% 2. Tool with non-human energy source 25% 3. Tool with non-human energy source & control 0%		3.75
Humanware Major features of the labourforce	1.Education level 2. Experience	4.77 7.7	6.2
Infoware Major features of info &doc	1. Availability 6.96 2. Retrievability (Type of info carrier) 5.25		6.1
Orgaware Major features of the organiz framework	a..Configuration b.Centralization c.Formalization d.Specialization e.Bussiness orientation R&D, training f.External relations	3.75 6 4.0 6 5.85 4,5 4,5	4.8

5.3 Input scores main structure

	raw materials Score .2	bldng materials Score 4	components Score 6	elements Score 8	building Score 10
Nature Found. + floors Walls roofs frames, doors & windows	In situ	In situ cement blocks timber rafters, purlins tiles 79%	Prefab wall panel elements frames, doors& windows trusses 21%	Prefab -	-
Availability	Low 40% normal 60% high -				
Quality	bad 53% reasonable 40% good 7%				

APPENDIX III-6

The construction industry

6.1 Initiating actors and investors in dwelling construction projects in Costa Rica

Actor	Activities
Public sector: national government and its agencies	Instituto Nacional de Vivienda y Urbanismo (INVU) and the Instituto Mixto de Sayunda Social (IMAS), which take the project management role. Through a formal bidding procedure the construction company with the best bid is selected for the project execution.
non governmental organizations	Fundacion de Bambu The projects involve in general series of houses in a certain area.
private organizations and contractors	Also built houses in series like the above mentioned organizations. In most cases the houses built by a contractor or real estate organization are built to be sold on the housing market.
private households	Construct their own house, which is most common in Costa Rica. The financing of these projects can take place with subsidies from the national housing financing system (SFNV), with mortgages from the mutuales (cooperative mortgage banks) or with private funds.

6.2 Dwelling construction project teams

team composition	activities in project
houseowner + hired labour (self-help) The execution of the dwelling constr. projects takes place in various forms of collabor. between the house owner and different actors	a. houseowner takes care for the project management: purchases the building materials, organizes the construction process and hires labour force for certain jobs. b. the houseowner purchases the building materials and leaves the project management and execution of the job to a contractor.
houseowner + contractor	House owner purchases the building materials and leaves the project management and execution of the job to a contractor
contractor	House owner leaves the responsibility for the whole project to a contractor from design and engineering to the finalization of the construction process.
consultants + contractor	House owner engages a professional, engineer or architect responsible for the design, engineering, the project management and supervision of the construction project that is then executed by a contractor.

6.3 Construction in the national economy Source: MIDEC 1996

	1990	1991	1992	1993	1994	1995
GDP million US$ (current)		5637	6721	7577,3	7945,9	8557,9
av annual GDP growth		2,27	7,73	6,34	4,51	2,55
GDP in millions of const. colónes 1966	12244	12521	13489	14239	14991	15374
Growth of GDP 1990-1995	3.6%	2.3%	7.7%	6.3%	4.5%	2.5%
inflation	27.3	25,3	17	9,1	19,9	22,6
exchange rate	102.3	134,7	137,1	150,7	164,4	193,9
Construction % GDP (const value 1966)	1990	1991	1992	1993	1994	1995
Construction	4.1%	3.7%	3.5%	3.8%	3.9%	3.3%
Growth construction GDP %	- 2.3%	-7.5%	2.6%	16.5%	6.2%	-12%

6.4 Contribution of the construction industry to GFCF
Source: Banco Central de Costa Rica 1993

year	GFCF	GFCF by Construction	% of total GFCF
1982	1,314.9	712.4	54.2
1983	1,369.7	698.6	51.0
1984	1,795.1	892.3	49.7
1985	1,891.6	929.4	49.1
1986	2,115.7	964.2	45.6
1987	2.336.2	929.5	41.0
1988	2,249.0	974.2	43.3
1989	2,595.6	1,082.1	41.7
1990	2,972.2	1,052.6	35.4
1991	2,500.7	925.2	37.0

6.5 Output of the construction industry m2/marketsegment 1990-1996

	1990	1991	1992	1993	1994	1995	1996	average
total m2	1,613,324	1,525,737	1,461,735	1,946,188	2,049,387	1,549,776	1,482,791	1,661,277
Housing	1,131,078	1,219,654	1.027,445	1,303,721	1,352,079	1,120,051	1,118,075	71%
Commercial	275,741	177,486	233,263	435,216	471,690	230,635	216,937	17%
Industry	146,184	90,306	143,416	134,552	141,311	148,790	85,419	8%
Other	60,321	38,291	57,611	72,699	84,307	50,300	62,360	4%

fig 6.2 Nr of houses < 70 m2 constructed/year

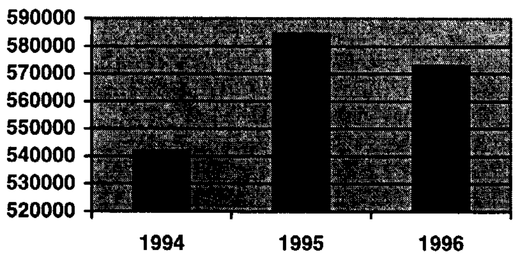


fig 6.3 Type of output (% of total output)

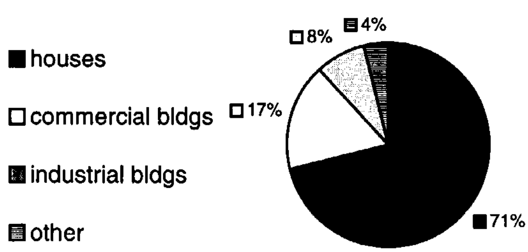


Table 6.6 Employment in the construction industry
Sources: Min de Trabajo Banco central de Costa Rica, Min de Planificacion Nacional

Year	Labor force	Construction labor force	% of total labor force
1980	767,120	52,445	6.8
1981	808,763	44,506	5.5
1982	759,879	43,308	5.7
1983	767,596	39,178	5.1
1984	793,500	40,917	5.2
1985	826,698	42,018	5.1
1986	854,218	49,393	5.8
1987	923,310	54,475	5.9
1988	951,190	55,979	5.9
1989	986,840	60,736	6.2
1990	1,017,151	65,970	6.5
1991	1,006,646	63,431	6.3
1992	1,042,957	61,354	5.9

Table 6.7 Wall construction systems and mjor materials applied in dwelling construction
Source: Wall construction systems and mjor materials applied in dwelling construction

* first semester

	1990	1991	1992	1993	1994	1995*
Total	12.734	13.413	12.396	16.111	16.750	9.483
Timber	283	202	140	1.098	462	225
Blocks or concrete	11.978	12.648	11.487	14.291	14.400	7.654
Rocalo	435	516	744	316	670	287
Asbest	23	36	17	110	246	217
Masonry	7	5	4	16	6	17
Metal	7	2	4	11	30	48
Other	1	4	_	269	936	1.035

fig 6.8 Floor Construction systems and major materials applied in houses
source: Ministerio de Economia, Industria y Comercio, Direccion General de Estadisticas y Censos

* primer semester	1990	1991	1992	1993	1994	1995*
Total	12.734	13.413	12.396	16.111	16.750	9.483
Timber	256	191	142	527	1.112	1.057
Floor tiles	4.691	3.660	3.858	3.765	3.019	1.358
Concrete	7.381	9.081	7.938	11.373	11.494	6.424
Small mosaic tiles	399	478	456	425	1.052	604
Synthetics	1	1	_	_	1	_
Soil	5	2	2	1	11	3
Other	1	_	_	20	61	37

Table 6.9 Materials applied for roof finishing (%)
Source: CONSTRUDATA - DME 1998

	corrug iron sheets		Fibrocment		roofing tiles		other	
	> 50m2	<50m2	> 50m2	<50m2	>50m2	<50m2	>50m2	<50m2
1987	86%	88%	5%	2%	0	6	9	4
1988	90	90	1	1	7	6	2	3
1989	90	90	1	1	7	2	2	7
1990	98	98	0	0	2	2	0	0
1991	98	98	0	0	2	2	0	0

Table 6.10 Imports of construction materials (%) of total imports.
source: Ministerio de Economia, Industria y Comercio, Direccion General de Estadisticas y Censos

	1990	1991	1992	1993	1994	1995
Value of Imports CIF [mill US$]	**1.989,7**	**1.876,6**	**2.440,0**	**2.884,7**	**3.024,8**	**3.273,7**
Construction naterials	63,7	73,2	85,4	92,3	117,9	
Primary goods*	1.045,3	1.033,7	1.217,6	1.325,9	1.507,0	_
Capital goods	467,5	394,4	555,0	721,4	621,0	_
Consumer products*	476,9	448,5	667,4	837,4	896,8	_
Construction materials[%]	3,2	3,9	3,5	3,2	3,9	_

6.11 The national administrations during the past decennia in Costa Rica

Period	President	Political party
1978-1982	Rodrigo Carazo O.	PUSC
1982-1986	Luis Alberto Monge Á.	PLN
1986-1990	Oscar Arias S.	PLN
1990-1994	Rafael Ángel Calderon F.	PUSC
1994-1998	José María Figueres O.	PLN

APPENDIX III-7

The national setting in Costa Rica

1. Geography	Source: INICEM-Market data, San Jose CR, Miami USA, 1994	
1.1 location	Central America	
latitude	10• North Latitude	
longitude	84• 15' 11" West Longitude	
borderlines km	Nicaragua: 309 km	Panama: 330 km
coastline km	1,290 km	
1.2altitudes	location	m above sealevel
major cities	San Jose Alajuela Cartago Heredia Liberia Puntarenas Limon	1.150m 952m 1.435m 1.150m 144m 4m 3m
highest point	Cerro Chirripo Grande	3.839 m
lowest point	Limon	3m
1.3 climate	**location**	**type**
a. hot and dry lowlands	Prov Guanacaste, parts of Puntarenas, av 4-150m above sea level	*av temp*: relatively high. av 26-29 C *rainfall:* av. 1.500 mm/yr relatively scarce very long dry season
b. warm and humid wet lowlands	Caribean and S-Pacific wet lowlands, av. 3m above sea level	av temp: relatively high and tropical 29C *rainfall:* av. 3.000-3.500mm/yr; increases inland, short dry season.
c. temperate	areas between 800 and 1500 m above sea-level (Central Valley)	av temp: 20 °C daily, max temp 24.9 C, min temp 16.3 C rainfall: 1.500-2.000 mm/yr; dry season december - april
d. mountain	over 1500m of altitude	av temp: daily 21 C, with cool and chilly evenings. rainfall: av. 1500 mm/yr; over 3000m of altitude the areas are often rather humid and misty
1.4natural disasters	**occurence**	
earthquakes	frequent	
volcanoes	Irazu Turrialba Barva Poas Arenal	3.432m 3.339m 2.906m 2.709m 1.633m
hurricanes	Regular	last one: Juan 1995
landslides	During heavy rains	

2. history:

colonalization	1502 - 1821	country: Spain
independence date	1821	

1502	**Discovered by Colombus during his fourth trip to the west.**
1560	Philip II ordered to christianize the native people, living scattered all over the country. Many of them died due to epidemics brought in by Europeans. Nowadays not many left
1562	Juan Vasquez de Coronado first governor of CR a peripherical region of the Spanish empire of Guatemala. A region with not very much more than forests.
1739	Foundation of San Jose as small village, Cartago was capital in colonial time
1821	Independent. Little immediate effects. The country had not received much attention nor governance from the Spanish during the colonial era. Four major towns of the Valle Central took over political power: Cartago, San Jose, Heredia, Alajuela disagreeing on forming the nation of Costa Rica.
1823	Short civil war won by the republican forces of San Jose. E stablishm of autonomous republic of Costa Rica within the framework of the Central American Federation.
1840	Emerge of Coffee cultivation, industry and trade organized by British and German traders. Coffee production more and more the main force behind the economy.
1870	Construction of Atlantic railroad, financed by foreign sources (British) important for coffee and later banana trade. Liberal political orientation.
1885	Start production of bananas. Emerge of Costa Rican proletatirat due to introduction of foreign capital and structures (British, German, Norht American)
1910	Constr. of pacific railroad financed by North American United Fruit Company (vast imperium all over central and south America, absol control & very influencial during the first half of 20th century.
1914	Change of political orientation: state intervention in the economy for reasons of social benefit, leading to regulations on land property and taxes on land property (1916) , custom taxes, and rent (1949) based on rejection of foreign companies to use Costa Rican sources to take profits to their home countries. Start of migrating from Central Valley to other parts of the country.
1920	Start of establishment of social institutions : Labour syndicates 1920.
1943	Formulation of Social Legalisation System (Calderon Guardia administr.): min. salary, max working day (8 hrs). Soc. Security Insurance system for professional risks, illness,old age mothern, invalidity, etc. Coop. for inexpensive housing for low income fam. in urban areas.
1948	Disputed elections leading to short civil war. Ended by political revolution and forming of Social democratic party (PLN) and a provisional government under Jose Ferrer.
1949	Abolishment of the army. Start changes in economic structure from agro exporting to industrialization and devt of a tertiary urban sector. CRica moved from a five party political scene (including a communists party), towards a two party PUSC (Soc Christian Unity Party) and PLN (Nat. Liberation Party) competing on the basis of similar economic politics.
1979	Influx of many refugees from neighbouring countries Nicaragua
1987	Initiation of C-American peace plan by President Arias.(PLN) PLN held power 1982-1992.
1994	Elections were won by Jose Maria Figueres of PLN.

Box 7.1 Some historic aspects of Costa Rica

Costa Rica was sparsely populated and a relative backwater in the pre-Columbian era some 10.000 years ago. At the time that Columbus arrived on September 18, 1502 probably no more than 20,000 indigenous inhabitants lived in several autonomous tribes, all with distinct cultures and customs. Costa Rica was colonized from 1562 until 1823 by the Spanish, who established Cartago as capital and started cultivating wheat, tobacco and coffee for exports. The colonists were forced to work on the land themselves. They had no local Indian labor force due to the death of many of the indigenous population caused by diseases brought in by the colonists. Central America already gained independence in 1821. This independence was the cause of a brief civil war about leadership between the leaders in San Jose and their rivals in Cartago and Heredia, which was won by San Jose in 1823 and Costa Rica joined the confederation of Central American States. After that time Costa Rica developed under progressive administrations towards a middle income country with a relative high degree of social services thanks to investments in public education and health services, enhanced land reforms, public works and the development of infrastructure (railways at the end of the nineteenth century), the establishment of guaranteed minimum wages (during the Calderon administration 1940-1948) all based on the taxes of the coffee earnings. In 1948 after another short fourty days civil war political reforms were introduced, the Communist Party was banned, the armed forces were abolished and national banks and insurance companies were nationalized

3. Government & politics

3.1 General data

Official country name	Republic of Costa Rica			capital : San Jose
Type	democratic republic			
Consitution	1949			
Executive branch	Chief of state			president 4-yrs term
Political parties	Partido Liberacion Nacional (PLN) Partido de union Soc. Cristiana (PUSC) and other			
Legislative branch	unicameral			legislative assembly
3.2adminstr. divisions	**provinces (7)**	**landarea km2**	**% total km2**	**% popul**
	San Jose	4959	10	36,5
	Alajuela	9753	19	17,5
	Cartago	3125	6	11,5
	Heredia	2657	5	10,5
	GUanecaste	10141	20	9,5
	Puntarenas	11277	22	8
	Limon	9188	18	6,5
3.3political orientation	**socio-democratic**		**PUSC**	
	republican	PLN		
	other: small parties			

3.4political stability

Changes in political orient.	every four year elections won alternatively by PLN or PUSC
Coups	civil war 1948

4. economic setting Source: INICEM Market Data San Jose, CR; Miami USA, 1994					
4.1 Basic data	*1991*	*1992*	*1993*	*1994*	*1995*
GDP million US$ (current)	5636.7	6721.3	7577.3	7945.86	8557.9
Av annual GDP growth	2.27	7.73	6.34	4.51	2.55
GDP/cap US$ (current)	1765	2057	2,116	2,343	-
Inflation	25.3	17	9.1	19.9	22.6
Exchange rate	134.7	137.1	150.7	164.4	193.9
4.2 production structure (% GDP)	**1992**		**1993**		
Industry	16.3%		15.3%		
(incl mining)	20.5%		19.4%		
Construction	2.6%		2.5%		
Services*	27.4%		29.2%		
Government	13.2%		13.8%		
Financial services	7.7%		8.3%		
other services	6.5%		7.1%		

4.3 Employment per sector

Source: Min de trabajo y seguridad soc, Dir general de planificacion del trabajo, 1994

(000s)	1990	1991	1992	1993	1994
T. Total employment	1017.2	1006.7	1043	1096.4	1137.6
1. Agric, fishing, hunting	263.7	256.4	251.2	247	243.6
2. Mining and quarrying	1.6	1.5	1.5	1.6	2.1
3. Manufacturing	183	188.7	197.2	196.8	203.5
4. Electricity, gas, water	12.5	11.4	13	15.9	16.8
5. Construction	66	63.4	61.4	67.4	74.6
6. Trade, restaurants &hotels	159.2	156.9	172.7	194.5	209.7
7. Transport & communic.	40.1	43.7	48.8	52	58.4
8. Finance, insurance, real estate, business services	33.88	36.79	37.74	46.56	50.61
9. Community, soc & personal services	249.8	238.7	250.9	260.3	268
10. Not adequately defined	7.5	9.3	8.7	13.6	10.4

4.4 International trade (mill US$ current 1991-1993)		Source: MIDEPLAN, 1994	
	1991	1992	1993
Exports (FOB)	1597.7	1828.9	2063.5
- Coffee	263.6	202.7	203.5
- Bananas	369.6	485.3	526.5
- Sugar	24.7	27.0	27.3
- Meat	69.3	44.2	68.7
- Other	843.5	1074.6	1120.0
Exports			
- Non traditional	728.9	900.6	1133.6
- Agric exports	167.5	194.3	262.0
- Agro-ind exp	52.8	94.0	127.5
- Manuf exp	508.6	612.2	742.8
Imports (CIF)	1852.0	2440.0	2872.0
Primary goods	1026.0	1218.0	1330.0
- Agricultural	97.0	111.0	120.0
- Industrial	651.0	861.0	950.0
- Construction materials	73.0	86.0	90.0
- Fuels	205.0	160.0	170.0
Consumer goods	421.0	657.0	810.0
Capital goods	390.0	555.0	717.0
- Agriculture	13.0	12.0	17.0
- Industry	279.0	394.0	480.0
- Transport	98.0	149.0	220.0
Diverse other	15.0	11.0	15.0

Trade balance		- 75.1		- 394.5	- 530.0
% GDP		1.3 %		5.9 %	7.0 %
External debt (mill.US$)	**1988**	**1989**	**1990**	**1991**	**1993**
Source: WB & IMF 1995	4543,8	4603,2	3772,0	3966,2	2080,0

Box 2 Trade balance in Costa Rica

More than before the Costa Rican government follows a liberal market economy, which facilitates the imports of all kinds of products. The locally produced products on the other hand are less protected, local enterprises experience a great deal of competition of the imported products. The total of imports increased with 17% in 1993 compared to the year before, to 44.5% of GDP. Average annual growth of imports in the period of 1981-1993 has been 5.6%. This deficit problem gave rise to government interventions on trade like the regulations on the imports of diary products. The deficit figures showed a decrease to US$ 931.100 *in 1994 and* US$ 734.300 *in 1995. The export of traditional products* – coffee and bananas- increased, while the export of non-traditional products to diversify the range of export products and to decrease the dependency on the international market dynamics has also been stimulated. Since the last decennium an increased percentage of income is generated by tourism

Box 3 Backgrounds of the international economic dependence situation

The present economic situation finds its roots in the past. The welfare state established in the 1960s and 1970s was financed largely through foreign loans, and the implementation of the industrialization policies during the same period were financed mainly by foreign investments. Next to this the expansion of the state apparatus in the past caused huge foreign debts, which situation exploded in the *late seventies, resulting in the debt crisis of 1980 - in Costa Rica. Between 1981 and 1984* the U.S.A. and the IMF injected $3 billion, equivalent to 10% of the nation's GNP of that period. International aid in terms of long term net resource flows to Costa Rica in 1993 has been 2.01 % of GDP. The total amount of resources was US$ 152 millions of which US$ 218. million are for the account of private capital flows, which is 3.1% of GDP. It has been impossible to meet any of the IMF goals, although government expenditures were cut. This became visible in the fact that financial resources available for substancial improvements in the social services sector such as education, health and housing shrinked more and more. State owned enterprises were sold, elements of the social welfare institutions were dismantled - as are subsidies and tax exemptions. Social protests increased for example with regard to the educational system and the high prices *citizens have to pay.* (Baker 1994, p.73-80).

4.6 Income distribution a. Abs. nr & b. % Source: MIDEPLAN 1994

	1987	1988	1989	1990	1991	1992	1993
All households	a.56,8520 b. 100%	a.587.143 b. 100%	a 612.795 b. 100%	a634.314 b. 100%	a 648.222 b. 100%	a 673.882 b. 100%	a 698.753 b. 100%
nr of lower inc. househ	a.200,877 b. 44.2%	a.223,042 b. 45.6%	a 205,710 b. 43.5%	a.216,204 b. 42,9%	a 245.649 b. 48.1%	a 251,493 b. 44.8%	a 215,137 b. 38.6%
total nr of middle & higher income	a. 253,67 b. 55,8%	a. 66,470 b. 54.4%	a. 67,162 b. 56.5%	a. 87,681 b. 57.1%	a.265.017 b. 51.9%	a.310,156 b. 55.2%	a. 41,864 b. 61.4%
2ndquintile of income	a. 36,016 b. 29.9%	a. 152,639 b. 31,2%	a. 146,133 b. 30.9%	a. 154,258 b. 30,6%	a. 152,639 b. 29.9%	a. 168,768 b. 30%	a. 171,170 b. 30.7%
3rd quintile of income	a. 58,096 b. 12,8%	a. 53,742 b. 11%	a. 57,936 b. 12.3%	a. 66,059 b. 13,1%	a. 53,742 b. 10.5%	a. 72,298 b. 12.9%	a. 78,006 b. 14.0%
4rd quintile of income	a. 23,819 b. 5,2%	a. 26, 538 b. 5,4%	a. 26,341 b. 5.6%	a. 27,631 b. 5.5%	a. 26.538 b. 5.2%	a. 31,419 b. 5.6%	a. 37,176 b. 6.7%
5th quintile income	a. 35,936 b. 7.9%	a. 32,098 b. 6.6%	a. 36,752 b. 7.8%	A 40,003 b. 7.9%	a. 32,098 b. 6.3%	a. 37,671 b. 6.7%	a. 55.512 b. 10.0%

5. Education	Source: Unesco's statistics on education 1995 on www		
5.1 Literacy	94.8% tot. pop.	94.7 % male pop	95% female pop.
5.2nr of stud/100,000 pop	2767		
5.3public exp on educ.	4.6% of GDP		
5.4Enrollment Note: Including private schools and Technical colleges. Source: División de Planeamiento, Ministerio de Educación Pública, febrero 1995			
	1994	1995	Increase
Pre school	62692	69000	10.0 %
Primary school	495079	507370	12.3 %
Secondary school	196553	20724	5.4 %
Special Education	11727	13440	14.6 %
Evening classes	1966	1950	-0.4 %
TOTAL	768017	789985	4.04 %

5.5Education system in Costa Rica	
1-6• grado	Primary school, obligatory and free of charge
7-9 grado	Secondary or basic school, not obligatory but cheap.
10-11 grade	Colegio Académico
10-12 grade	Colegio Profesional or técnico
University	Bachillerato and Licenciatura
Institutions for courses:	Basic technical education
Instituto Nacional de Aprendizaje (INA)	
Colleges for Vocational training	Basic techn educ, medium level techn. educ and Acad Bachalaureat

Box 7.4 Problems in the education system

The education system at present has to deal with numerous problems like a lack of education material, a severe shortage of qualified teaching staff, out-dated learning methods, remote rural schools which are often difficult to reach in the best of weather. Costa Rica is faced with 13,3% (24.929) of student drop-outs at the secondary education level and 3,2% of the children at the primary school level, caused by learning problems or for reasons of income earning necessities. (La Nació, 28 febrero 1995). To change this situation in 1992 a programme for the improvement of the quality of the Basic education (PROMECE) was launched as well as a program named "Bono Escolar" to support the lower income families to purchase school uniforms, shoes and school supplies.(MIDEPLAN, Panorama 1993, abril 1994). Next to this a new plan for adult education was approved, with the objectives (1) to offer the opportunity to adults to obtain a bachillerato at three levels and (2)to put the students in touch with courses that can give them prospects which they had not considered in their first option.

6. health Indicators Source: Bread for the WorldInstitute 1994 in Lara S. 1995	
Life expectancy	76 yrs
Infant mortality / 1000 life births	14
Fertility rate (no children/women)	3.2
Daily caloric supply (% of total requirements)	121%
% of one-year old children fully immunized	93%
Physicians per 10,000 people	12.5
Access top safe water	94%
Access to health,sewage and sanitation services	97%
Public health expenditure (% GDP)	3%

7. Land & natural resources

7.1 land

Land area (mill hectares) 5.1

Landuse	arable	meadows	perm crops	forests	Other
% total landarea	6%	45%	7%	34%	8%

Box 5 On the natural resources in Costa Rica

Water is actually the only natural resource that is abundantly available and which allows the production of hydro electric power. An extensive power generation, transmission and distribution network provides relatively inexpensive electricity. The frequent occurrence of earthquakes in the country forms a constraining factor for further exploitation of this source of energy. The search for oil -in particular by Mexican companies like PEMEX- have not been successful so far. Through open cast mining brown coal (lignite) is extracted as alternative energy source, but it does not render much consolation to meet the energy demand. This is why Costa Rica relies on imports of oil from Venezuela and Mexico. Ellenberg,L Bergemann, A. 1990) The occurrence of some minerals like copper, zinc, lead, mangan, and sulfur is known, but a concentrated extraction of these is not feasible so far. Sand, aggregates and limestone for the construction industry are extracted in limited amounts. Costa Rica has large bauxite deposits at Boruca that are exploited currently, facilitating alluminium melting as an important industry. Compared to the resources in other Latin American countries the gold- and silver mining output of Costa Rica has always been very moderate and therefor did not receive too much attention of the international community. he forestry resources deteriorated significantly in particular due to the stimulation of the extensive cattle stock farming in rather hugh forest area. In the beginning of this century over 90% of Costa Rica was covered with forests. Forestry areas diminished from 78% to 29% of the total land area in the period between 1950 and 1987. In view of the pattern of consumption of timber and the rate of deforestation and the Government declared an emergency situation concerning the forestry activities were started ,which resulted in the establishment of some 28.427 ha new plantations between 1986 and 1989. (Ministerio de Recursos Naturales, Energia y Minas.1990) Additionally simultaneous efforts took place to find – on an integrated manner – solutions for deforestation and at the same time for a number of other problems like unemployment, poverty and a housing deficit. These resulted in the establishment of a program for the cultivation and propagation of 500 ha of bamboo Guadua (Guadua Angustifolia). The plantations were proposed to be located on strategic sites of the country with the necessary agro-ecological conditions to supply the required material for different construction sites. Until that time the bambu Guadua was only growing in very limited quantities. This specimen is considered rather valuable because of its strength, thickness (18cm), length, straightness. Other bamboo types like the Vulgaris were already available in the country.

7.2 natural resources

Source. UNDP Human Development Report 1992

Natural resources	Costa Rica
a. Internal renewable water resources /cap (1,000 m3/year 1990)	31.5
b. Forest area % total land area 1990	35
Arable land	6
Other	59
c. Annual rate of deforestation % '80-90	6.9%
d. Annual % change of prod. of fuel wood	3.2%
e. Commerc. Energy consump /cap(kg oil equivalent) 1965 -1989	267-614
f. Annual % of change energy consump. % 1980-1989	3.1%
g. Commerc. Energy consumed in kg of oil equival per $100 GDP 1965-89	67 - 35
h. Annual rate of change energy consump. % 1965-1989	-2.6%
i. Green House index (carbon heating equival. in metric tons/cap 1988-89	4.1

7.3 Mineral resources Source: Dorgan, C.A. Gale country &world rankings reporter, 1995

Non metallic minerals	type in 1000 m tons	1983	1985	1987
	Limestone flux and calcareous stone	110	100	1000
	Sand & gravel	280	250	100
	Clay	1	1	200
	Kaolin	1	1	n.a.
	Salt unrefined	109	# 30	13
	Abrasives, nat.pozolan, pumice, etc	1.8	1.8	6
Metallic minerals	• copper, zinc, lead, mangan, and sulfur • gold & silver • bauxite deposits at Boruca			

8. Physical infrastructure Source, the World Fact Book 1995, CIA, Washington DC, 96

8.1 Roadnetwork

Roadnetwork in Costa Rica	Paved	Unpaved	Total
Km	5600	29960	35560
in % of total	15%	85%	100

8.2 Transport (distr. of motor vehicles in % of total)

Family cars	Lorries	Motorcycles	Jeeps	Special equipmt (agric. & constr)	Public buses
45%	27%	11.5%	11%	4%	1.5%

8.3 Railroad : in majority out of order since last severe earthquake

8.4 Major sea harbors : Limon & Puntarenas

8.5 Electricity infrastructure

% dwellings with electricity	Number of subscribers	Electricity prod in Gwh / yr 1993	electr.consumption Gwh 1993
Urban: 100% Rural: 86.8%	800.000	4.385 GWH	3.890 GWH

8.6 Water distribution

% of all households supplied with piped water 92.8%

8.7 Telephone communication system Source: INCENEM San Jose CR, Miami USA 1994

No of subscriptions Area	Residential	commercial	public phones no/area	publ phones: no/1000pop	access to teleph services%	teleph. Density %
a. Metrop. Area Sjose b. Major cities c. urban locations d. rural locations e. total	a. 178.995 b. 35.403 c. 42.735 d. 1.319 e. 258.452	a. 44.428 b. 7.199 c. 10.951 d. 213 e. 62.791	urban: 5.859 rural: 1.566	2,3	89% Private: 32,2% Public: 55,8%	17,2%

8.8 other communication channels Source: INCENEM San Jose CR, Miami USA 1994

Television sets no/1000inhab	tv channels a. UHF b. VHF c. Cable channels	Radio channels a. AM b. FM	Journals in no a. major b. other	Magazinesin no a. major b. other
138 Source: World Ref. Atlas 1994	a. 26 b. 16 c. 30	a. 74 b. 55	a. 7 b. 38	a. 8 b. 35

Box 7.6 Backgrounds of the Costa Rican infrastructure

Since its early development periods Costa Rica highly relied on transport by road resulting in a quite modern road network with some 5600 km of highways. The main roads to the cities are of reasonable quality, but the roads to the smaller communities are in a bad state of maintenance. Improvements are still not sufficient to secure a qualitatively optimal road network.

The railway systems in the country were established in the 19th century through foreign investements by both Brittains for their coffee trade and the North Americans for their transport to and from the banana plantations. During the earthquake in 1991 the railway system has been severely damaged and most of it has been closed since then.

Only the harbours of Limon and Caldera/Puntarenas are of any (economic) importance, despite the fact that Costa Rica has a relatively large coast line and the existence of a number of harbours The harbour of Limon accounts for 80% of the total of cargo flows over sea. Despite an increase in total cargo through the harbour of Limon during the last decade its competitive position to other ports in the area declined. High investments are necessary to up-grade the existing transport infrastructure.

9. Population & Urbanization source: INCENEM, San Jose CR, Miami USA, 1994

9.1 Major demographic data

Total popul. 1994	pop. growth	Changes in pop.growth rate %	Pop. by sex 1994	Urban/rural pop. %	av. pop. density hab/km^2	Population density in San Jose
3.232.526	1892:255.400 1927:489.000 1950:858.200 1955:1,023.900 1963:1,379.800 1970:1.730.778 1980:2.284.495 1990:3.014.598	1950: 3,47% 1970: 2,57% 1990: 2,25%	Men: 50,55% Women: 49,45%	Urban: 44,08 % Rural: 55,92%	63	Pop: 86.178 km2: 9,47 density: 9.100

9.2Agestructure

Age groups	< 15 yrs	15 < age < 65 yrs	> 65 yrs
% of total population	37%	58.5%	4.5%

9.3cultural homogenity: 95% inhereted mixtures of the mestizo blend of the Spanish invadors and colonists with the Indians and at the same time often some African heritage.

9.4Average household size 4.2 persons

Number of persons per household	1-3 pers	4 pers	5-6 pers	7-9 pers	10 or more
% of total households	36.6%	22.1%	29.3%	10.0%	2.0%

9.5Household characteristics by income	Low income	Higher income
No of household members	49.00	41.00
Source of income per hh	1,1	1,7
Employment /hh	1,0	1,6
Income /hh/month	18 720 colones	91 946 colones

9.6Nr of lowest income households Source::DGEC, 1995

Hh under poverty line(absolute no)	1987	1988	1989	1990	1991	1992	1993	1994
	92 789	102 074	99 597	99 842	120 609	120 842	93 728	95 032
% Hh under poverty line	21,3 %	21,6%	21,9 %	20,5 %	24,4 %	22,2 %	17,4 %	15,8 %

9.7Urbanization in Costa Rica Source: INCENEM, San Jose CR, Miami USA, 1994

Urban Pop.	1980	83	84	85	86	87	88	89	90	91	92	93
% of total population	43	44	45	45	45	46	46	47	47	48	48	49

Box 7.7 Backgrounds of the present population situation

At the time Costa Rica was discovered in 1502, some 25 thousand indian farmers lived in the country. Attracted by the nice climate circumstances the Spanish invadors settled in the central part of the country. Due to diseases brought into the country by the colonialists the total number of Indians decreased soon, whereas the number of settlers and foreign traders grew during the next centuries who came to live as permanent residents with a background of many nationalities and cultures. Since 1920 growth due to immigration decreased. Until 1980 nearly all population growth can be attributed to natural increase. Thanks to the accessibility of health services in the country the mortality rate continually decreased. The birth rate was traditionally high and would continue to augment until the late 1950s. Around 1960 "Costa Rica experienced one of the most pronounced declines in fertility not only in Latin America but in the whole world, surpassed only by Formosa and Singapore." (Hall 1985, p.102) At present the population is still increasing, both due to natural growth and during the last decades of this century due to the arrival of more than 200.000 refugees from neighboring countries. This influx has slowed in the recent years thanks to the ending of the conflicts. But still nearly 70,000 Nicaraguans crossed the borders in search of jobs. Most of these immigrants are illegal and thus not officially registered. Estimates of their numbers range between 10 and 20% of the Costa Rican population (300.000 – 600.000 people). The migrated refugees form a problem for Costa Rica: most of them are poor, uneducated, malnourished and have a rather unfavorable physical condition. Also North Americans immigrate to Costa Rica, a process that has started in the late 1980s. They are in general retired people, looking for a peaceful and in-expensive place of residence.

Box 7.8 On the lower income households in Costa Rica

The number of households that lives in poverty decreased since 1993 to the level of 1987. In 1994 the income level was not sufficient to provide the basic needs for each member of the household for some 95.032 (15,8%) households. The figure on the basic costs for food and the minimum salary (the salary of a labourer in the agricultural sector or in the construction sector) shows that the costs of food have increased more than the salaries. The monthly income of the lowest income households averages less than 16,486.6 colones (current col. 1994) while the basic costs of food for an average household of 5.5 persons was 21.151 colones. This indicates that a family only could spend 8% of its income for other necessities such as housing, clothing and other things. But many households have more than one income earner. The official statistics indicate that the part of the population that lives in rural areas earn a lower income. But they have the disposition of land for farming and growing their own food . This is not the case for those living in the urban areas, which makes that the poverty for those living in urban areas in reality is worser than for those in rural areas.(See appendix III)

Box 7.9 On urbanization in Costa Rica

The (economic) stimuli for urbanization in Costa Rica changed profoundly after 1960. The changes started around 1950. Before, the majority of the population was concentrated in and near San José for reasons of the commercial and financial activities related to the coffee production. Until the end of the 1950s, the urban economy remained tied with the agro-exporting system. After 1963, when Costa Rica entered the Central American Common Market (CACM), industry started to develop, mainly in the region of San José. Most of the industrial production by then was focussed on import-substituting production. Many people were then attracted to the possibilities of urban employment, causing a larger migration to the area around San José. (Carvajal 1983, p.15-26) The developing industry, however, is not the only factor causing urbanization. Due to the slow growth of employment in the primary sector, many people migrated from the rural areas - attracted by real or perceived possibilities of employment. The jobs in industry increased only very slowly, leading to a direct transfer of labor in the primary sector to the tertiary sector of the economy. This *tertiary urbanization* appears clearly in the composition of urban employment (of total Costa Rica) in this period. In 1973, the services sector provided for 33,7 % of the total urban employment in Costa Rica, more than the total of the secondary sector. More than half of the people occupied in this branch were government employees, working in public administration and social services as health and education, indicating a further extension of the State's role in the economy, and especially in the urban economy of San José. The other part of employment in *services* was largely composed of jobs like domestic servants and bootblacks, revealing a concealed underemployment in the urban areas. (Hall 1985, p.223-225).

APPENDIX III-8

Strengths and weaknesses of the technological capabilities and technology status in the dwelling construction sector

8.1 Promoting and constraining product technological features of the output		
type	single storey modern urban houses	
Attribute	**Constraining**	**Promoting**
Geometry		Conform Costa Rican requirements: shape 100% rectangular: facilitates easy extension of the house 100% hip and gable roof : < leakage size av 49 m2 rooms av. 3 rms / hse
Functionality	Non-multiple usability Limited accessibility 60%	Facilities 100% available floor space 49m2 per household inside cooking 100% inside bathing 100%
Materialization & construction systems	Traditional Concrete block masonry Needs extra reinforcement Relatively high costs Prefa PC: reinforcem needed Bambu: preservation needed Zitro: reinforcem. needed high import content of roofing sheets, reinforcement	Main structure CB masonry: conventional known Prefa PC: advanced , low cost, fast constr Bambu: advanced , low cost, fast constr Zitro: advanced, fast constr Roofing structure: 100% rafters and purlins or trusses non earth floors: easy to clean
Physique-technical quality	earthquake resistance in 96% of the projects need extra precautions and still are not sufficient to prevent severe damage heat accumulation under roof too high relative humidity too high	Reasonable physique technical quality
Production characteristics	*single unit production,* traditional process:only 6% of building materials &components of work sections produced off site construction time /house months CB system	*Mass construction projects* 21% of building materials &components of work sections produced off site construction time /house months

8.2 Promoting and constraining process technology features

	Constraining	Promoting
tools and equipment simple hand tools; 15 % hired mech. & electr equipm.	less standardization less guaranteed quality of output higher time consumption	low capital investment
Labor force	shortage of skilled labor low experience: un-skilled labor low level of knowledge & skills, ability to read blue prints, capacity to judge the quality of materials and work low motivation	high experience: project managers &foremen 80% rel. high education level project managers (univ.72%) rel high experience skilled labor 83%
information, guidelines & documentation availability & nature of information carrier		constr specifications 90% standards & regulations documents former projects planning & control time planning progress control financial administration material data bases equipment data bases 50% computerized data bases
Organization	Hired employees on temporary basis Skilled labor 81% Un-skilled labor 85% Foremen 33% Employment selection upon recomm. Directing/communication: verbal during meetings direct, informal on all occasions R&D occasionally 50% Regulation and control limited Quality control seldom safety precautions seldom stock control n.a.	formal sector & sole / household fixed workshop management objective: expansion site protection by guard 60% training on the job 60%
	External relations Few Most via the branch organization CCC	external realtions material suppliers formal equipment formal financing SNFV + from client competition other contractors position in actor network: Government formal relation R&D institutes no direct relation Educ institutes no direct relation Branch organ. Formal registration Labor organ partly formal relation

8.3 Promoting and constraining project setting factors on the construction project execution

Factors	Promoting factors	Constraining factors
Climate	many activities can be carried out outside	Negative influences on project execution performance (rain season) high relative humidity causing a vulnerability of the product for fungus and rot
Landform and soil types	Moderate good drainage Relatively simple foundations Availability of sand for building construction	Hazardous lands: plots near the river basin and sea side are subject to flooding and landslides
Natural disasters		Occurrence of earthquakes, hurricanes, volcanoes lower lands are vulnerable for flooding during rainy season
Infrastructure	Reasonable accessibility of construction sites water and electricity supply sufficient	
size of the projects	Economies of scale in mass construction projects	
Project financing	Although not sufficient a limited guarantee of availability of sufficient finances for project execution	
legal status	Legalized plots	
Project management	Relatively high level of education & experience	some times in hands of non-experienced houseowners.
Formal sector project execution	Certain warranty for quality of the output, access to formal information and documentation.	Production of required product (house) still beyond the purchasing power of the target households without financing system Involvement of many different actors.

8.4 Promoting and constraining features of the technology capabilities

National stock	Promoting feature	Constraining feature
Technologies	* reasonable range of dwelling types which comply with lifestyle * reduced production complexity due to development of prefab systems * application of modular system * high level in-house facilties * durability construction systems * legal status * low capital intensity of process technologies * low cost labor * flexible organization * formal	* high import content * too high costs for lowest income group * high import content of tools & equipmt * in-sufficient technical skills and knowledge * in-efficient organizational framework

Table 8.4 continued next page/...

.../Table 8.4 continued

Human resources	* relatively large size young population * high literacy * *high enrollment rates in* education sys * avail. of trained managemt staff * avail of supervision & control staff * avail of R&D staff * avail of consultancy staff	* lack of trained labor force * lack of skilled crafts men
Natural resources	* availability of land	* limited stock of mineral resources * low level of mining * deficient transport facilities * high rate of deforestation * in-sufficient energy sources
Technology infrastructure	* R&D capacities * capacities of professionals, architects, engineers, consultants	* performance of actors * lack of financial means * lack of tailor made education & training * limited local production of material & equipment * in-adequate policies & strategies * low standardization * low income level customers

8.5 Promoting and constraining factors of the sectoral technology setting

promoting factors	Constraining factors
relatively limited natural population growth compared to other countries	Increasing gap between need and supply of houses due to 1. Influx of refugees, 2.relatively large percentage of young population
Almost 75% of the construction output is in the housing sector, which implies the possibility of gaining experience in jobs in the sector	current in-adequacy of the existing housing stock
innovations and techn developments like Prefa PC and the Prefab Bambu system, which involve reduction of costs and production time as well as the qualitative requirements for process technological inputs on site and an improvement of standardization and quality of the product technological features	high import content of the major building materials ÿ high costs and un-affordability of the constructed houses for the lower income households
government intervention in investment in dwelling construction for the lower income households, reflected in the establishment of the national housing financing system	. the limits to the functioning of the national housing financing system implied less public investment in construction which is in line with the decrease of GFCF . high inflation and the high interest rates ÿ decreased the investments in construction
Enabling policies of the government to search for integrated solutions of the housing problem including employment, income generation, training	non-existence of a comprehensive policy for the construction sector

8.6 Promoting and constraining factors of the national technology setting

	Promoting	Constraining
Economic setting	economic growth, which is reflecting the short term production improvement and enhances the investment in construction	* high inflation: increase in the costs of living, production & construction not in line with increase wages, thus reduction of investments. * high interest rates & lack of means on the capital market enhances a reluctance to invest * on going devaluation: risks for contractors in particular in long lasting projects * production structure with a low developed capital goods sector & large dependence on agriculture (little diversification):dependence on foreign resources * the large service sector employment: overruns of the public sector budget, lower social services expenditures and less financial means for housing * un equal income distribution * un favorable trade balance * low exchange rate * high dependence on foreign aid * low industrialization rate
Political setting	* relatively political stable & peaceful no international disputes decreases risks of investment * liberal policies * government support for an improved housing situation, reflected in the existence of . a well planned and coordinated financing system for housing . adapted building regulations for houses for lower income households.	* low social services budget * in adequate and vague policies * relatively short four year terms of policies alternatively in favor of government intervention or liberal policies, which implies non- continuity of strategies * a democratic bureaucracy resulting in a large size public sector, with large government expenditures pattern and overruns of the govenrment budget decreasing the means for social services * government interventions in the supply of building materials for dwelling construction: a weakness of regulations on imports of building materials constraining the opportunities for local building materials industries to develop
Education [illegible]	* comparatively well developed [illegible] system reflected in high literacy rates; [illegible] increased number of graduates from higher level educational institutes: [illegible] human resources for the [illegible] industry.	* current lack of educational means * low level of in-company training * non adequate vocational training system
Infrastructural setting	* reasonable communication facilities	* deficiencies in transport network

Table 8.6 continued next page/...

.../ Table 8.6 continued

Demographic setting	* *peaceful cultural homogeneity,* facilitates the standardization of product technological attributes * relatively large potential labor force * relatively small size of population and low rate of population growth, which facilitates the pace of development for the total society	* large percentage young population * relatively large size lower income population without access to housing puts an extra pressure on the performance of the construction sector. * concentrated population density in the Central Valley enhances a concentration of the housing problem. * the urbanization pattern -concentrated in Central Valley-: *increase of un-employment, traffic* congestions, environmental pollution * influx of refugees
Location & climate	* relative small size of the country requires limited infrastructural means * lack of natural resources forms a stimulance for technology development	* the climatological circumstances and occurrence of disasters - hurricanes earthquakes and volcanic outbursts * extra engineering requirements and building costs for precautions. * humidity and excessive rainfall: often delays in the construction progress. * lack of natural resources which enhances a dependence on imports of raw materials and vulnerability of building costs, a non sufficient energy production and deforestation

Appendix IV

I research design | II tanzania | III costa rica | IV conclusions

CONCLUSIONS

Contents

APPENDIX IV

Comparison of the technology mapping data in Tanzania and Costa Rica

Table 1 Produtec qualities	Tanzania	Costa Rica indiv. projects	Costa Rica mass projects
* functionality	+	+	+
* size	+	+	+
* facilities	--	++	++
* phys-technical quality	±	±	+
* production complexity	-	±	++
* costs	+	±	±

Table 2 Process technologies	Tanzania	Costa Rica
Technoware or the Physical facilities		
* type	-	-
* state of maintenance	- -	±
* possibility for renewal	-	±
* transport equipm	- -	±
Human abilities and knowledge		
* un-skilled /formally un-skilled.	-	-
* experience	-	-
* literacy; read technical drawings and specification	-	±
Project management	- -	+
Documented facts and information	-	+
Organizational framework	- -	+

Table 3 Project setting factors that influence the TPP	Tanzania	Costa Rica
climate and natural disasters	±	- -
landform	-	-
soil conditions	+	+
physical infrastructure	- -	±
Legislation	- -	+
Size	- -	+
project management	-	+
Financing	--	±

Table 4 Human resources stock	Tanzania		Costa Rica	
Population size	26,74 million	++	3,2 million	-
age structure	40% < 15yrs	+	33% < 15 yrs	+
Labour force/ ec active pop.	13.800000 = 51,6%		1.100000= 31%	
Illiteracy	32.2%	--	2%	++
Education enrollment				
Primary	69%	±	103%	++
Secondary	5%	-	43% (97%neth)	+
Tertiary	0.002%	--	2.8%	±
Vocational training	on the job	-	limited	±
Education opportunities				
* secondary & third level	Low	-	reasonable	+
* vocational training	Low	- -	limited	±

Table 5 Overview of the major natural resources for the construction industry

	Natural resources a. Available b. Exploited & used in production	Tanzania	CR
Plot	a. Available land	++	++
	b. Serviced land	-	+
Cement & Cement based products	a. Clay, lime and gypsum	++	+
	b. Exploited & used in production	+	+
Aggregates	a. Sand, rocks & gravel	++	+
	b. Exploited & used in production	±	+
Lime products	a. Lime	++	+
	b. Exploited & used in production	±	±
Gypsum products	a. Gypsum	++	-
	b. Exploited & production	--	--
Clay & clay products	Kaolin	++	+
	Exploited & used in production	-	±
Ceramic products & Sanitary ware	Kaolin, salt, gypsum, lime	++	±
	Exploited & production	-	-
Iron and steel products	iron ores, coal, magnesite for lining of furnaces	++	--
	Exploited & production	-	--
Aluminum products	bauxite	++	++
	Exploited & production	-	+
Wood and timber products Agro-based products (grasses, sisal, etc)	forestry resources /agricultural resources	++	++
	Exploited & production	-	+
Bamboo and bamboo prod.	bamboo resources	++	+
	Exploited & production	--	+
Thermoplastics	Crude oil, petro-chemicals like benzene, salt, caustic soda	--	--
	Exploited & production	-	-
Paints, Chemicals	(petro-)chemicals	--	--
	Exploited & production	-	±
Sheet glass	white quartz sand, limestone, soda	++	+
	Exploited & production	--	-
Gasses for welding	local availability	--	--
Rubber, resins, etc	agricultural resources	++	-
	Exploited & production	-	-
Water	Water	±	++
	Exploited & production	-	++
Energy	crude oil, coal, wind, water, solar, biomass	±	+
	Exploited & production	-	+

Table 6 Technology infrastructure of the dwelling construction sector

Actor	Nature of activity	Performance		actor network contacts	
		Tanz	CRica	Tanz	CRica
Investor *private* *Sector*: * households * families * community * neighborh. * organiz.	initiative	+	++	-	±
	principal of dwelling construction projects	-	-		
	judgem of quality of materials & work	-	-		
Investor *Public sector* * MIVAH 55% of total assignments of dwelling construction projects				--	+
	initiative	--	±		
	principal of project	--	±		
Consultants	* doc & information	-	+	-	+
	* design, engineering	-	+	-	+
	* management & organiz. services	-	+	-	+
Materials & Equipment suppliers/ producers	production of materials & equipment	--	±	-	+
	supply	--	±	-	+
R&D institutes, libraries, doc centers	technology developm	--	±	--	±
Educational institutes	primary level	±	+	--	±
	secondary level	--	+		
	vocational training	--	±		
	third level	--	+		
Financing organizations	availability of funds	--	±	--	+
	accessibility	--	+		
Government	regulation	-	±	-	+
	coordination	--	+		
	stimulation	--	±		
Branch organizations	inform & documentation	--	+	--	±
	coordination	--	±		
	diffusion of techn	--	±		
Labor organizations	control of labor conditions coordination	±	+	±	+

APPENDIX IV-2

The construction industry in developing countries

Table 1The performance of the construction industry in general in developing countries shows the following characteristics Source: UNCHS 1991

Technology structure	* the construction technologies in use in most of the Developing countries do not meet the functional requirements as set for the construction industry in general. * there is a contradictory situation of a long history of traditional construction from locally available materials and a rich stock of recent construction-related R&D results which are not put into practice.
Technoware	* there is a lack of development of basic simple equipment required for e.g. the extraction of raw materials, processing of materials and for the physical construction on-site. In some cases these have to be imported.
Humanware	* Human resources are not well developed. There is a shortage of professional, managerial , supervisory and R&D personnel. There is a tendency of firms to mechanize when they grow thus loosing their experience in labor intensive construction techniques and specific craftsmanship
Information & communication	* The use of inappropriate media and methods, an in-adequate executive capacity and communication structure
Organization	* The organizational structure is rather diffuse, activities are carried out on ad-hoc basis
Planning and management	* Technology is not seen as a competitive element in the business plans. Consciousness of the crucial role of technology in competition should be enhanced, through strengthening of the technology infrastructure.
Materials and inputs	* a lack of popularity of traditional and locally developed materials among potential users.
Finances	* a limited availability of financial resources, credit for the acquisition of equipment, wing to the rudimentary nature of the local financing institutions, which is again a reflection of the lower level of development in the country.
Construction output	* a poor durability of the end-products as a result of the poor application of recommended production technologies.
The sectoral technology infrastructure and R&D	* The local R&D capabilities and effectiveness is weak and needs to be strengthened. This can be done through e.g. the appointment of an advisory board, planning of R&D programs and allocation of resources. However lack of financial means inhibits this often. *Technology developments/ innovations are not disseminated to the smaller enterprises and even less to the informal sector

APPENDIX IV -3

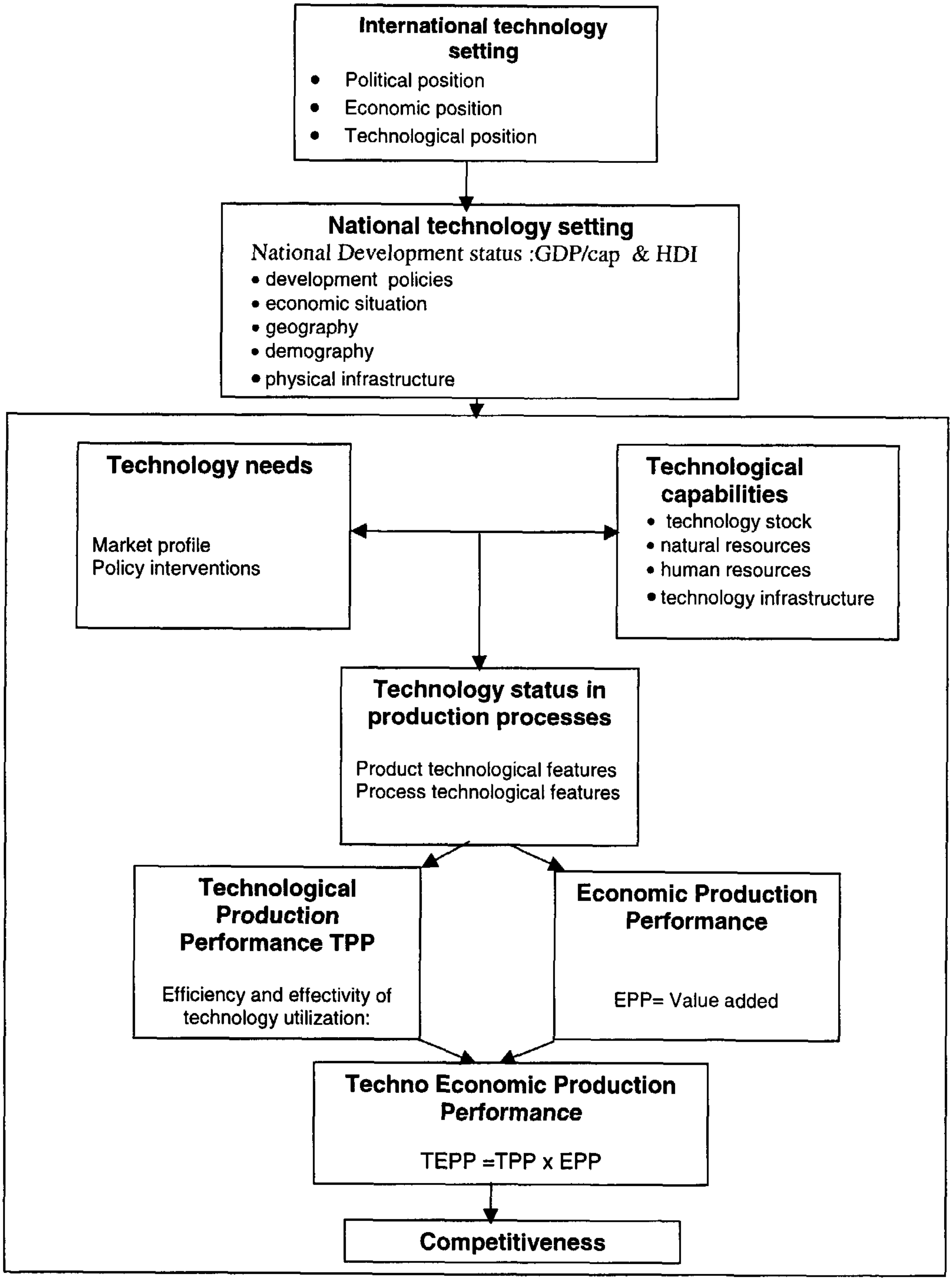
Guideline for Technology Mapping Studies

to determine the technological production performance and competitiveness in an industry in a 10 steps procedure

Technology Mapping procedure

1	Determine the particularities of the industry that needs to be investigated. (specific aspects like particularities of products, production processes or actors in the actor network of the industry) and adaptation of the basic research instruments for data collection in the industry that is to be investigated
2	Map the current demand for the products that can be produced by the industry. in quantitative and in qualitative terms (technology needs)
3	Map the state of art of the Technological Capabilities (the available stock of national resources) that can serve as input in the production processes in the industry: The (1) availability of *equipment, tools and intermediate products*, (2) availability of *human resources*; (3) availability of *natural resources*; (4) availability of a *technology infrastructure*: the production units, organizations and other institutes that may supply the necessary elements for production in the sector
4	Map the particular operational setting of (a sample of) the production units in the industry. Major indicators are (1) location, (2)type /ownership (3) size, (4) age (5) market orientation (6) relations with government
5	Map the technology status in the industry by aggregation of the data of the production processes at company level. The studies are carried out at company level.
6	Map the technological efficiency, effectivity and technological production performance of the enterprises. The terms of reference for the produced products in quantitative and in qualitative terms are taken as criterion.
7	Map the socio-economic production performance of the industry
8	Map the characteristics of the national and international setting of the industry under investigation.
9	Determine the actual and desired competitiveness by evaluation of the actual production performance, technology status and technological capabilities vis-a-vis the desired production performance, technology status and technological capabilities against the background of the desired production performance, the national- and the international setting
10	Determine the opportunities, problems and constraints for the development of the industry and formulate recommendations for technology management and policy interventions to guide the developments towards an improved competitiveness.

Research model



Samenvatting

Het onderwerp van dit proefschrift is de status van de Technologische Capabiliteit en de Technologie in productie sectoren in een land.

Dit onderzoeks-project vond zijn oorsprong in de nieuwsgierigheid naar de specifieke rol van de technologische capabiliteit en technologie in de concurrentie positie van industrieën, alsmede hun effect op de maatschappelijke ontwikkeling in een land.

Technologische capabiliteit is een betrekkelijk nieuw concept. Theorieën, die slechts sinds de laatste twee decennia in zwang zijn, duiden op de status van de technologische capabiliteit als een belangrijke factor voor een efficiënt en effectief gebruik van technologie in productie processen. Dit zou de internationale concurrentie positie van landen en de bedrijven in deze landen ten goede komen. De huidige mondiale ontwikkelingen leiden tot een toenemende internationale concurrentie strijd. Tegelijkertijd is er een. toenemende mate van internationale afhankelijkheid te constateren. Deze afhankelijkheid betreft in het bijzonder de beperkte productiemiddelen, die in de wereld ter beschikking staan om te kunnen voldoen aan de steeds toenemende en sneller veranderende vraag naar goederen en diensten. Deze trend dwingt tot voortdurende verbetering, aanpassing en ontwikkeling van technologie om efficiënt en effectief te kunnen produceren.

Technologische capabiliteit wordt gezien als het totale complex van middelen (totale vermogen) dat in een land aanwezig is om voortdurend en anticiperend op de voortgaande mondiale ontwikkelingen efficiënt en effectief te produceren. Het complex van middelen omvat (1) de aanwezige technologie, (2) het arbeids potentieel, (3) het potentieel aan natuurlijke hulpbronnen, (4) het aanwezige totale technologie systeem. Deze laatste component bestaat uit het netwerk van -in min of meerdere mate- aan de productie gerelateerde organisaties en instituten. De technologische capabiliteit komt tot uiting in het efficiënt en effectief (a) produceren door het toepassen en onderhouden van technologie, (b) verbeteren en ontwikkelen van technologie voor productie doeleinden (technologie ontwikkeling), (c) gebruik maken van bestaande technologie door deze op adequate wijze te selecteren en tegen redelijke condities en kosten over te nemen uit binnen- of buitenland (technologie transfer).

De conclusie uit bovenstaande theorieën is dat het in kaart brengen van de status van technologische capabiliteit in productie sectoren en van de technologie status in de productie processen zinvol kan zijn. De gegevens kunnen belangrijke bouwstenen aandragen voor de formulering en implementatie van technologie management- en beleidsplannen, die leiden tot een optimalisering van de technologische capabiliteit in productie sectoren en de technologie status in de productie processen.

Het doel van deze studie was om een algemeen toepasbare methodologie te vinden, waarmee de status van de technologische capabiliteit en de technologie in productie sectoren in kaart gebracht zou kunnen worden. De zogenoemde *Technology Mapping Methodology* zou een bruikbaar instrument moeten vertegenwoordigen voor de formulering van technologie management plannen in bedrijven en technologie beleid op national niveau.

Literatuur studies leidden tot de conclusie, dat de tot noch toe gehanteerde mono-disciplinaire analyses van technologie en technologie gebruik in productie processen geen gedetailleerd inzicht geven in de status van technologische capabiliteit en technologie in de productie processen. De concepten zijn complex en vergen een multidisciplinaire benadering. (deel I hoofdstuk 1). Besloten werd om te pogen een methodologie voor Technology Mapping te

ontwikkelen. Deze werd gebaseerd op literatuurstudies met betrekking tot technologische capabiliteit, technologie gebruik in productie, de efficiëntie en effectiviteit van de productie processen en hun bijdrage aan een verbeterde concurrentie positie van bedrijven en sectoren, die uiteindelijk zou moeten leiden tot sociaal economische ontwikkelingen in een land. Een analytisch kader voor Technology Mapping werd gevormd via een synthese van de belangrijkste elementen uit de analytische kaders, die werden gevonden in technologie gerelateerde studies van verschillende disciplinaire aard. (deel I hoofdstuk 2)

Alhoewel de bruikbaarheid en algemeen toepasbaarheid van de methodologie in verschillende sectoren, ongeacht tijd en plaats een voorwaarde was, is ondervonden dat het onderzoeks instrumentarium in de praktijk aangepast dient te worden aan de bijzonderheden van de te bestuderen sector. Dit heeft in deze studie plaatsgevonden voor de bouw sector. (deel hoofdstuk 3). De methodologie werd toegepast in de woningbouwsector in Tanzania en Costa Rica.

De toepassing van de methodologie in de woningbouwsector in Tanzania en Costa Rica diende tweeërlei doel. In de eerste plaats werd hiermede een evaluatie van de bruikbaarheid en validiteit van de ontwikkelde methodologie voor Technology Mapping mogelijk. In de tweede plaats werd verondersteld dat door de uitvoering van de Technology Mapping studies de sterke en zwakke aspecten van de technologische capabiliteit en de technologie in de woningbouw projecten aan het licht zouden komen.

De keuze van de woningbouw sector in de betrokken landen is met reden gemaakt. In beide landen is sprake van woningnood, die in het bijzonder de lagere inkomens klasse in de stedelijke gebieden treft. De bouwsector, die een belangrijke rol vervult in de volkshuisvesting blijkt niet in staat om voldoende goede en voor de doelgroep betaalbare woningen te bouwen. Door het verbeteren van de zwakke elementen en het benutten van de sterke aspecten van de technologische capabiliteit en de technologie in de woningbouw projecten zou de efficiëntie en effectiviteit van de bouwprojecten verhoogd kunnen worden.

De resultaten van de veld applicatie van de Technology Mapping methodologie in Tanzania en Costa Rica gaven aan dat de mogelijkheid tot verbetering van de productie van de woningbouwsector te vinden is in de ontwikkeling van de componenten van technologische capabiliteit. Voor Tanzania betekent dit dat er een mogelijkheid ligt in een verbeterde benutting van het rijke potentieel aan natuurlijke hulpbronnen. In Costa Rica biedt het aanwezige relatief hoog ontwikkelde arbeidspotentieel in de sector een stevige basis voor de reeds in gang gezette verdere technologie ontwikkeling. De benutting van deze geconstateerde potentiële middelen ter verbetering van de woningbouw productie vereist echter een aantal doelgerichte investeringen, die niet kunnen plaatsvinden zonder ondersteuning vanuit de nationale setting van de beide landen. Met behulp van de uitkomsten van de Technology Mapping Studies kan men gefundeerd tot prioritering van de investeringen komen. (deel II en deel III)

Een vergelijking van de uit de Technology Mapping studies gegenereerde gegevens in Tanzania en Costa Rica leidde tot conclusies, die de uitgangspunten van deze studie ondersteunden. Alhoewel de studie slechts twee landen omvatte kon een opmerkelijke conclusie worden getrokken: de ratio tussen de nationale ontwikkelings status uitgedrukt in de zogenaamde Human Development Index (HDI) bleek overeen te komen met de ratio tussen de gevonden indices voor de technologische capabiliteit en de technologische productie performance.

Tenslotte werd geconcludeerd dat de Technology Mapping methodologie een bruikbaar instrument is gebleken voor het formuleren en stellen van prioriteiten in technologie management en beleids plannen. (deel IV)

De informatie die met de Technology Mapping studies gegenereerd kan worden wordt in feite onmisbaar geacht voor adequaat technologie management en technologie beleid en is complementair aan de data, die uit de -in het algemeen- toegepaste sociaal-economische analyses voortvloeien. Voor deze laatste gegevens zijn meestal uitgebreide data banken in landen aanwezig. Het verdient aanbeveling om ook voor de specifieke technologie data additionele data banken in de landen op te zetten naast de bestaande sociaal economische-. Dit betekent dat inzet noodzakelijk is voor het genereren van gegevens over de technologische capabiliteit en de technologie status in productie sectoren. Het kan beschouwd worden als een ware uitdaging aan ingenieurs om hierin een belangrijke rol te vervullen.

Resumen

El tema de este tesis es el nivel de la capacidad tecnológica y de las tecnologías usadas en los sectores productivos de un país.

Esta proyecto de investigación tiene su origen en la curiosidad por saber el papel especifico de la capacidad tecnológica y el nivel de la tecnología en la posición competidora de industrias y en su efecto sobre el desarrollo social de un país.

Capacidad tecnológica es una noción relativamente nueva. Teorías de las ultimas dos décadas indican que el nivel de la capacidad tecnológica es un factor importante para el uso eficaz y efectivo de tecnologías en los procesos de producción lo que beneficia la posición competidora internacional de países y de las empresas de estos países.

El desarrollo mundial actual implica una lucha competidora internacional cada vez mas intensiva. Al mismo tiempo se observa cada vez mas dependencia internacional. Esta dependencia se trata en particular de los medidas limitadas que mundialmente son disponibles para poder satisfacer la demanda para bienes y servicios cada vez creciendos y mas rápidamente cambiandos. Esto obliga a mejoramiento continuo, adaptación y desarrollo tecnológico para llegar a una producción satisfactoria.
Capacidad tecnológica es considerada como el conjunto total de las medidas (poder total) presente en un país para producir eficaz y efectivo continuamente y anticipando el desarrollo mundial.
El conjunto de las medidas contiene el potencial (1) la tecnológica presente (2) el potencial obrero, (3) el potencial de los recursos naturales, (4) el sistema tecnológico presente consistiendo de la red de organizaciones y institutos mas o menos liados a la producción.

La capacidad tecnológica se mostra en (a) el nivel de la producción y la aplicación y mantenimiento de tecnología (b) el mejoramiento satisfactorio de la tecnología para producción (desarrollo tecnológico) (c) el uso efectivo Y eficaz de la tecnología existente selecionandola de maniera apropiada y transferiendola desde la fuente (transferencia tecnología)

Las conclusiones de las teorías mencionadas mas arriba indican la utilidad de hacer mapas del nivel de la capacidad tecnológica en los sectores productivos y del nivel de las tecnologías en los proceses de producción.
Los datos pueden contribuir a la formulacion y implementacion de management y políticas tecnológicas, conduciendo al uso optima de la capacidad tecnológica en los sectores de producción y las tecnologías en los procesos de producción.

La meta de este estudio es encontrar una metodología aplicable en general con que el nivel de la capacidad tecnológica en los sectores de producción y las tecnologías en los procesos de producción pueden ser dibujado. La llamada *Technology Mapping Methodology* tiene que ser un instrumento útil para el management dentro las empresas y para los políticos.

Estudios en la literatura hacen concluir que los analises mono-disciplinarios de tecnología y uso tecnológico utilizados hasta ahora no dan una noción detallada de la capacidad tecnológica y las tecnologías en los procesos de producción.

Las nociones son complicadas y exigen en estudio multi-disciplinario (ref. parte I capitulo 1)
Hemos decido de tratar de desarrollar una metodología para *Technology Mapping.* Esta metodología esta basada sobre estudios de literatura con respeto a las nociones capacidad tecnológica, uso tecnológico en producción, la eficaz y efectividad de procesos de producción y su contribución a mejorar la posición competidora de empresas y sectores,

resultando finalmente al desarrollo socioeconómico de un país.
El cuadro analítico para Technology Mapping es hecho por el síntesis de los elementos mas importantes de los cuadros analíticos, utilizados en los estudios de diferentes disciplinas relacionados a la tecnología (parte I capitulo 2)
Aunque el uso y la aplicación general de la metodología en sectores diferentes, irrespecto al tiempo y lugar fue una condición la experiencia ha mostrado que en el practico los instrumentos tienen que ser adaptados a las particularidades del sector.
En este estudio esto ha ocurrido para el sector de la construcción (parte I capitulo 3)
La metodología es aplicada en el sector de viviendas de Tanzania y Costa Rica.

La aplicación de la metodología en el sector de la construcción de viviendas ha servido dos metas.
En primer lugar una evaluación fue posible de la utilidad y validar de la metodología desarrollada para *Technology Mapping.*
En segundo lugar se suponía que por la ejecución de los estudios *Technology Mapping* los aspectos fuertes y débiles de la capacidad tecnológica y el uso tecnológico en proyectos de construcción de viviendas seran descubiertos.
La elección del sector de la construcción de viviendas es hecho con razón. En los dos países existe una crisis de la vivienda en particular para las clases inferiores de las ciudades.
El sector de la construcción juegua un papel importante en la oferta de viviendas. Sin embargo el nivel de producción aparentamente no satisface la necesidad para buenas viviendas que las clases inferiores de las ciudades pueden pagar. El mejoramiento de los elementos débiles y el uso de los aspectos fuertes de la capacidad tecnológica y uso tecnológico en proyectos de construcción podría a ser beneficiarios.

Los resultados de la aplicación de la metodología *Technology Mapping* en Tanzania y Costa Rica demuestran que es posible mejorar la producción de viviendas desarrollando los componentes de la capabilidad tecnológica.
Para Tanzania eso significa que hay una posibilidad en un mejor uso de la potencia en recursos naturales. En Costa Rica la potencia obrera relativamente muy desarrollado da un baso fuerte para el desarrollo tecnológico continuo en el sector.
El uso de estas medidas potenciales no puede ocurrir sin ayuda adecuada de la parte del gobierno nacional (parte II y parte III)

Comparando los datos de los estudios *Technology Mapping* en Tanzania y Costa Rica se puede concluir que los puntos de partida de este estudio son correctos. Aunque el estudio contiene solamente dos países una conclusión notable se puede observar: el ratio entre el nivel de desarrollo nacional expresado en el HDI índice es conforme al ratio entre los índices de la capabilidad tecnológica y la capabilidad productiva. Finalmente se ha concluido que la metodología *Technology Mapping* es un instrumento útil para formular y prioritar políticas tecnológicas. (parte IV)

La información obtenida con los estudios *Technology Mapping* es considerada indispensable para políticas tecnológicas y es complementaria a los datos que resultan de los analices socioeconómicos generalmente aplicados. Para los últimos datos muchos veces extensos *data-banks* (bancos de data) son presentes en países.

Es recomendable *establecer databanks* adicionales para datos específicamente tecnológicas, es decir para datos de capacidad tecnológica y el uso de tecnologías en sectores productivos.

Es considerado un *desafío para ingenieros* de tener un papel importante en esto.

Bibliography

Part I : Research design

Abernathy, W.J. and J.M. Utterback (1978), *Patterns of Industrial Innovation.*

Abramovitz, M. (1956, Resource and output trends in the United States since 1970. University Press.

Amann, R., J. Cooper and R.W. Davies (1977), *The technological level of Soviet industry.* Yale University Press.

Amsden, A. H. (1989), *Asia's next giant: South Korea and late industrialization.* Oxford: Oxford University Press.

Angle, H.L., (1989), *Research on the management of innovation : the Minnesota studies,* Andrew H. Van de Ven, Harold L. Angle and Marshall Scott Poole.(eds) - London Harper & Row, 1989. - XXI, 720 p.

Arrow, K.J., S. Karlin and H. Scarf (Eds.) (1962), *Studies in applied probability and management science.* Stanford: Stanford University Press.

Asian Productivity Organization (1983), *The construction industry in Asia: a survey.* Tokyo.

Atkinson, G. (1995), *Construction quality and quality standards: the European perspective.* London: E & FN Spon.

Barnes, B. and Shapin, S. (eds), (1979), *Natural Order, Historical Studies of Scientific Culture,* Beverly Hills and London: Sage

Bell, M., B., Ross-Larsen and L.Westphal (1984), Assessing the Performance of Infant Industries. *Journal of Development Economics, 16,* 101-128.

Bertholet, C.B. and H. Gaillard (1978), *De modelbouw binnen de comparatieve management- en organisatiekunde.* Eindhoven: Eindhoven University of Technology.

Bertholet, C.J.L. and P. T. van Tilburg (1989-1990), *Technology for developing countries,* (not officially published).

Bhalla, A.S. (1985), *Technology and employment in industry: a case study approach.* Geneva: International Labour Office.

Bhalla, A.S. and A.G.Fluitman (1985), "Science and Technology Indicators and Socio-Economic Development", in *World Development,* Vol. 13 (2), pp 177-190

Blumenthal, T. and M. Teubal (1979), The role of future oriented technology in Japan's economic development. *Hitotsubashi Journal of Economics, 19,* 34-43.

Bon, R. (1988), *Direct and indirect resource utilization by the construction sector: the case of the USA since World War II.*

Boon, G.K. (1964), *Economic Choice of Human and Physical Factors in Production,* North Holland, Amsterdam.

Botter, C.H. (1987), *Produktiemanagement.* Deventer: Kluwer bedrijfswetenschappen.

Burie, J.B. (1973), *De structuur van het bouwproces.* Utrecht: Rijksuniversiteit Utrecht.

Bijker , W.E.. (1987), *The social construction of technological systems : new directions in the sociology and history of technology* ,Bijker Wiebe E., Thomas P.Hughes and Trevor Pinch. (eds)- London : MIT

Caldwell, B.J. (1982-1984), *Beyond positivism: economic methodology in the twentieth century.* London: Allen & Unwin.

Calvert, R.E. (1970), *Introduction to building management.* Newnes-Butterworth.

Carlson , B., (1990) *Inside technology* ,Wiebe E. Bijker, W. Bernard Carlson and Trevor Pinch. (eds) - London : MIT Press

Channon, D.F. (1978), *The service industries.* London: McMillan.

Chase, R.B. and N.J. Aquilano (1992), *Production and operations management: a life cycle approach.* Boston.

Chenery, H.B. (1949) Engineering Production Functions, *Quarterly Journal of Economics,* Nov, pp 507-531

Chenery, H.B. (1950) *Engineering Bases for economic Analysis,* PhD thesis , Harvard University Cambridge.

Chow, K.F. (1985), *Construction Joint Ventures in Singapore.* Singapore: Butterworths.

Collins, H.M. (Ed.) (1982), *Sociology of scientific knowledge: a source book.*

Constant, E.W. (1980), *The origin of the turbojet revolution.* Baltimore: Johns Hopkins University Press.

Cookenboo, C. jnr. (1954), *Costs of Operating Crude-Oil Pipelines,* The Rice Institute, Pamphlet, Vol. XLI. No. 1, April.

Cooper, C., Kaplinsky, R., BELL, R. and Satyarakivit, W. (1975), "Choice of Technology for Can Making in Kenya, Tanzania and Thailand", in A.S. Bhalla (ed.), *Technology and Employment in Industry,* ILO, Geneva.

Cooper, Ch.M., Clark, J., (1982), *Employment, Economics and Technology: The Impact of Technological Change on the Labour Market,* Brighton, Wheatsheaf

Cowing, T.G. (1970), *Technical Change in Steam-Electric Generation - An Egineering Approach,* Unpublished Ph.D.Dissertation, Univ. of California, Berkeley

Dacy, D.C. (1965), Productivity and price trends in construction since 1947. *The review of economics and statistics, 47 Nov.*.

Dahlman, C and L. Westphal (1982), Technological effort in industrial development - an interpretive survey of recent research In:F. Steward and J. James (Eds.), *The economics of new technology in developing countries.* Pinter: Westview Press.

Dahlman, C.J., B. Ross-Larson and L. E. Westphal (1987), Managing Technological Development: Lessons from the Newly Industrializing Countries In: *World Development.*

Dalton, G. (1974), *Economic systems and society: capitalism, communism and the third world.* London: Penguin.

Denison, E.F. (1967), *Why growth rates differ: postwar experience in nine western countries.* Washington: Brookings Institution.

DGIS (1990), *Nieuwe kaders voor ontwikkelingssamenwerking in je jaren '90: een wereld van verschil:.* 's Gravenhage: SDU Uitgeverij.

Dhar, P.N., and H.T. Lydall (1961), *The role of small enterprises in Indian economic growth.* Delhi: Asia Publishing House.

Dosi, G. (1982), Technological paradigms and technological trajectories. A suggested interpretation of the determinants and directions of technical change. *Research Policy, 11*, 147-162.

Dosi, G., C.Freeman, R. Nelson [et al.] (Eds.) (1988), *Technical change and economic theory.* London: Pinter.

Drewer, S. (1980), Construction and development: a new perwpective. *Habitat International, 5 No. 3/4*, 395-428.

Drewin, F.J. (1982), *Construction productivity: measurement and improvement through work study.* Amsterdam: Elsevier.

Dunning, J.H. (1982), *Towards a taxonomy of technology transfer and possible impacts on OECD countries.* Reading: University of Reading.

Duysters, G., (1995) *The evolution of complex industrial systems : the dynamics of major IT sectors* Maastricht : Rijksuniversiteit Limburg,.

E.E.C. (1991), *Construction a challenge for the European Industry, DG XII.* Bruxelles: Commission of European Communities.

Erkelens, P.A. (1991), *Self-help building productivity. A method for improving house building by low income groups applied to Kenya,* (diss.). Eindhoven: Eindhoven University of Technology.

Erve, H.J. v.h. (1994), *Bouwprocesleer,* (not officially published).

ESCAP (1986), *Technology transfer, an ESCAP training manual: Booklet 1, technology transfer basic concepts.*

ESCAP (1989a), *A framework for technology based development. : an overview of the framework for technology-bases development* Bangalore: United Nations.

ESCAP (1989b), *A framework for technology based development: technology status assessment.* Bangalore: United Nations.

ESCAP (1990), *Technology transfer, Booklet* 2. Bangkok.

Evenson, R.E. and L.E. Westphal (1994), *Technological change and technology strategy.* Maastricht: United Nations University.

Feigenbaum, A.V. (1993), Total quality In: W.F. Christopher and C. G. Thor, *Handbook for productivity measurement and improvement.* Portland: Productivity Press.

Flores, E. (1971), Agricultural production and rural industries In: R. Robinson, *Developing in the Third World: the experience of the 1960's.* Cambridge: Cambridge University Press.

Fluitrman, F. (ed) (1989), *Training for Work in the Informal Sector,* International Labour Organization, Geneva.

Forsyth, David J.C. (1977), "Appropriate Technology in Sugar Manufacturing", *World Development,* Vol.5, No.3, March, pp. 189-202.

Fransman, M. (1984), Technological Capability in the Third World: an overview and introduction to some of the issues raised in this book In: Fransman and K. King (Eds.), *Technological Capability in the Third World.* London: Macmillan press Ltd.

Freeman, C and L. Soete (1987), *Technical change and full employment.* Oxford: Basil Blackwell.

Freeman, C. (1982), *The economics of industrial innovation.* London: Pinter.

Freeman, C. and B.A. Lundvall (1988), *Small countries facing the technological revolution.* London: Pinter.

Freeman, C., J. Clark, and L. Soete (1982), *Unemployment and technical innovation: a study of long waves and economic development.* Westport, CT: Greenwood Press.

Furubotn, E.G. (1965), "Engineering Data and the Production Function", *American Economic Review,* Vol.55, June, pp. 512-516.

Gaillard, H. (1994), *The search for and adequate theoretical framework and research strategy*. Eindhoven
Gaillard, H., 1994 *The industrialization of developing countries, the micro-level perspective*, ITDS, Eindhoven (Not officially published Eindhoven University of Technology).
Goulet, D. (1977), *The Uncertain Promise: Value Conflicts in Technology Transfer*. New York: IDOC.
Grupp, H., O. Hohmeyer, R. Collert and H. Legler (1987), *Technometric, Verlag TUV Rheinland*. Köln.
Gupta, T.N. (1993), *The construction industry and the implication for its development: the indian experience*. UNIDO.
Harris, G. (1992), *The sociology of development*. Londen: Longman.
Heertje, A. (1973), *Economie en technische ontwikkeling*. Leiden: Stenfert kroese.
Hendriks, A. (1957), *De prijsvorming in het bouwbedrijf, structuur van het bouwbedrijf en de wijze van prijsvorming*. Rotterdam: Uitgeverij Wyt.
Hershauer and Rusch (1984), Hershauser and Rusch' Model. In: Sumanth, D.J., *Productivity, engineering and management: productivity measurement, evaluation, planning, and improvement in mnufacturing and service organizations*. London: McGraw-Hill.
Hillebrandt, P.M. (1984), *Analysis of the British construction industry*. London: MacMillan.
Hofstede, G. (1980), *Culture's consequences: international differences in work-related values*. London: Sage
Hughes, T.P. (1969) Technological momentum in History: Hydrogenation in Germany 1898-1933, *Past and Present*, no 44, 106-32
Hughes, H. and B. Weisbrod (1983), *Human resources, employment and development: world congrss of the International Economic Association*. London: MacMillan.
Hughes, T.P. (1971), *Elmer Sperry: inventor and engineer*. London: John Hopkins Press.
Hughes, T.P. (1987), The evolution of large technological systems In: W.E. Bijker, T.P Hughes, and T.J. Pinch (Eds.), *The social construction of technological systems: new directions in the sociology and history of technology*. Massachusetts: the MIT Press.
International Labour Office (1987), *Yearbook of labour statistics*. Geneva: International Labour Office.
International Organization for Standardization, *ISO-TR/1994* : international standard. - Geneve :International Standards Organization
Jacobs, D., J. Kuijper and B. Roes (1992), *De economische kracht van de bouw: noodzaak van een culturele trendbreuk*. Den Haag: Stichting Maatschappij en Onderneming.
Jager, H. de and A. L. Mok (1989), *Grondbeginselen der Sociologie: gezichtspunten en begrippen*. Leiden: Stenfert Kroese.
Janssen, J.J.A., 1994, Bouwtechniek voor ontwikkelingslanden, Technische Universiteit Eindhoven, dictaat 7859
Jasanoff, S., G.E. Markle, J.C. Petersen, and T. Pinch (1995), *Handbook of science and technology studies*. London: Sage Publications.
Jong, J. (1974), *De kosten en kostenbewaking in het bouwbedrijf*. Culemborg: Stam Technische Boeken.
Justman, M, M. Teubal, D. Foray, et al. (Eds.) (1996), *Technological infrastructure policy: an international perspective*. Dordrecht: Kluwer Academic.
Justman, M. and M Teubal (1988), *The structuralist view of economic growth: some conceptual and formal issues*, (not officially published).
Justman, M. and M Teubal (1989), *Economic growth, structural change and technological progress*, (not officially published).
Justman, M. and M Teubal, (1990), The Structuralist Perspective to EconomicGrowth and Development: Conceptual Foundations and Policy Implications, in .: R.E. Evenson, G. Ranis, Boulder, *Science and Technology: lessons for development policy*. Westview.
Kamya, A. (1987), *Industrialization in Sub-Saharan Africa: problems and research needs*. Zambia: UNZA.
Keddie, J. and Cleghorn, W.H. (1977), "Corn Beer: An Alternative to Lager", *Appropriate Technology*, Nos. 3,4.
Kendrick, J.W. (1993), Productivity: Why it matters - how it is measured In: W.F. Christopher and C. G. Thor, *Handbook for productivity measurement and improvement*. Portland: Productivity Press.
Kendrick, J.W., (1976), *The formation and stocks of total capital*, . by J.W. Kendrick, Yvonne Lethem and Jennifer Rowley. - S.l. : National Bureau of Economic Research; Columbia University Press
Kline S.J. and Rosenberg N (1986), An overview of innovation In: *The Positive Sum Strategy*, Landau, R. and Rosenberg N. (eds) , Washington DC, National Academy Press
Koonings, K. and D. Kruijt (1988), *Ontwikkelingsvraagstukken: theorie beleid en methoden*. Muiderberg: Coutinho.
Kuhn, T.S. (1970), *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Kuhn, T. S (1977) *The essential tension: selected studies in scientific tradition and change* - Chicago : University of Chicago Press

Kurz, M. and Manne, A.S. (1963), "Engineering Estimates of Capital-Labour Substitution in Metal Machining", *American Economic Review*, Vol. 53, pp. 662-679.

Lall, S (1982), *Developing countries as exporters of technology: a first look at the Indian experience*. London: MacMillan Press.

Lall, S (1987), *Learning to Industrialize: the acquisition of technological capability by India*. London: Macmillan.

Lall, S. (1985), Trade in technology by a slowly industrializing country: India In: N. Rosenberg and C. Frischtak (Eds.), *International technology transfer: concepts, measures and comparisons*. New York: Praeger.

Lall, S. (1992), *Alternative development strategies in SubSaharan Africa*. New York: St. Martin's Press.

Lall. S. (1990) *Building industrial competitiveness in developing countries* - Paris : OECD

Lapperre P.E. (1993), *Problems of developing countries in institutional perspective: consequences of international disorder*, (not officially published TU Eindhoven).

Lapperre, P.E. (1992), *Man, technology, society and development: from the hunters and gatherers to the first industrial revolution 3,5 million years ago until AD 1760*, (diss.). Eindhoven: Technische Universiteit Eindhoven.

Large, P. (1980), *The Micro Revolution*, London: Fontana

Lave, L.B. (1966), "Engineering Production Functions and Capital-Labour Substitution in Metal Machining-Comment", *American Economic Review*, 56, September.

Leontief, W.W. (ed0 1953), *Studies in the Structure of American Economy*, N.Y.: Oxford Univ. press, London.

Lewis, W.A. (1955), *The theory of economic growth*. London: Allen and Unwin.

Lilley, S. (1980.), Men, machines and history. Retrospect and summary. In: E.J. Fischer (Ed.), *Geschiedenis van de techniek: 22 teksten over geschiedenis van de techniek* Den Haag: Nijhoff.

Lundvall, B. A. (1992), *National Systems of innovation: towards a theory of innovation and interactive learning*. London: Pinter.

MacKenzie, D and J. Wajcman (1985), *The social shaping of technology*. Milton Keynes: Open University Press.

Madewell, C.J. (1986), Innovative solutions to the challenges of heavy civil projects In: C.B.Tatum (Ed.), *Construction innovation: demands, successes and lessons*. New York: American Society of Civil Engineers.

Malecki, E.J. (1991), *Technology and Economic Development*. New York: Longman.

Markowitz H. (1956), Industry wide, Multi-industry and Economy-wide process analysis, in T. Barna (ed), *The Structural Interdependence of the Economy*, Wiley, New York.

Marx, K and F. Engels (1902), *Gesammelte Schriften von Karl Marx und Friedrich Engels 1841 bis 1850*. Stuttgart: Dietz.

McBain, N.S. (1977), *The Choice of Technique in Foorwear Manufacture for Developing Countries*, Overseas Research Publication, No.24, Ministry of Overseas Development, HMSO, London.

McKean, R.N. (1968), The use of shadow prices In: S.B. Chase (Ed.), *Problems in public expenditure analysis*. Teh Brookings Institution.

Merriam Webster editorial staff (1995), *Merriam Webster's Collegiate Dectionary, tenth edition*. Merriam Webster Inc.

Meyer-Ehlers, G. (1963), *Wohnung und Familie*. Deutsche Verlags-Anstalt.

Miles, D. and R. Neale (1991), *Building for tomorrow: international experience in construction industry development*. Geneva: International Labour Office.

Moavenzadeh, F. (1987), The construction industry In: L. Rodwin, Dept. of urban studies and planning, MIT (ed), *Shelter, Settlement and Development*. Boston: Allen & Unwin.

Moore, F.T. (1959), Economics of Scale: Some Statistical Evidence, *Quarterly Journal of Economics*, Vol 73.

Morison, E. (1966), *Men, Machines and Modern Times*, Cambridge Mass, MIT Press.

Nakamura, G. (1986), Strategic Management in major Japanese hightech companies. *Long range planning, 19*, 82-91.

Nam, C.H. and C.B. Tatum (1988), Major characteristics of contructed products and resulting limitations of construction technology. *Construction Management and Economics, 6*, 133-148.

Nelson, R.R., (1988) *Technical cooperation and international competitiveness* : proceedings of an international conference, Lucca, Italy, 2-4 April 1986 / ed. by Herbert Fusfeld and Richard R. Nelson. - Troy : Rensselaer Polytechnic Institute School of Management

Nelson, R.R. and S.C. Winter (1982), *An evolutionary theory of economic change*. Belknap Press of Harvard University Press.

Ofori, G. (1990), *The construction industry: Aspects of its economics and management*. Singapore: Singapore University Press.

Ogburn, W.F. (1964), *William F. Ogburn on culture and social change; selected papers*. Chicago: University of Chicago Press.
Ogburn, W.F. and M. F. Nimkoff (1956), *A handbook of sociology*. London: Routledge and Kegan Paul.
Ogburn, W.F. and Thomas, D. (1922), "Are Inventions Inevitable?", *Political Science Quarterly*, 343, 83-98
Oglesby, C.H. (1989), *Productivity improvement in construction*. London: McGraw-Hill.
Pack, H (1974), *The Choice of Technique and Employment in the Textile Industry*, ILO, Roneo
Pack, H. (1979), Technology and employment: constraints on performance In: S.M. Rosenblatt (Ed), *technology and economic development, a realistic perspective*. Colorado: Westview Press.
Pack, Howard (1974), "The Employment Output Trade-Off in LDC's - A Micro-economic Approach", *Oxford Economic Papers*, Vol.26, No.3, November, pp. 388-404.
Park, S.H. (1989), Linkages between industry and services and their implications for urban employment generation in developing countries. *Journal of development economics, 30 No. 2*, 359-379.
Parsons, T. (1966), *Societies: evolutionary and comparative perspectives*. Englewood Cliffs: Prentice Hall Inc.
Patel, P. and K. Pavitt (1987), Is Western Europe losing the technological race. *Research Policy, 16*, 59-85.
Pavitt, K (1983) Patterns of technical change : evidence, theory and policy implications , Brighton : University of Sussex
Pearce, D.W. and C.A. Nash (1981), *The social appraisal of projects: a text in cost benefit analysis*. London: MacMillan.
Pearl, D.J. (1971), "An Economic Analysis of the Progress in Crude-Oil Pipeline Technoloby During the Period 1952-69", Unpublished B.A. Thesis, Oxford Univ.
Pearl, D.J. and Enos, J.L. (1975-76), "Engineering Production Functions and Technical Progress", *Journal of Industrial Economics*, Vol.24, pp. 55-72.
Pickett, James, Forsyth, D.J.C. and Mcbain, N.S. (1974), "The Choice of Technology, Economic Efficiency and Employment in Developing Countries", *World Development*, Vol.2(3), March, p.47.
Pickett, James and Robson, R. (1977), "Technology and Employment in the Production of Cotton Cloth", *World Development*, Vol. 5, (3), March, pp. 203-215.
Pinch, T. (1987), *The social construction of technological systems : new directions in the sociology and history of technology* ,Wiebe E. Bijker, Thomas P.Hughes and Trevor Pinch. (eds)- London : MIT
Porter, M.E. (1980), *Competitive strategy: techniques for analyzing industries and competitors*. New York: Free Press.
Porter, M.E. (1985), *Competitive advantage: creating and sustaining superior performance*. London: Collier MacMillan.
Porter, M.E. (1986), *Competition in global industries*. Boston: Harvard Business School Press.
Porter, M.E. (1990a), *The competitive advantage of nations*. New York: MacMillan.
Porter, M.E. (1990b), *National competitiveness*. New York: The Free Press.
Reidel, J and S. Schultz (1978), *Construction and building materials in developing countries*. Munich: Weltforum Verlag.
Romijn, H.A. (1996.) *Acquisition of technological capability in small firms in developing countries* Tilburg : Katholieke Universiteit Brabant
Rosegger, G. (1996), *The economics of production and innovation: an industrial perspective*. Oxford: Butterworth Heinemann.
Rosegger, G., B. Gold and M.G. Boylan Jr. (1980), *Evaluating technological innovations: methods, expectations and findings*. Heath.
Rosenberg, N. (1976), *Perspectives on technology*. Cambridge: Cambridge University Press..
Rosenberg, N. (1982), *Inside the black box*. Cambridge: Cambridge University Press..
Rosenberg, N. (1986), *Inside the black box: technology and economics*. Cambridge: M.A.
Rosenberg, N. (1990), Science and technology policy for the Asian NIC's: lessons from economic history. In: R.E. Evenson, G. Ranis, Boulder, *Science and Technology: lessons for development policy*. Westview.
Rostow, W.W. (1960), *The stages of Economic Growth*. Cambridge, Cambridge University press.
Rowe, A.J. and Markowitz, H. (1955), *An Analysis of Machine Tool Substitution Possibilities*, RM 1512, DDC Document No. AD87449, Rand Corporation.
Royal Institute of British architects (1968), *Construction indexing manual: incorporating the authoritative United Kingdom version of the international SfB classification system and superseding the RIBA SfB/UDC Building Filing Manual 1961*. London: Royal Institute of British Architects.
Rubinger, B. (1985), Technology policy in Japanese firms. *Technology in Society, 7*, 281-296.
Sagasti, F. (1979), Towards endogenous science and technology for another development. *Development dialogue, No.1*.
Schmookler, J. (1966), *Invention and economic growth*. Harvard: Harvard University Press.

Schumacher, E.F. (1973), *Small is beautiful: a study of economics as if people mattered.* London: Blond & Briggs.

Schumpeter, J.A. (1934), *Business cycles: a theoretical, historical and statistical analysis of the capitalist process.* Mc Graw-Hill.

Smith, Vernon L. (1957), "Engineering Data and Statistical Techniques in the Analysis of Production and Technological Change: Fuel Requirements in the Trucking Industry", *Econometrica,* Vol.25, April.

Smook, RAF, et all, (1995) *Organisatie van het bouwen,* Ctbd 211, , TU Delft -CT

Solow, R.M. (1971), *Growth Theory: an expostion: The Radcliffe lectures, delivered in the University of Warwick 1969.* Oxford: Claredon Press.

Stewart, F. (1974), Technology and Employment in Less-Developed Countries. *World Development, 2,* 17-46.

Stewart, F. (1977), *Technology and underdevelopment.* London: MacMillan Press.

Stewart, F. (1978), Technological self reliance of the developing countries: towards operational strategies In: *UNIDO, Development and transfer of technology series.* New York: UNIDO.

Stewart, F., H. Thomas and T. de Wilde (1990), *The other policy, the influence of policies on technology choice and small enterprise development.* London: Intermediate Technology Publications.

Storper, M. and R. Walker (1989), *The capitalist imperative: territory, technology and industrial growth.* Oxford: Basil Blackwell.

Strassman, P. (1985), Employment in Construction: multi country estimates of costs and substitution elasticities for small dwellings. *Economic Development and Structural Change, 33 No 2,* 395-414.

Sumanth, D.J. (1984), *Productivity, engineering and management: productivity measurement, evaluation, planning, and improvement in mnufacturing and service organizations.* London: McGraw-Hill.

Sutcliff, R.B. (1971), *Industry and development.* London: Addison Wesley Publ. Comp..

Tassios, T. (1992), *Structure and function of the construction industry with emphasis on developing countries.* UNIDO.

Tatum, C.B. (1987), Process of innovation in construction firm. *Journal of Construction Engineering and Management, 113, No.4.*

Tellegen, F.Ph.A. (1965), *Wonen als levensvraag: filosofie van het wonen, apologie van het gewone.* Amsterdam: Wetenschapppelijke Uitgeverij.

Teitel, S. (1993) *Industrial and Technological Development,* Inter-American Development Bank, Washington DC

Timar, J. (1958), *Classification and Analysis of industry based on know-how and skills.* National Planning Office.

Todaro, M.P. (1997), *Economic development.* London: Longman.

Toynbee, A. (1972), *A Study of History.* New York: Weathervane books.

Turin, D.A. (1973), *The construction industry: its economic significance and its role in development.* London: University college environmental research group.

Turin, D.A. (1975), *Aspects of the economics of construction.* London: Godwin.

Turin, D.A. (1980), What do we mean by building?. *Habitat International, 5 No. 3/4.*

Uhlig, S.J. and Bhat, B.A. (1977), "Capital Goods Manufacture and the Choice of Technique in the Maize-Milling Industry", *World Developments,* Vol. 5, No. 9/10, (Sept./Oct.)

UNCHS (1985a), *The use of selected indigenous buiding materials with potential for wide application in developing countries.*

UNCHS (1985b), *The reformulation of building acts, regulations and codes in African countries.*

UNCHS (1986), *Global report on human settlements.* Nairobi.

UNCHS (1991), *Technology in human settlements: role of construction.* Nairobi: Habitat.

UNCTAD (1972), *Guidelines for the acquisition of foreign technology to developing countries.* United Nations.

United Nations (1985), *National accounts statistics: main aggegates and detailed tables.* New York: United Nations.

United Nations Department of International Economic and Social Affairs (1968), *International Standard Industrial Classification of all economic activities.* New York: United Nation.

United Nations Department of International Economic and Social Affairs (1988), *United Nations Construction Statistics Yearbook 1985.* New York: United Nations.

Usher, A.P. (1954), *A history of mechanical inventions.* New York: Dover.

Verspagen, B. (1992), *Uneven growth between interdependent economies: an evolutionary view on technology gaps, trade and growth,* (diss.). Maastricht: Universitaire Pers.

Weggeman, M.C.D.P. (1996), *Organisatiekunde, kunst of wetenschap en het belang van betekenisvolle organisaties,* (not officially published TU Eindhoven.).

Weiss, C. Jr. (1990), Scientific and technological contraints to economic growth and equitiy In: *Evenson, R.E. and G. Ranis, Science and technology: lessons for development policy.* Boulder: Westview.
Wells, J. (1986), *The construction industry in developing countries.* London: Croom Helm.
.Westphal, L.E., L. Kim and C. Dahlman(1984) *Reflections on Korea's Acquisition of Technological Capability,* Discussion Paper No DRD 77, Development Research Department, The World Banl, Washington, DC
Westphal, L.E., L. Kim and C. Dahlman (1985), *Reflections on the Republic of Korea's Acquisition of Technological Capability.* New York: Praeger.
Westphal, L.E, cs, The Development of Technological Capablity in Manufacturing, in R.E. Evenson, G. Ranis, Boulder, *Science and Technology: lessons for development policy.* Westview
Wheeler, J.C. (1990), *Development co-operation, efforts and policies of the members of the development assistance committee: 1990 report.* Paris: OECD.
White, L. Jr. (1978), *Medieval religion and technology: collected essays.* California: University of California Press.
Whitehead, J. A. (1990), *Empirical production analysis and optimal technological choice for conomists : a dynamic programming approach-* Aldershot : Avebury.
Woodward, J. (1959), Management and technology. In *Problems of progress in industry,* nr 3, HMSO.
World Bank (1984), *The construction industry: issues and strategies in developing countries.* Washington D.C..
Zeldenrust-Noordanus, M. (1956), *Onderzoek naar enige psychologische aspecten van de woninginrichting.* Amsterdam: Universiteit van Amsterdam.
Zwaan, A.H. van der, (1984), *Ontwerp van organisatie onderzoek.* Assen: Van Gorcum.

Literature part II : Tanzania

ADB African Development Bank (1994) *African Development Report*
Aeroe, A (1992) *Rethinking industrialization in Tanzania, the case of the rural constrcution industry,* a MSc thesis for the Centre for Development Research, Copenhagen, Denmark
ARDHI Instit (1992) *Prospectus 1992-93, Training in Building and Land development,* Dar Es Salaam
Arundhati Inamdar (1994) *An analysis of affordability and willingness to pay;* a study in the framework of the World Bank Tanzania urban sector engineering project.
Bank of Tanzania. (1994) *Economic bulletin for the quarter ended 30th September 1994.* Dar es Salaam
BRU Building Research Unit (1985) *The Tanzanian Building regulations 1985,* Building Research Unit of The Prime Minister's Office, Dar es Salaam
BRU (1974) *Minimum requirements for permanent single storey houses,* Technical pamphlet no 2, Svare, TI, BRU, Dar es Salaam
BRU (1981) *Loads for structural design, technical guideline no 2,* BRU Dar es Salaam
BRU (1984) *The use of local timber for building,* A symposium report, BRU, Dar Es Salaam
BRU (1990) *Foundations for simple buildings, BRU technical guideline no 4,* BRU, Dar es Salaam
BRU, Building Research Unit, Svard, C (1984) *Design of rural low cost houses, design and choice of materials for rural housing in Tanzania,* BRU, Dar es Salaam
BRU, Kimati, VH(1995) *Recent appraoches in building production techniques and shelter delivery systems in Tanzania,* BRU, Dar es Salaam
BRU, Tolonen, Yrjo(1964) *The strength and other data for mangrove poles,* BRU, Dar Es Salaam, 1964
Chisanga, V (1995) *Climate vis-a-vis prefabricated housing,* CHS, Dar es Salaam, 1995
CHS Centre for Human Settlements Studies (1995), *Urban and housing Indicators study for Dar es Salaam,* CHS, ARDHI Institute, Dar es Salaam
Chunsi, KS &Sige, JK (1995) *Wood prefabricated materials for building construction,* Tanzania Forestry Research institute, Moshi
COSTEC (1992)*Technology based development in Tanzania,* Dar Es Salaam, 1992
Dam, A. van *Het onderwijs in Tanzania.* CESO, Den Haag, 1990.
Esmeijer, C., (1997), *Production and application of lime in Tanzania : with special reference to the construction sector* / by Casper Esmeijer , supervised by Emilia L.C. van Egmond-de Wilde de Ligny. - Eindhoven : Technische Universiteit Eindhoven
Fleischeuer, M.J.A.(1994) *Road construction in Tanzania.* M.Sc thesis supervised by Egmond, E.van ITDS/Technology Management, Eindhoven University of Technology
H. Haule, PK & Limbe, L (1993) *Role of local industries in the development of local technologies,* TIRDO Paper presented at the 2nd annual R&D seminar on industrial and energy research Dar es Salaam

Hoek-Smit, M.C.*(1991) The Urban Housing Sector in Tanzania; Analysis of the Urban Housing Survey 1990*, World Bank, Ministry of Regional development and local government, Dar es Salaam

ILO (1983) *Preinvestment study for the development of small scale construction enterprises in Tanzania*, ILO, Management Development branch, Geneva, 1983

Kimambo, R.H. (1984) *Mining and mineral prospects in Tanzania*. Eastern Africa Publications Ltd., Arusha

Kimambo, RH (1988) *Development of the non-metallic minerals and the silicate industry in Tanzania, A profile of the silicate industry in Tanzania*, Arusha, Tanzania

Kisimbo, AT (1993) *Transfer of technology: Temdo experiences*, prepared by Kisimbo, AT, Head of Technical Extension Services, Tanzania Engineering and Manufacturing Organization, TEMDO, Dar Es Salaam 1993

Komba S.C. et al. (1989). *Increased productivity through incentive schemes in the construction industry in Tanzania*. Dar es Salaam

Komba, S.C. (1988) *An ad-hoc evaluation of the level of performance of the construction sector in Tanzania.*, Dar es Salaam

Komba, S.C. , (1992). *Identification & promotion of utilisation local resources and locally produced materials for construction industry in Tanzania*. Final report phase I, National Construction Council, Dar es Salaam

Kussendrager, N., (1991) *Tanzania* ; Koninklijk Instituut voor de Tropen, Amsterdam

Kyessi, A., Mwaiselage, A.A and Seleki, B., (1995), *Shelter situation in Tanzania*, a paper presented during the National Workshop on Prefabrication in Housing Construction, CHS, ARDHI, Dar es Salaam

Kyessi, A.G., (1995), *Overview of the Human Settlements Development and Management in Tanzania;* conference paper presenteed at the National workshop on launching Habitat II for NGO's, CBO and other actors, Dar es Slaam, 12-14 paril 1995, CHS, ARDHI, Dar es Salaam

Lapperre, PE (1994) *Elements of Tanzanian History*, a working paper, (unpublished), ITDS, Technology Management ,TUEindhoven

Lubell, H (1991) *The informal sector in te 80's and the 90's*, an OECD report, OECD, Paris

Makileo, H & Kinasha (1995)*Building construction industry in Tanzania*, CHS, Dar es Salaam

Maliyamkono,TL (1990) *The second economy in Tanzania*, University of Dar Es Salaam

Manyeresa, J.M. (1990).*Housing delivery system in Tanzania: an attempt to cut down cost*. Report no. 1647, 55th ICHPB, Institute of Housing Studies, Rotterdam

Mark, D.F.W. van der. (1975) *Tanzania. Landendocumentatie*, Koninklijk Instituut voor de Tropen, Amsterdam

Maro, W.E. et al. *Construction cost trends and control mechanisms in Tanzania*. Economic Research Bureau/University of Dar es Salaam, 1991.

Marshall Macklin Monaghan Ltd, (1979) *Dar es Salaam Master Plan*, Ministry of Lands, Housing and Urban Development, Dar es Salaam

Materu, J.S. (1993), *An overview of the performance of the shelter sector in Tanzania*, a conference paper for the 5th HABINET International Semniar on construction management for sustainable selfhelp housing in HABINET countries, novembr 1993; CHS, ARDHI, Dar es Salaam

Mateso, P., (1993) *Urban Planning in Tanzania: State of art and proposals for improvement*, MSc thesis Institute for regional wissenschaft der Universitat Karlsruhe. Germany,

Ministry of Finance (1992) *Rolling Plan and forward budget for Tanzania 1993-94 / 1995-96*, a joint publication by The Presidents Office Planning Commission and the Ministry of Finance Dar Es Salaam

MLHUD, Ministry of Lands, Housing and Urban Development, (1995) *National Land Policy*, Dar es Salaam

MLYD Min of Labour and Youth development (1991*) Tanzania the informal sector, 1991*, prepared with assistance from UNDP/ILO, URT/91/028, Dar Es Salaam

Mutagahywa,B & Materu, PN (1992).*Academic - Industry links, Development of a vital partnership*, Faculty of Engineering, University of Dar es Salaam

Mwaiselage, A.A., (1984) Self help housing cooperations in urban and rural Tanzania; MSc thesis, Katholoieke Universiteit Leuven, Belgium

Mwaiselage, A.A., (1986) Training of small contractors in construction management; study for workshop building process and resoruce management., Institute for Housing Studies Rotterdam

Mwaiselage, A.A., (1992*) Development of Local Construction Capacity in Building Works through Small Scale Contractors in Tanzania*, Centre for Housing Studies (CHS) , Ardhi institute, Dar es Salaam.

Ndatulu, T.S., Makileo, H.B.,(1989) *Housing Cooperations in Tanzania*, BRU, Dar es Salaam

NBAQS&BC National Board of Architects, Quantity Surveyors & Building Contractors. (1991).*Workshop on procurementand management of foreign funded construction projects in Tanzania*. Workshop papers, Arusha

NBAQS&BC (1992) *List of registered architects, quantity surveyors and building contractors dec 1992*, Dar Es Salaam

NBS National Bureau of Statistics (1990) *Population census 1988, Dar Es Salaam regional Profile*, Dar Es Salaam, december 1990

NBS National Bureau of Statistics (1991) . *Statistical abstract 1991.* Dar es Salaam

NBS National Bureau of Statistics (1992) *Directory of industries, Industrial census (1989)* Vol I + II, Sept. 1992,Dar Es Salaam

NBS National Bureau of Statistics (1992) *Higher and Technical Education Statistics in Tanzania, 1987/1988 - 1991/1992,* Dar Es Salaam, 1992

NBS National Bureau of Statistics (1992) *Population census, Basic demographic and socio-economic characteristics, 1988,* Dar Es Salaam

NBS National Bureau of Statistics (1993) *Education and training statistics 1991,* Dar Es Salaam,

NBS National Bureau of Statistics (1993) *Foreign Trade Statistics,* 1990, Dar Es Salaam

NBS National Bureau of Statistics (1994) *Environment Statistics in Tanzania Mainland,* Dar Es Salaam

NBS National Bureau of Statistics (1993) *Labour force survey 1990-1991,* NBS, Labour department, Dar Es Salaam

NBS National Bureau of Statistics.(1994) *National accounts of Tanzania 1976-1993.* Dar es Salaam

NBS, National Bureau of Statistics (1994) *Household Budget Survey 1991/1992, Volume III Housing Conditions in Tanzania Mainland,* the President's Office, The Planning Commission, Dar es Salaam

NCC National Construction Council (1991), *National Construction Industry Development Strategy.* National Construction Council , Ministry of Works Dar es Salaam

NCC National Construction Council (1995), *Proposed National Construction Industry development Policy,* National Construction Council , Ministry of Works, Dar es Salaam

NCC National Construction Council. (1982) *Role of contractors in national development.* Seminar papers. Arusha

NCC National Construction Council. (1993) *Workshop on the use of Schedule of Rates and applicability of NCC fluctuation formula under prevailing economic conditions.* Workshop papers. Dar es Salaam

NCC National Construction Council (1992) *Research and development issues in the construction industry in Tanzania,* Dar Es Salaam

Nnkya, A (1984) *Housing and design in Tanzania,* Royal Danish Academy of Art

Nyanchia, WL1993 *Industrial Development: Perspectives on challenges ahead,* prepared by Nuachia, Director of investments and project implementation, Ministry of Industry and Trade, presented on conference on African Industrialization, Dar Es Salaan, november 1993

Nyonyi, Ms WNA1993, *Technology dissemination in Tanzania: Tirdo Experiences,* prepared by Ms Nyonyi, head of the infromation dept, Tanzania,industrial research and development organization, paper presented to Africa Industrialization Seminar, Dar Es Salaam november 1993

Rubaratuka,IA. (1995) *Cost saving strategies in housing construction,* CHS, DAR ES SALAAM

Rijkenberg, S.J. (1996) *Adaptations to a cost control system : cost control as a tool to achieve productivity improvement on building sites of Skanska Jensen Int. in Tanzania* / by Saskia J. Rijkenberg ;supervised by Emilia L.C. van Egmond-de Wilde de Ligny. - Eindhoven : Technische Universiteit Eindhoven

SDP, Sustainable Dar es Salaam Project of the Dar es Salaam City Council, (1995) *Community Infrstructure programme for Dar es Salaam, preliminary 5 year Programme proposal,* Dar es Salaam City council, Dar es Salaam

Silver, MS(1993)*The Growth of manufacturing Industry in Tanzania, an economic history, Tanzania and the impact of structural adjustment programmes.,* V 93-90872, UNIDO Dar es Salaam

Tegelaers, M., (1995) .*Performance upgrading of informal building contractors in Dar es Salaam. A case study intothe characteristics and problems of informal small scale building contractors in Dar es Salaam, Tanzania.*M.Sc thesis supervised by Gaillard,H., Egmond, E van,ITDS/Technology Management, Eindhoven University of Technology

The President's Office / The Planning Commission. (1990) *National Investment Promotion Policy,* Dar es Salaam.

Treffers , M., (1996) *The informal building process for houses in Dar es Salaam, Tanzania : a contribution to the upgrading of the informal construction sector and to the formulation of a management plan for hazard lands* / by Marten Treffers supervised by Emilia L.C. van Egmond-de Wilde de Ligny Eindhoven Technische Universiteit EindhovenTIRDO (1992)*Tanzania Industrial Research and Development Organisation: Facts about TIRDO,* Dar es salaam

Uliwa, P. SIDO (1992*) The contribution of the informal sector/micro enterprises in absorption and diffusion of locally generated technology,* Dar Es Salaam, 1992

UNCHS (1993) World Urbanization Trends, Estimates and projections of urban population and urban agglomerations to the year 2025, UN New York

UNDP. *Human Development Report.* Oxford University Press, Oxford/New York, (various issues), New York.

UNESCO. Statistical Yearbook. (various issues), Paris.

UNIDO(1993)*The regeneration of Tanzanian Industry: Liberalization and Privatization*, PPD.193, UNIDO, Vienna
UNIDO(1993) *African Industry in Figures, 1993*, UNIDO, Vienna
University of Dar es Salaam (1993) *Review of Training and Practice of Engineers in Tanzania*, Proceedings of a workshop on 16th and 17th September 1993, Fac of engineering, Univ of DAR ES SALAAM , Dar Es Salaam
Watugulu, T.M. (1992) .*Construction industry economic statistics in Tanzania 1976-1990.* National Construction Council, Dar es Salaam
Wells, E.J. (1984) *Expansion of public sector construction in Tanzania.* National Construction Council, Dar es Salaam, 1984.
World Bank ,*World Tables* (various issues), World bank, Washington DC
World Bank Population and Human resources East Africa Department (1995), Socio-Economic growth and poverty alleviation in Tanzania, WB, Washington DC
World Bank(1993) *Tanzania: a poverty profile*, Ferriera, ML, WB, Washington DC
World Bank(1995) *Human Resource Development Survey, Tanzania*, Ferriera, ML, Griffin, CC, WB, Washington DC, Vol. I, Annexes I & II

Literature Part III Costa Rica

Acuna Ortega, V.H., Molina Jimenez, I., (1994) *Historia economica y social de Costa Rica* (1750-1950), Editorial Costa Rica, San Jose , Costa Rica
Aguilar Bulgarelli Dr. Oscar and Brenes Rosales Dr. Raymundo (1993) *Banco Hipotecario de la Vivienda (BANHVI). Una institución para la Justicia Social.* San José, Costa Rica
Alfaro Rodríguez, Dionisio (Compilador). (1994) *Código Urbano, República de Costa Rica.* Colección LEYES Editorial Porvenir S.A.
Banco Central de Costa Rica. Departamento Monetario,(1993-1995) *Sección Balanza de Pagos. Principales Estadísticas sobre las Transacciones Internacionales de Costa Rica* San José, Costa Rica
Bennis, M.,(1997), Inflatiespook heeft geen ruggengraat, about J. Stiglitz, vice-president Worldbank, in Algemeen Dagblad 18-10-1997
Biesanz, R, Biesanz, Mavis Hitunen Biesanz , (1993) *The Costa Ricans*, Prentice Hall, New Yersey 07632
Business Roundtable (1980). Measuring Productivety in Constrution. 200 Park Avenue, New York, USA (221 682 6370).
Cámara Costarricense de la Construcción. (1995) Estadística y Economía. Revista Construcción, mayo - junio 1995
Camera Costarricense de la Construcci¢n (1996) Organo oficial de la Ca mera Costarricense de la Construcci¢n, a¤o 3 San Jose, Costa Rica
CIA, (1995) The World fact Book, CIA, Washington DC
CIVCO Centro de Investigaciones en Vivienda y Construcción. (1992) Experiencias y Necesidades de Capacitación de Mano de Obra Especializada en el Sector Construcción. Report, Cartago, Costa Rica
CIVCO, Centro de Investigaciones en Vivienda y Construcción. (1993).Informe de Labores Período 1993. Cartago, Costa Rica
CIVCO, Centro de Investigaciones en Vivienda y Construcción. (1993).Seminario Centroamericano sobre Tecnologías y Sistemas de Construcción para Vivienda de Interés Social. Perfil de los países. DANIDA - CIVCO - Consejo Centroamericano de la Vivienda. Cartago, Costa Rica
CFIA, Colegio Federado de Ingenieros y de Arquitectos de Costa Rica. (1994) Desarrollo del Sector Económico de la Construcción en Costa Rica entre 1986 y 1993. In Revista del Colegio, No. 3
CFIA, Colegio Federado de Ingenieros y de Arquitectos de Costa Rica.(1993) Guía de requisitos para presentación de planos ante la Oficina receptora de permisos de Construcción. CFIA, San José, Costa Rica,
CFIA, Colegio Federado de Ingenieros y de Arquitectos de Costa Rica.(1993)Reglamento de Contratación de Servicios y Tarifas. CFIA, San José, Costa Rica,
Comisión Nacional de Emergencia, Dirección de Prevención y Mitigación. , (1993) Uso del suelo con fines constructivos en áreas de amenaza natural. San José, Costa Rica
Comisión Económica para América Latina (CEPAL),(1996) *Costa Rica: Una revisión de las políticas aplicadas a partir de 1986*, julio 1996

Derks, M.A.P.H., (1996) Analisis e identificaci¢n de la problematica en el proceso de la ejecuci¢n de vivienda de interes social en Costa Rica, CIVCO, Cartago Costa Rica MSc thesis supervised by Egmond, E. van, ITDS/Technology management, TU Eindhoven

Director Generaat Internationale Samenwerking.(1991) *Beleidsplan voor de periode 92-95, regio midden america no.6.*, The Hague, the Netherlands

Dorgan, C.A. (1995) *Gale country and world rankings reporter* : 3.000 country & world area rankings on a variety of topics, including arts and leisure, demographics, education, government expenditures, taxes, etc., from government, business, and general interest sources ; London : Gale Research

Economist Intelligence Unit (Linden, U.K.) (1994) Country report on Costa Rica, 3th quarter 1994.

Ellenberg, L., Bergemann, P.,(ed) (1990), *Entwicklungs Probleme Costa Ricas* , Saarbrucke, Fort Lauderdale, breitenbach, ASA Studien 18.

Fernández Figueroa, Eduardo (INS). mayo - junio 1995. Salud Ocupacional. in Revista Construcción, Cámara Costarricense de la Construcción San Jose Costa Rica

Fernández Flores, Juan Alejandro. 1987.Los Costos en la Construcción Civil. Trabajo final para obtener el grado de Licenciado en Ingeniería Civil. Universidad de Costa Rica, Facultad de Ingeniería, Escuela de Ingeniería Civil

Fernando Zumbado Jiménez, 1991. *House Now! Building for hope in Costa Rica.* Building and Social Housing Foundation

Figueroa, Eduardo Fernández. 1991. Evaluación, Cuantificación y administración del riesgo como herramienta gerencial para las empresas constructoras. Proyecto de graduación presentado para optar al grado de licenciado en ingeniería de construcción. Instituto Tecnológico de Costa Rica, Departamento de Ingeniería en Construcción

Fuentes Molina, Abraham E. , 1993. Rendimiento de mano de obra en la construcción de viviendas. Informe formal de práctica de especialidad. Instituto Tecnológico de Costa Rica, Departamento de Ingeniería en Construcción, Cartago

Haber, Harvey (APA Publications: Inside Guides). 1993 .Inside Guides: Costa Rica

Hall, C., (1991), El Cafe y el desarrollo Historico Geografico de Costa Rica, Editorial Costa Rica, San Jose , Costa Rica

Gutiérrez, Jorge, Vliet, Willem van , Arias, Ernesto, and Pujol Rosendo. (1993) *.In defence of Housing. Housing policies and practices in Costa Rica.* in Habitat International vol. 17, No.2, pp. 63-72,

Herrera, W., 1985 Clima de Costa Rica, vegetaci¢n y clima de Costa Rica, vol.2, Editorial Universidad Estatal a Distancia, San Jose, Costa Rica

http://www.odci.gov/cia/publications/nsolo/factbook/map-gif/cs-150.gif

INICEM-Market Data (1994-1996), *Costa Rica: Datos e Indicatores Basicos,* San Jose, Costa Rica

Jacobs, Edwin M. , 1993. La industrialización de la producción de vivienda en Costa Rica: el caso de marcos, puertas y ventanas. MSc thesis supervised by Egmond, E. van, ITDS/Technology Management, TU Eindhoven

Landaeta, G., 1994 *Strategies for Low-income housing, a comparative study on Nicaragua, Mexico, Guatemala, Cuba, Panama, Costa Rica and El Salvador,* Lund University, Sweden.

Lara, S., Barry, T., Simonson, P., (1995), *Inside Costa Rica,* Interhemisphere Resource Centre, New Mexico 87196

MIDEPLAN, (1996) *Panorama Nacional 1995, balance social, economico y ambiental,* San Jose, Costa Rica

Ministerio de Economía, Industria y Comercio - Dirección General de Estadística y Censos, Sección Estadísticas Vitales. 1995.Costa Rica, Cálculo de población, por provincia, cantón y distrito al 1 de julio de 1994. San José, Costa Rica

Ministerio de Economía, Industria y Comercio, Dirección General de Estadísticas y Censos, Sección Estadísticas y Censos. julio 1994Encuesta de hogares de propósitos múltiples módulo de empleo. San José, Costa Rica,.

Ministerio de Economia, Industria y Comercio, Direccion General de Estadisticas y Censos, 1996 San Jose, Costa Rica

MIDEPLAN Ministerio de Planificaci¢n Nacional y Politica Econ¢mica , 1985, Sistema de Regionalizacion del Ministerio de Planificaci¢n Nacional y Pol¡tica Econ¢mica, decreto (regulation) No. 16068-Plan de 15 de Febrero de 1985

MIDEPLAN Ministerio de Planificación Nacional y Política Económica (MIDEPLAN-PNUD). 1994.Costa Rica en Cifras: 1950-1992. By: Juan Rafael Vargas y José Olegario Sáenz

MIDEPLAN Ministerio de Planificación Nacional y Política Económica marzo 1994. Panorama Económico de Costa Rica 1993. San José,.

MIDEPLAN Ministerio de Planificación Nacional y Política Económica. , marzo 1994. Panorama Social de Costa Rica 1993. San José

MIDEPLAN Ministerio de Planificación Nacional y Política Económica. 1995.Costa Rica: tendencias sociodemográficas, económicas y ambientales, 1980-1994. Fondo de población de las Naciones Unidas, San José, Costa Rica

Ministerio de Vivienda y Asentamientos Humanos. 1995Informe Anual de Labores 1994-1995

Ministerio de Viviendas y Asentamientos Humanos. 1993.Sectoría Ejecutiva de Planificación Sectorial. Seguimiento Plan Nacional de Vivienda y Asentamientos Humanos 1992.

Ministerio de Viviendas y Asentamientos Humanos. 1994 Sectoría Ejecutiva de Planificación Sectorial. Seguimiento Plan Nacional de Vivienda y Asentamientos Humanos 1993

Morales Quirós, Ing. Eduardo. Ministerio de Viviendas y Asentamientos Humanos. 1994. Programa de Desarrollo Habitacional de Base Comunitaria. Despacho del Viceministro. El déficit de Viviendas. San José, Costa Rica,

Orlich, Francisco J., 1994 Plan Nacional de Desarrollo 1994-1998. Diagnóstico y Estrategia. MIDEPLAN, San José

Productos de Concreto S.A. 1997, Diseños de casas, Sistema Prefa PC, San Jose Costa Rica

Productos de Concreto S.A., 1997, Un concepto consolidado en vivienda prefabricada, Sistema Prefa PC San Jose, Costa Rica

Proyecto Estado de la Naci¢n, (1996) *Estado de la Naci¢n en desarrollo humano sostenible, informe 2*, San Jose, Costa Rica

Rodriguez vega, E., (1992) *Biografia de Costa Rica*, Editorial Costa Rica, San Jose , Costa Rica

Rottenberg, S., (ed) (1993) Economy of Poverty, Equity and Growth: a Comparative study on Costa Rica and Uruguay, World Bank, Washington DC

Schreur, P., (1998) *Analysis of the construction process of low-income housing in Costa Rica: a search for opportunities to improve the performance of the construction process and the applicability of technology-based research methodology*; MSc thesis in colllaboration with CIVCO-ITCR, Cartago Costa Rica, supervised by Egmond-de Wilde de Ligny E.L.C. van, ITDS/Technology Management TU Eindhoven

Thielemans, J (1997) *Estudio comparativo de impacto ecologio en estructuras: "bloques de concreto vs. panelescon bambu" un enfoque de analisis de ciclo vida*, MSc thesis in colllaboration with CIVCO-ITCR, Cartago Costa Rica, supervised by Egmond-de Wilde de Ligny E.L.C. van, ITDS/Technology Management TU Eindhoven

United Nations Economic and Social Commission for Asia and the Pacific United Nations, *A framework for technology-based development, technology content assessment, Technology Atlas Project*

Vargas Calderón, Ing Sonia (Compiladora).(1992).Seminario Taller Inaugural. El CIVCO y el Sector Construcción: Investigación y Desarrollo. Centro de Investigaciones en Vivienda y Construcción. Cartago, Costa Rica

ZITRO(1993) *Guia del constructor: sistema prefabricado de vivienda ZITRO antisismico*

ZITRO (1997) *Sistema Prefabricado de Vivienda Zitro: Manual Tecnico*, San Jose, Costa Rica

Glossary

Adequate housing refers to shelter that meets the *basic requirements* of tenural security. structural stability and infra structural support and that has convenient access to employment and community services. (UNCHS 1994)

Affordability of a house: means that the house is within the financial abilities of the inhabitants.

Construction industry refers to "all enterprises, institutions and persons which are involved in the realization of a building construction project on-site, this includes those activities that lead to the shaping of a man-made built environment which meets the human needs for shelter and infrastructure".(ISIC 1968)

Construction project management refers to the attuning of the tasks and responsibilities of the various parties in the construction process and has an impact on the efficiency and effectivity of the construction process.

Construction process involves "all necessary activities and the interactions between the parties -involved in construction- with the objective to establish a building and/or a built environment responding to human needs." (Ofori 1990) The process includes activities entailed by the physical realization of the designed facility and can be subdivided in different phases from identification to demolition.

Development is generally used to indicate the phenomena of change in a society , in principle with a national goal to achieve a high and rising standard of living for the inhabitants of the country. (Goulet1977, Porter1990).

Direct and indirect actors have an impact on the final construction process on-site. The *direct actors* in the construction industry -like in any other sector- can be classified in two directly involved aggregated groups: Ia. the *demand-side actors* (public sector clients, private owners, property companies, investors) and Ib the *supply-side actors* (the construction units) *Indirect actors* in the construction industry include a. technology supplying institutions (R&D institutes, educational institutes, architects & consultants, building materials suppliers, equipment suppliers and plant hire firms) and b. *technology supporting and regulating institutions* (financing institutions, the national government and public agencies, branch organizations and labor unions)

Economic Construction Project Performance (ECPP) ECPP = *Value of the site output / Costs (M+ T(L+E +I+ Man+ Sub))* Whereby M = materials, T= technology, L= labor,, E= equipment, I= inform, Man= managemnt, Sub= subcontractor.

Economic growth refers to the increase in the quantity or the value of the goods and services produced in a local economy through "mobilization of domestic and foreign saving to generate sufficient investment to increase economic growth". Economic growth should be seen as one of the means to achieve societal development goals. Economic growth requires the allocation of capital in production.

Geographic-physical variables of importance for the construction industry are (a) the geographic location of the country, (b) geology, (c) demography and urbanization and (d) physical infrastructure.

Household refers to (1) a person, who lives alone in whole or part of a housing facility and has independent consumption or (2) a group of two or more persons who occupy the whole or a part of a housing facility and share their consumption.

Human resources stock refers to the stock and nature of human resources in a country that can be committed to the production system in a sector. This stock is a partial indicator of the technological capabilities in a country that reflects the potential of human embodied technologies for a sector in terms the quantity, educational and experience level of persons. Indicators are 1. the population profile, 2. the age structure, 3. the educational profile, 4. the employment profile, 5. the skill profile in terms of labor - force employed as researchers, teachers, managers/engineers, specialized technicians, crafts persons(skilled), laborers (semi-skilled & unskilled).

Indigenous technology developments are technology changes through local efforts and with local means (such as local R&D activities, on-the-job innovative activities in the enterprises, education programs).

Industrialization is a process of standardization and systematization of production systems, with the objective to achieve a faster and more efficient production process that result in a better performance, a higher productivity and an increased contribution to economic growth.

Intermediate product-technologies in the construction projects represent the "building-components" like windows, doors and casements and even "building-elements" like complete parts of a wall structure, roofing structure, etc that are produced off-site with a standardized industrial process.

International technology setting indicates the characteristics of the international environment that have an impact on the performance of a production sector in a country on the national and international technology market.

International technology transfer refers to the technology investments (selection, acquisition and adoption of new techniques, product-technologies and process technologies) from foreign sources.

Lower income households: those households with an income below the current minimum wage in the respective country

Nation refers to a community of people -composed of one or more nationalities - living together on a more or less defined territory, with an independent status and sharing the national resources within a framework set by the national government.

National setting refers to the characteristics of the country that have an impact on the technological production performance of sectors. The setting in a country is determined by (a) the social system characteristics, (b) the characteristics of the geographic physical system (c) the historic backgrounds of the country

Natural resources stock refers to the total stock of exploited natural resources in a country that can be committed to the production system. This stock is a partial indicator of the technological capabilities. It reflects the capabilities to exploit and utilize the available natural resources in the production system. Indicators are the quantity and attributes of the exploited natural resources for the major inputs in a production process (land, water, energy, forest, metallic and non-metallic mineral resources).

Product technological features of the production output of a construction process (buildings composed out of elements, work-sections and construction products) is determined by its (a) function, (b) geometric appearance, (c) materialization, (d)technical-physique attributes , (e) production complexity (time) (f) price

Production input comprises all resources that are directly needed on site in the realization of the site output.

Production output of a construction process includes whole facilities (the total finished building as construction end-product) and can be de-composed in the components of the building : (1) construction products (building materials), (2)work sections(building components), (3) elements (ISO/TR 14177:1994). The *construction site output* is a building, which quantity and quality is specified by the client.

Production process technology is the technology needed for the transformation of resources (natural resources and intermediate products) into the production output. The process technology is composed of a combination of four components. These components embrace: (1) object embodied technology (Facilities or Techno ware), person-embodied (Abilities or Human ware), document embodied (documented facts or Infoware), institution embodied (frameworks or Orgaware) Any transformation process only can take place when a minimum is present of all four components of technology. All four components can be marketed separately. (UN-ESCAP 1989) The process technology components can be classified upon rate of advancement.

Production refers to the application of means and procedures for the transformation of the inputs (natural resources and intermediate products) into desired outputs (goods and services). (Chase and Aquilano) Capital (including natural resources and produced resources, intermediate products such as equipment, tools and machines) is a key-element for production.

Social system variables of importance for the construction industry are (a) the political system, (b) the economic system, (c) the educational system.

Society refers to communities of people which are characterized by having common traditions, organizations, collective activities and interests.(Webster's) *Societies* can be seen as a network of social interrelations between human beings: a social system, with their characterizing structure and culture, embedded in a particular physical environment. (Lapperre 1993)

Stock of houses includes the adequate houses, the houses at sub-standard level and the houses in-adequate for habitation.

Sustainable Development is "a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future as well as present needs" (WCED, 1987) The objective of striving after sustainable development is to ensure the improvement of the quality of life both for present and future generations. To achieve a strong sustainable development it is necessary to optimize the allocation and scale of the use of capital in production, which is certainly a clear assignment for technologists and engineers.

Technological construction project performance is the product of efficiency and effectivity of the construction process **TPP = Inp. Teff x T effect. = Inp. x THIOr/THIOi x Oi/Or.**

Technological effectivity of production projects refers to the rate to which the product-technological characteristics of the desired output are achieved both qualitatively and quantitatively.

Techn Effectivity =O i/ O r (Oi= idealtypical output, Or= real output)

Technological efficiency of production projects refers to the ratio of actually utilized versus the theoretically possible utilization of means and procedures for the transformation of inputs into desired outputs.

Techn .Eff = THIOr / THIO (THIOr= real THIO , THIOi = idealtypical THIO) The nature of the production input determines the rate of efficiency. Thus in the calculation of the efficiency coefficient we have to take into account the status of the product technologies of the building components and the building elements expressed in a coefficient . The technology efficiency of the production process then has to be multiplied with this coefficient .
Techn.Eff = Inp.THIO r / THIOi ;(THIOr = real techn. inputs , THIO i = ideal typical techn input)

Technological project performance refers to "the degree to which the realization of a required and predetermined construction project output can be realized efficiently and effectively within the framework of the predetermined costs and construction period"

Technological self-reliance refers to the domestic abilities to determine and decide on the objectives, norms, standards, values, expectations (the cultural components of the technology sub-system in a nation) with regard to technology and technological development,. Technological self-reliance also refers to the abilities to build-up, maintain, and further develop the network of collaborating organizations, institutes and enterprises which acquire, adapt, utilize, develop technologies and support these activities for the benefit of effective production . Technological self reliance thus can be defined as the *autonomous capacity* in a country to make and implement decisions and thus to exercise choice and control over areas of partial technological dependence or over a nation's relations with other nations. The autonomous capacity is seen as an important element for sustained socio-economic development. A nation should dedicate its efforts to the development of its technological creative system in order to decrease the technology dependency position and create a technological self-reliance situation.(UNIDO, Stewart 1978)

Technology planning can be defined as the analysis of relevant information from the present and the past and an assessment of probable future developments, so that a course of action (plan) may be determined, that enables an organization, a sector or a nation to achieve its stated objectives.(Porter A 1995) Planning at the different levels of economy exhibits the following characteristics: (1) the existence of national, sectoral or organizational goals, (2) a possible identification of alternative strategies, (3) existence of logic and analytic procedures to assist in decision making on courses of action, (4) implementation of the decisions through former and well elaborated planning appears to be feasible in most cases.

Technological capabilities are to the total stock of *national resources* that can be committed to the production system, giving the necessary inputs for efficient and effective production. The stock of national resources is composed of the stock of technologies, human resources, natural resources the organizations and institutions that are part of the sectoral technology infrastructure. This stock of resources should supply the country with the means, skills, know-how and knowledge to select, master and adapt the technologies needed and most appropriate to the social system of the country concerned. This stock should also enable the country to develop and generate its own new technologies (self-reliant technology generation). "The technological capability and the potential which is to be found at the different levels of economy can control as well as respond economic change is a core element for development". The technological capabilities are the core element for development and are to be found at the different levels of economy and can control as well as respond economic change, (Rosenberg, Freeman, Hollander, Enos) Due to lack of technology capabilities, a country may fail to use the scarce resources efficiently, resulting in rather high costs to enterprises and to the national economy.

Technological dependence means that a country heavily relies on foreign sources of technology acquired from the international technology market to meet the local demand for products and services, which in the long run causes the situation of dependency. These countries seemingly do not have a indigenous technology creating system. This position of sub-ordination is characterized by an asymmetric situation between countries and in countries (with dualistic economic characteristics) which is enhanced by *the international technology market* which is characterized by its oligopolistic nature with a limited number of suppliers of technology and a rather extensive demand, (Steward 1990) *in-appropriate technology choices* which result in not meeting the basic needs of the majority of the population, *un-favorable costs, terms and conditions of the international technology transfers* which is assumed to be caused by *a weak technology basis and infrastructure* in the technology acquiring countries.

Technology developments are any changes in the existing product technologies and /or in the process technologies resulting in continual rises in total factor productivity not only based upon additions to capital stock but also by improvements to the existing capital stock (Dosi 1988). Technology development is considered to be a prerequisite for effective production to keep pace with the dynamics of societal development which are reflected in changes in the demand for goods and services in a country and on the international market. Technology developments include 1. adaptation and improvement of existing technologies, e.g. technology changes in established and exisiting product- and process technologies ; 2 generation of new technologies through basic research, either in-house/ on-the-job in enterprises or in R&D and scientific institutes or through international technology transfers.; 3 investments in new plants : introduction of new techniques, product-technologies and process technologies

Technology has a double meaning

a. ***Process- technology*** which is a particular complex of knowledge and skills, embodied in artefacts like tools and machines, persons, documented facts (information), organizations, procedures and processes *which is applied applied for* the production of goods and services in production *and*

b. ***Product-technology*** *which is embodied in* the output of production processes required by a society in which and by which it is being used.. (UNCTAD 1972, Stewart 1978, Bertholet 1990). Technology may be considered at the level of a specific process or activity (hence of an individual or group of a few persons), an organization, an industry, a district or region, a country, or even at global level.(UNCHS, Habitat, 1991)

Technology sub-system in the social system *(institution)*: a system of thinking (using existing science based knowledge and skills, standards, values, expectations), of organizing (using different structural set ups) and of taking actions (behaviour) which ultimately determines the way on which and the means with which the objectives for the use of technologies are being reached

Technology infrastructure *(technology network)* the network of the technology utilizing organizations and firms of the construction technology sub-system and the other technology supporting, promoting agents and groups dedicated to efficiency and effectivity of technology utilization and technology development and the complex- and outcome of interactions between them. The network includes (1) *R&D and scientific institutes*, which carry out fundamental and applied research, (2) *Production systems* (enterprises, sectors), which mainly carry out applied research (if any!) or bring about technological developments on the shop-floor. (Kline and Rosenberg 1986), (3)*technology promotion agents*, which support the technology development processes and are involved in the diffusion of newly generated technologies.

Technology management refers to the coordination of technology utilization and change, through processes of planning, organizing, directing and controlling in order to achieve stated objectives in an organization or enterprise.. The objective of technology management is to effectively achieve the desired products by efficiently running a production process in an organization.

Technology management plan refers to an instrument to guide and control processes of technology utilization and technological development in single organizations

Technology policy plan: an instrument to guide and control processes of technology utilization and technological development in a country and is concerned with the direct effects of technology on society. Technology policies need to be formulated and implemented to affect the paths of technology development, industrialization and socio-economic development. In fact one could speak here about the "management" of technology at national level.

Technology stock refers to the quality and quantity of the available range of technologies of the technology sub-system - the range of (a) process technologies and (b) product technologies which can be committed to production processes in the sub-system.

List of abbreviations and acronyms

General	
CPP	Construction project performance
GDP	Gross domestic product
GFCF	Gross fixed capital formation
GNP	Gross National Product
HDI	Human Development Index
ILO	International Labor Organization
ISIC	International System for Industrial Codification
ITS	International technology setting
NDS	National development status
NTS	National technology setting
SPP	Sectoral production performance
STC	Status of Technology Capabilities
STN	Sectoral technology needs
STP	Status of technologies in production processes
STS	Sectoral technology setting
Teff	Technological efficiency
Teffect	Technological effectivity
TPP	Technological production performance of production processes
TUE	Eindhoven University of Technology
UNCHS	United Nations Center for Human Settlements
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific United Nations
UNIDO	United Nations Industrial Development Organization
WB	World Bank

Tanzania	
BRU	Building research Unit
CHS	Center for Housing Studies
HBS	Household Budget Survey
MLHUD	Ministry of lands Housing and Urban Development
MoW	Ministry of Works
NBAQS&BC	National Board of Architects, Quantity Surveyors and Building Contractors
NBS	National Bureau of Statistics
NCC	National Construction Council Tanzania
NDC	National Development Corporation
NHC	National Housing Corporation
RoB	Registrar of Buildings
TANESCO	Tanzania Electricity Supply Company
TBR	Tanzania Building regulations
TBS	Tanzania Bureau of Standards
THB	Tanzania Housing Bank
UdeS	University of Dar es Salaam

Costa Rica	
AyA	Instituto Nacional de Acuaductos y Alcantarillados
BANHVI	Banco Hipotecario de la Vivienda, Housing Mortgage Bank
CCC	Camera Costarricense de Costrucion, Chamber of Commerce of the Construction sector
CCSS	Caja Costarricense del Seguro Social, Costa Rican Social Security
CEPAL	Comisión Económica para America Latina y el Caribe
CFIA	Colegio Federado de Ingenieros y Arquitectos de Costa Rica, Association of Engineers and architects of Costa Rica
CIVCO	Centro de Investigaciones en Vivienda y Construcción of the Instituto Tecnologico de Costa Rica (ITCR) in Cartago, Centre for research on Housing and Construction
CONICIT	Consejo nacional de Investigaciones Cientificas y Tecnologicas, the National Council for Scientific and Technological research
COVI	Comisiones Cantonales de Vivienda, Cantonal Housing Commission
DGEC	Dirección General de Estadisticas y Censos, General Directorate of statistics and Census
FONAVI	Fondo Nacional de la Vivienda, National Housing Fund
FOSUVI	Fondo Subsidiado de la Vivienda, Fund for Housing Subsidies
GAM	Gran Area Metropolitana, grand Metropolitan Area
ICE	Instituto Costarricense de Electricidad, Costa rican Elelectricity Institute
ICT	Instituto Costarricense de Turismo, Costa rican Insitute for Tourism
IMAS	Instituto Mixto de Ayuda Social
INA	Instituto Nacional de Aprendizaje, national institute for vocational training
INII	Institutode Investigaciones en Ingenieria, the Technology research institute of the University of Costa Rica
INVU	Instituto Nacional de Vivienda y Urbanismo, national institute for housing and urban development
ITCR	Instituto Tecnologico de Costa Rica, Technological Insitute of Costa Rica
MEP	Ministerio de Educación Básica, Ministry for primary education
MIDEPLAN	Ministerio de Planificaci¢n Nacional y Politica Econ¢mica, Ministry for national planning and economic policies
MIVAH	Ministerio de Vivienda y Asentamientos Humanos, Ministry for Housing and Human settlements
MINAE	Minesterio de Ambiente y Energia
MOPT	Ministerio de Obras Públicas y Transporte, Ministry for Public Works and Transport
ONG	Organizaciones Non gubernamentales, Non-governmental organizations
PC	Productos Concretos, Concrete products
PIB	Producto Interno Bruto, gross domestic product
PRODUS	Programma de investigación en desarollo urbano sostenible, Universidad de Costa Rica, Research programme on sustainable urban development of the University of Costa Rica
SFNV	Sistema Financiero Nacional de la Vivienda, National Financing System for Housing
SISVAH	Sistema de Información del Sector de Vivienda y Asentamientos Humanos, Information system on the housing sector and human settlements
SNE	Servicio Nacional de Electricidad, National Electricity services
UCR	Universidad de Costa Rica, University of Costa Rica
VB	Visto Bueno, Board for control of building aesthetics
BAMBU MC	construction system of prefab wall panels, made outof cane (Cana brava= Bambu-MC) nailed onto a timber framework
BAMBU ME	construction system of prefab wall panels, made outof split bambu battens Bambu estrillas = Bambu- ME
CB	Concrete blocks masonry construction
PREFA PC	construction system of prefab reinforced concrete wall panels, fixed horizontally between concrete columns
ZITRO	construction system of prefab reinforced concrete wall panels, fixed vertically on top of foundation wall