Decision support tool for Environmental Sustainability

How a decision support tool can help the private sector to create more environmental sustainable urban area developments.

P2 Graduation report
TU Delft, MSc Management in the Built Environment
June, 2016

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Lab supervisors:	E.W.T.M (Erwin) Heurkens & F.A.M. (Fred) Hobma
First supervisor:	Y. (Yawei) Chen
Second supervisor:	R. (Ruud) Binnekamp

"*Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.*"
(IPCC, 2007a: 4)

Colophon

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Image front page: The dashboard of CityMaker. The program developers pronounce that this interactive computer program can calculate an area development at finance, sustainability, spatial design, parking and needs of residents, which reduces handling time and improves results. (Techniplan Adviseurs, 2012)

Foreword

In front of you lies the P2 report of Marco Vogelzang, a research proposal and literature review for the graduation lab Sustainable Private Sector-led Urban Development of the master Management in the Built Environment. In this research sustainability, the changing urban development process and decision support tools are the three central topics. The research focus is on how a decision support tool can help the private sector to create more environmental sustainable urban area developments.

But why? In my future career I would like to develop myself to a project / process manager or a real estate developer of sustainable urban areas who improves the quality of life. I am interested in strategic innovation and change management for sustainable cities and local (urban) area development. In order to accomplish this I study the master Management in the Built Environment at the TU Delft, I attend courses about Urban Environmental Management at the Wageningen University and did a bachelor in Landscape Architecture. In my thesis I would like to combine all and execute a research in the subject of sustainable urban area development by using smart technologies. The studio Sustainable Private Sector-led Urban Development fits perfectly in this description.

Besides that, I have some personal learning objectives I would like to accomplish:

- Understanding how to get urban development sustainable;
- Understanding (new technological tools for) real estate developers;
- Understanding of the playing field for the various stakeholders in urban area development;
- Executing individual research.

I want to say some thanks already to Erwin Heurkens and Fred Hobma for helping me in the first weeks to frame my research, Yawei Chen for her critical and very useful advices during the next weeks and Ruud Binnekamp for the enthusiastic and interesting first guidance meeting. I am looking forward to the next step, the empirical part of graduation and I am sure I will get great guidance with you all.

Enjoy reading!

Marco Vogelzang

June, 2016

Summary and Reflection

This is a research in how a decision support tool can help the private sector to create more environmental sustainable urban area developments. It is the final step for graduation in the master Management in the Built Environment of the TU Delft. This graduation thesis is done by the graduation lab: Sustainable Private Sector-led Urban Development.

Problem statement

Worldwide there is a need for sustainable urban developments. Climate is changing and resources are overexploited (IPCC, 2014; Robertson, 2014; Rovers, 2008). In the Dutch situation the government is taking a more facilitating role in urban area development and the private sector gets into the created gab, as the new leading party in these urban developments (Heurkens, 2012). A new development approach and a need for sustainability increase the complexity of urban development and *"[current] methods are inadequate to deal with the scale and complexity of contemporary urban form and [the] multidisciplinary collaborative practice."* (Al-Douri, 2013: 523), while the possibilities of technology in city development are increasing (Townsend, 2013). Concluding, on one side there is the change in the urban development process with the need for sustainability and on the other side there are rising technological possibilities. Can these technologies be used in the private sector-led urban development process in order to optimize the environmental sustainability?

Research questions

Main research question:

- How can the use of a decision support tool improve the environmental sustainability of a private sector-led urban area development?

Sub research questions:

- How is environmental sustainability reached in urban development projects?
- How are decision support tools used in urban development projects to reach environmental sustainability?
- How can (the use of) a decision support tool be optimized to reach environmental sustainability in a private sector-led urban development process?

Research methods

First, case studies and semi-structured interviews will be used to gather information about the product and process side of current practices (in the Netherlands) in order to create environmental sustainable neighbourhoods. Second, the same methods (case studies and semi-structured interviews) will be used to gather information about the use of decision support tools in urban area development to reach environmental sustainability in these developments. Third, the results will be used in the creation of a model (or the adding to an existing model) how the use of a decision support tool can be optimized to reach environmental sustainability in a private sector-led urban development process. This model should also enhance the process side. If possible, an expert panel or expert interviews will be held in order to verify the result.

Literature and general practical preference

PhD thesis: Heurkens (2012)
Previous graduation master theses: Steen (2016), Schilder (2016) and Buskens (2015)
Other books: Adams and Tiesdell (2012), Franzen *et al.* (2011), Townsend (2013), Binnekamp, Van Gunsteren and Van Loon (2006) and Van Loon, Heurkens and Bronkhorst (2008)
For more literature, see the reference list of the P2 report.

Relevance

This research is an investigation in a large societal issue (sustainability) and in an actual occurring trend (shift to private sector-led urban development).

In the scientific world it is unclear how decision support tools can help in these private sector-led urban development process in order to reach environmental sustainability. However, there are an increasing number of tools available.

Table of Contents

1. Introduction

This report contains the research proposal of an investigation in how real estate developers can use decision support tools to support them in optimizing environmental sustainable urban areas.

First, an introduction will be given on global trends and how they affect the current practise of urban area development in the Netherlands. The first part ends with the relevance of this research. In the second part the research methodology is explained and the part third, the literature study, shows a more in-depth analysis in what (environmental) sustainability is, how the urban development process is changed to more private sector-led, and which type of tools are currently available to support the urban area development practise. In the end a provisional table of contents of the final report and a schedule for the duration of the whole research project is given.

1.1 Global trends

The world is facing some major challenges, like climate change, resource depletion and urban growth. Besides that, technological innovation is offering major opportunities.

First trend is climate change, the climate is changing and research showed that humans are causing this rapid change (Imbrie & Imbrie, 1980; IPCC, 2007a). An indication of how rapid is rapidly can be found in the report of the Intergovernmental Panel on Climate Change (IPCC, 2007b), which showed that eleven of the twelve years between 1995 – 2006 were the warmest observed years since the instrumental records began in 1850. The same organization (IPCC) states that "*anthropologic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever.*" (IPCC, 2014: 4) The atmospheric concentrations of greenhouse gases (GHGs) are currently at the highest point in at least the last 800,000 years. The IPCC concludes it is extremely likely that GHGs are the dominant cause of the observed global warming (IPCC, 2014). In that way humans are causing climate change, which implies that humans can do something. This is a huge sustainability challenge. The effects could be devastating. For instance, more than two third of the cities are situated in a delta and thereby vulnerable to the indirectly consequences of climate change, namely the risk of flooding (Aerts et al., 2009). Flooding is caused by heavy rainfall and a rising sea level, which again is caused by the rising temperature. Global warming is part of climate change (Blackmore, 2010; IPCC, 2007b). It seems contradicting that on one hand cities needs to adapt to climate change, and on the other hand, cities are a major contributor to climate change as well. This contradiction is due to the high density of all kinds of activities that come together in urban areas. A main contributor to climate change is the GHGs emitted by traffic, industry and domestic heating (EPA, 2016). Since the former happens substantially in urban areas, this is the place to implement measures to reduce the GHG emissions. Yigitcanlar and Kamruzzaman (2015) drives it even further, cities as human-dominated organisms degrade natural habitats, simplify species composition, disrupt hydrological systems and modify energy flow and nutrient cycling. These impacts of human activities are originated from population increase, urbanization, high use of private motor vehicle, industrialization and mass livestock production. They are increasing exponentially and causing a great deal of the environmental, social and economic challenges at global and local scales. (Yigitcanlar & Kamruzzaman, 2015). The need of mitigation and adaptation in the built environment is clear, this is a huge problem to be tackled in urban development.

The second trend is the challenge of resource depletion, 30 years after the publication of 'Limits to Growth' (more can be found in the literature review), the same writers state "*the flows of energy and materials required to sustain industrial growth are depleting non-renewable stocks.*" (Meadows, Randers & Meadows, 2004: 129) Economic growth is generating environmental pressure and there are limits to ongoing economic growth, for that reason economic development needs to be realized within the limits of the carrying capacity of the earth (Meadows *et al.*, 1972; Meadows *et al.*, 2004; Tellegen, 2011). Worldwide cities are responsible for almost 75% of the global resource consumption, while covering only 2% of the earth surface (Madlener & Sunak, 2011). Concept are introduced to change the linear mind-set to a circular one, like Cradle to Cradle (McDonough & Braungart, 2002) and the circular economy (Ellen MacArthur Foundation, 2012), but further steps have to be made. "*We will have to develop fundamentally different production processes that organized in a different way and use different raw materials.*" (Kroeze *et al.*, 2010: 7)

The third trend is the challenge of urban growth. In 2008 more than half of the world population lived in cities (UN, 2010). This rate and the global population are increasing. This means a massive urban growth can be expected in the next decades. The United Nations expect an almost doubled urban population in 2050 (UN, 2012). This does imply that globally a huge demand for housing, employment and others facilities is expected in the city. However, urban growth is not that much of an issue in most parts of the Netherlands. Growth can mainly be expected in the Randstad-region (Nabielek, Kronberger-Nabielek & Hamers, 2013), but it this huge

urban growth on global scale needs to be tackled in a sustainable matter. Therefor it would be great if the outcome of this thesis can be used internationally.

The fourth trend is the opportunity of technological innovation or the emergent of digitalization of technology. 2008 was not just the year that more people lived in cities than at rural areas, but also the year that there were more wireless connections (i.e. mobile phones) than wired connects (i.e. desktop computers) and the year that more things got connected to the internet than humans (Townsend, 2013). Townsend (2013) identifies how these landmarks lead to the development of the 'Smart City' concept. In this concept digitalization and big data play a major role in delivering information to decision makers in how to manages their cities. Seeing technology as the holy grail in (sustainable) development is old fashioned. According to Matthewman (2011) a shift had occurred from a technocratic expert approach to an equivalent placement of technology in a larger network of social and technological actors, called Actor-Network Theory. In this theory the importance of non-human agency, the power of technology, is seen in a social network of actors. He mentioned the positive and empowering aspect of technology, as stimuli for thought, reflection and personal development. Levels-Vermeer and Van der Weerd (2012, December 12) are giving an example of not implementing the technology available with as topic renewable energy generation in the Netherlands. They say that is more a political and economic challenge than a technical one. Often you hear that the technology is available, but that are other problems. The same can be found in the book of Townsend (2013: 77), he state that it is often not the technology that is failing, but that the real challenge lies in managing the people and organizations that would use such big, complex technical systems. In this case systems of urban dynamics was used. A question is how this technology can be used in the social system of governance.

1.2 Changing urban development process

After the economic crash in 2008 Dutch municipalities had to learn their lessons on the facts of the risk they were taking with their active ground policies. Recent decades many municipalities have bought ground for its own account and risk with the aim to develop them and afterwards sell them with profit. Partly as a result of the economic crisis on municipal land development many millions have to write off of the land development. After the crisis the losses are in the billions throughout the Netherlands. (Rfv, 2015) Partly because of this reason, the government is withdrawing from an active role in urban development and taking a more facilitating role. The private sector is stepping into this gap. Heurkens (2012) has explored this and identified a changing urban development process in the Netherlands from public sector-led to private sector-led. Private parties are taking the initiative more often and this central role could give the private party more opportunities for control. Could this central role also lead to a bigger Corporate Social Responsibility to tackle previous changes?[1] In the literature review incentives are given why private parties want to work on these challenges.

The empowerment of society have influenced this change as well. The result is the involvement of more stakeholders into the planning process. Carsjens (2009) calls this participatory planning.

With the changing urban area development process it is important for the real estate developer to find a solution how to reduce the complexity in order to create sustainable urban areas. According to Apanavičienė *et al.* (2015) there are very few attempts in scientific literature integrating the investors and real estate developers' responsibility for these kind of problems within their financial expectations. The author propose a multi-criteria decision analysis sustainability assessment to reach positive sustainability effects.

1.3 Dealing with complexity

A huge need to tackle the sustainability challenges, a change in the urban development process and more stakeholders involved are making the urban development process more complex. Researches confirms that new tools can help in overcoming the complexity of this process (Al-Douri, 2013; Beirão, 2012; Decker, 1992; Kunze *et al.*, 2012).

In 1992 Decker already mentioned the possibility to use "*computers as tools for analysis of urban spaces*" (Decker, 1992: title); "*This could yield the ultimate tool for design analysis and representation in that all previous methods could be addressed and accessed together from one place.*" (Decker, 1992: 173). He named the layer approach of McHarg in Design with Nature. In this tool all information could be in different layers and be easy accessible. He makes the comparison to the transparent paper used in design drawing. In his tool data can be assigned as attributes, which are linkages to other sources of information on the computer. The 3D world can offer different points of view, because the camera can move around easily. Designers do not have to make a new drawing for every viewpoint. Dynamic models are possible to render different points in time and

1 The topic of Corporate Social Responsibility of private parties is under investigation by Rowie Huijbreghts, another graduation student in the same graduation lab.

the computer can be used as a rational tool for analysing urban areas. An the computer offers many other possibilities. (Decker, 1992) A virtual world and different analysing layers are not enough. The urban growth causes a speed of development at a scale that is never seen before in human history. The Urban Centre of Computation and Data states that there is a need for new tools for architects and urban planners to ensure energy-efficient and liveable neighbourhood developments in the decades to come (UCCD, 2014, October 24). Kunze *et al.* (2012) go even further and state that these "*support tools can be become the foundation of a new visual design process for developing sustainable future cities.*" (Kunze *et al.*, 2012: 279) Beirão (2012) agreed upon this that the developed new planning processes and tools can improve the quality of areas. For implementation urban designers need to implement changes into the traditional urban design process and develop tools to support them. (Beirão, 2012: 26) Al-Douri (2013) also states that the current urban design method have to change: "*literature [is suggesting] that present urban design plans and methods are inadequate to deal with the scale and complexity of contemporary urban form and multidisciplinary collaborative practice.*" (Al-Douri, 2013: 523) Binnekamp *et al.* (2006: 5) also promotes the use of the computer: "*The very nature of architectural design requires that communication is done to a large extent through images, two or three dimensional. The classical vehicle for this, the paper drawing, lacks the flexibility of the computer drawing, which can be altered almost instantly.*" Recent developments have brought a wide range of urban modelling technologies to address this inadequacy, but they have not made the directed impact on the design process yet (Al-Douri, 2013). According to Lazić, Perišić and Šidjanin (2015) is the highest potential for these new technologies in urban design at the neighbourhood scale level.

Concluding, I want to investigate the new tools contributing to the decision making process in sustainable urban development. I want to focus at the combination of the social (organizational) aspects and the technical ones, also seen as process and product. I also want to know how impact can be optimized. I predict that such a technology can play a great role in the private sector-led urban development process to get more sustainable development.

1.4 Relevance research

This research is an investigation in a large societal issue (sustainability) and in an actual occurring trend (shift from public to private sector-led urban development). The shift to sustainable development have to be made on a city, neighbourhood/district and building scale level. This research contributes by investigating how decision support tools can help in these private sector-led urban development process in order to reach environmental sustainability. This is still unclear in the scientific world. However, there are an increasing number of tools available.

2. Research methodology

This chapter illustrate the research methodology. First an analysis of the problem leading to a problem statement is given, followed by the research questions. Fourth, the research design and methods are explained. Lastly, the expected results are given.

2.1 Problem analysis

In the introduction is explained that the urban development process is getting more complex. There is a new division of roles of parties and more stakeholders are involved, besides that there is a huge need for sustainability. But how can these be combined with the result of sustainable development? Technology can reduce complexity. But how can it help in the urban development process?

Understanding is needed why sustainability is also a problem that the built environment needs to tackle. IPCC (2007b) investigate the potential for different sectors to mitigate climate change by reduction of CO_2 emissions (how this relate is explained in the literature review). Particular the building and energy supply sectors are key sectors to archive positive change towards sustainability, as shown in Figure 1.

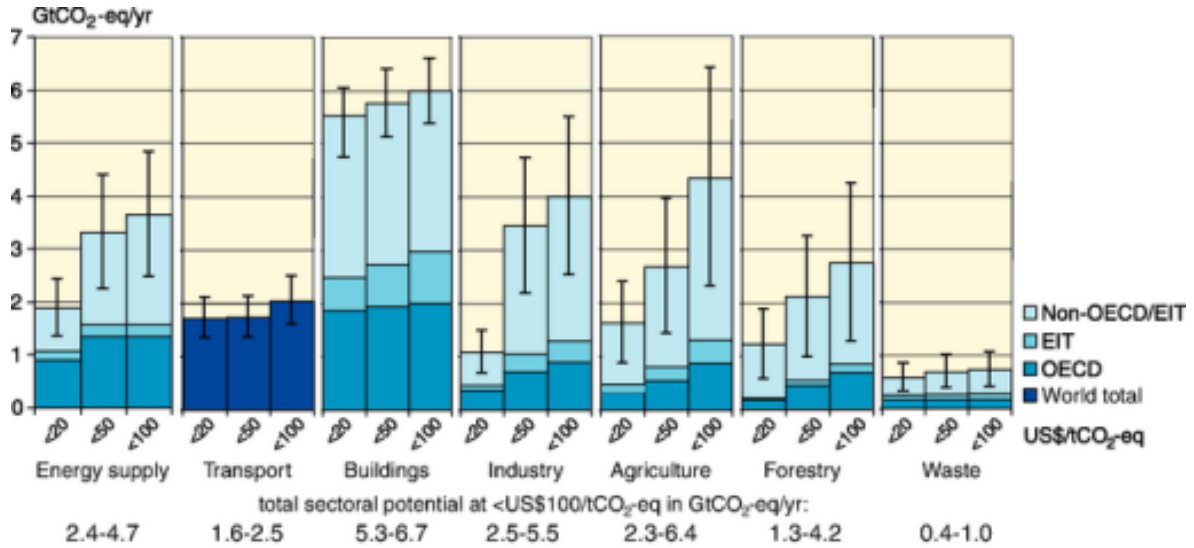


Figure 1: Mitigation potentials by sector in 2030 estimated by the IPCC. The potentials do not include non-technical options such as lifestyle changes (IPCC, 2007b).

Most Organisation for Economic Co-operation and Development (OECD)-countries are mostly high-income economies and regarded as developed countries (OECD, 2016), like the Netherlands. Figure 1 also showed that the most potential for these developed countries lies in the same sectors. Transport in this figure includes all the transport of goods and people over the world and can therefore not be subscribed to one of the categories (IPCC, 2007b). Urban design can influence the needed amount of energy, the need for transport and the buildings (explained in the literature review). The built environment in developed countries, like the Netherlands, has an impact on the mitigation of climate change.

When comparing the Netherlands to other European counties, the Netherlands lack behind addressing issues like increasing the share of renewable energy and reducing the GHG-emissions (shown in Figure 24 and Figure 26 in Appendix 1). When looking at the energy use per sector in the Netherlands the residential units consume a big part of it (shown in Figure 25 in Appendix 1). For reducing the GHG-emissions and the need for energy and increasing the share of renewable energy supply the residential stock offers great potential. Van Timmeren (2012: 313) argued that "*Especially, the introduction of solutions on an intermediate scale-level of the neighbourhood or urban district offer opportunities.*" For identifying the scale level is a balance is needed between economies of scale in needed sustainable solutions and the involvement of people who use the technology. The first one is needed for financial feasibility. Some solutions are expensive and therefor require an implementation on a higher scale level. The second one is needed to let people take their responsibility and have the awareness of what these technologies are doing. But do not forget: "*The human scale is unique, try to address as much as possible to this scale-level of implementation.*" (Van Timmeren, 2012: 337)

2.2 Problem statement

Worldwide there is a need for sustainable urban developments. Climate is changing and resources are overexploited (IPCC, 2014; Robertson, 2014; Rovers, 2008). In the Dutch situation the government is taking a more facilitating role in urban area development and the private sector gets into the created gab, as the new leading party in these urban developments (Heurkens, 2012). A new development approach and a need for sustainability increase the complexity of urban development and "*[current] methods are inadequate to deal with the scale and complexity of contemporary urban form and [the] multidisciplinary collaborative practice.*" (Al-Douri, 2013: 523), while the possibilities of technology in city development are increasing (Townsend, 2013). Concluding, on one side there is the change in the urban development process with the need for sustainability and on the other side there are rising technological possibilities to support decisions. *How can the use of a decision support tool improve the environmental sustainability of a private sector-led urban area development?*

2.3 Conceptual framework

The conceptual framework is the various aspects or features that are involved and how they might be related to each other (Robson, 2011). The main aspects of this thesis are environmental sustainability, the changing urban development process and increasing possibilities of technology. Figure 2 shows how they relate.

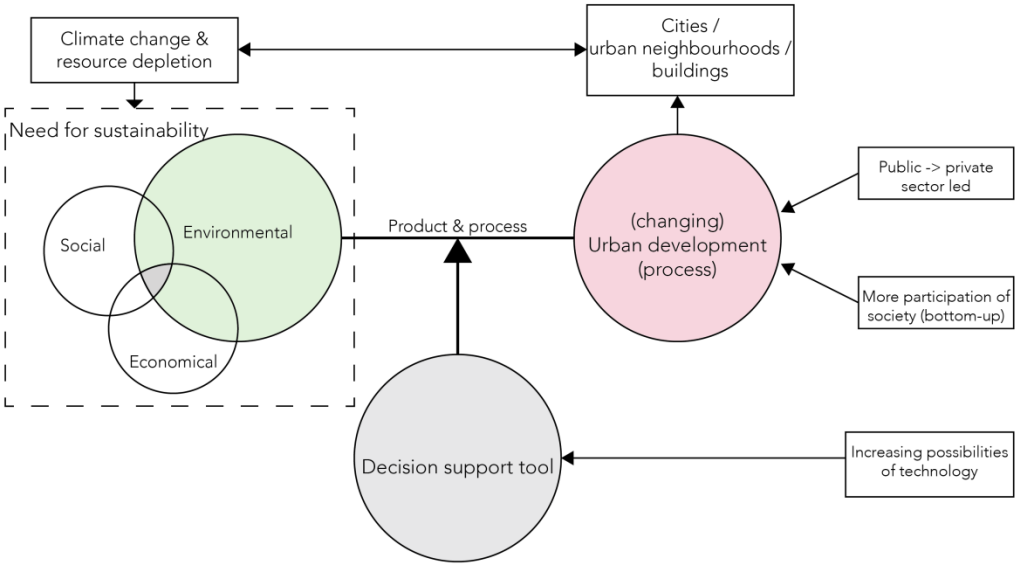


Figure 2: Conceptual model of this research (own ill.)

As shown in Figure 2 is it expected that the (environmental) sustainability and the changing urban development process have a direct relationship. The relationship between environmental sustainability and urban development is explained in the previous part and more in-depth in the literature review. The relationship between environmental sustainability and the changing urban development process have to be investigated first before involving decision support tools.

2.4 Research questions

"A research question is a question that provides an explicit statement of what it is the researcher wants to know about." (Bryman, 2012: 9)

General research question:

- How can the use of a decision support tool improve the environmental sustainability of a private sector-led urban area development?

The sub research questions are added to each other in order to answer the general research question.

Sub research questions:

- How is environmental sustainability reached in urban development projects?
- How are decision support tools used in urban development projects to reach environmental sustainability?
- How can (the use of) a decision support tool be optimized to reach environmental sustainability in a private sector-led urban development process?

2.5 Research Design

"*A research design is the road map that you decide to follow during your research journey to find answers to your research questions as validly, objectively, accurately and economically as possible.*" (Kumar, 2014: 122) Bryman (2012), Kumar (2014) and Robson (2011) identified three different research designs. Qualitative, quantitative or a combination of both. Bryman (2012) and Kumar (2014) calls this a mixed method approach and Robson (2011) a multi-strategy. The difference between qualitative and quantitative based upon three things; "*how the data was collected, how it was analysed; and how the findings were communicated.*" (Kumar, 2014: 171) and have an effect on the amount of freedom and flexibility and if the questions predetermined or developed during data collection. This research will be mainly a qualitative explorative investigation about the possibilities of how decisions support tools can improve environmental sustainability in a private sector-led urban development. However, some quantitative numbers about the amount of sustainability (energy/GHG reducing) would be great.

In more detail this research will be a cross-sectional design with case study elements, like explained in Bryman (2012: 69). According to Bryman (2012: 66) is a case study an "*detailed and intensive analysis of a single case.*" In this research multiple cases will be involved to obtain the research objectives. The cross-section

will be made in the current time. Maybe some aspects could be like longitudinal design –used for allowing inside in time order of variables by surveying the sample at least twice (Bryman, 2012)-, but the sample is not surveyed twice. Some cases could be more recent than other changes and developments in time have to be taken into account. Some more detailed variables of this research are discussed in the literature review. It will not be done in great detail, because there is a problem of pre-specifying many of the details in the research design of flexible design studies. "*The design, and much of the specific features of the project, is typically viewed as emerging and evolving during the project.*" (Robson, 2011: 393) The research design is showed in Figure 3, but it also incorporate the research methods and aims, therefore it is suggest to first read the next parts.

2.6 Research Methods

In this research case-studies, semi-structured interviews and operational research will be used as methods. These methods will be explained in that order including sampling criteria. After that validity and reliability and triangulation are discussed.

Case-studies

"*In a case study design the case you select becomes the basis of a thorough, holistic and in-depth exploration of the aspect(s) that you want to find out about. […] The case study is based upon the assumption that the case being studied is typical of cases of a certain type and therefore a single case can provide insight into the events and situations prevalent in a group from where the case has been drawn. […] it is a very useful design when exploring an area where little is known or where you want to have a holistic understanding of the situation, phenomenon, episode, site, group or community. […] This design is of immense relevance when the focus of a study is on extensively exploring and understanding rather than confirming and quantifying. It provides an overview and in-depth understanding of a case(s), process and interactional dynamics within a unit of study but cannot claim to make any generalisations to a population beyond cases similar to the one studied.*" (Kumar, 2014: 155) The case must be a bounded system, an entity in itself (Kumar, 2014). A case study can thus be used for an in-depth exploration of the first to sub research questions.

For the first sub research question sustainable neighbourhoods/districts, or other names for the same concept like zero-impact districts, eco-districts, etc. are the topic of investigation. Sampling will be done with the use of selection criteria. These criteria are based upon the features of the general research question:

1. Sustainable / Zero-impact / Eco-neighbourhood
2. Involvement of private sector / private sector-led
3. Use of decision support tools plays an important role

Interesting cases could be for instance EVA-Lanxmeer in Culumborg and/or Boo1 in Malmo. Selection will be done when starting at answering the sub research question.

For the second sub research question decision support tools, or other terms for slightly the same concept like planning support tools, design and decision support tools, urban modelling or simulation tools, etc. as long as they give new insights/information to support a decision. Sampling will be done with the use of selection criteria. These criteria are based upon the features of the general research question:

1. Integration of at least finance, sustainability and urban design
2. Focussed on product and process
3. Useful in private sector-led urban development process

Interesting cases could be for instance the Urban Decision Room, CiTYMAKER, BRIDGE, StrateGIS, Cigarbox, Urban Strategy or EcoDistr-ICT. Selection will be done when starting at answering the sub research question.

For both, first a desk research with second-hand information will be applied. Second-hand information is information gathered from "*articles, journals, magazines, books and periodicals to obtain historical and other types of information.*" (Kumar, 2014: 172) and second semi-structured interview for more in-depth information and verification will be used.

Semi-structured interviews

"*Interviewing is a commonly used method of collecting information from people.*" (Kumar, 2014: 176) Interviews are classified differently according to the amount of flexibility. Kumar (2014) describes two types of interviews: the structured and the unstructured interview. The first one is characterized by an evolutionary, flexible and open approach, while the second one is pre-determined, rigid and closed. Intermediate are interviews at different levels of flexibility and specificity. "*Unstructured interviews are extremely useful in exploring intensively and extensively and digger deeper into a situation, phenomenon, issue or problem.*" (Kumar, 2014: 177) "*In a structured interview the researcher asks a predetermined set of questions, using the same working and order of questions as specified in the interview schedule. […] One of the main advantages of an structured*

interview is that it provides uniform information, which assures the comparability of data" (Kumar, 2014: 178) The interview schedule is the list of questions. Those questions could be open-ended or closed and pre-tested. The interview schedule is a tool, while the interview is a method. (Kumar, 2014) Unstructured interviews requires more interviewing skills than does structured interviewing (Kumar, 2014). Robson (2011) and Bryman (2012) identified a third interview option, the semi-structured interview. In this category "*the interviewer has an interview guide that serves as a checklist of topics to be covered and a default wording and order for the questions, but the wording and order are often substantially modified based on the flow of the interview, and additional unplanned questions are asked to follow up on what the interviewee says.*" (Robson, 2011: 280)

The objectives of the interviews are to get in-depth knowledge into a situation and to verify the desk research of the case studies by gathering first-hand information. A flexible and open approach with a certain structure fits best for these objectives. Besides that the researcher has little experience in unstructured interviewing and a tool like an interview schedule is useful. For that reasons semi-structured interviews are fitting the best within this research. The interview schedule in this case would include introductory comments, a list of topic headings and possible key questions to ask under these headings, a set of associated prompts and closing comments (Robson, 2011).

Operational research by creating a model

The results of the previous two parts will be used in the creation of a model (or the adding to an existing model) how the use of a decision support tool can be optimized to reach environmental sustainability in a private sector-led urban development process. This model should also enhance the process side. The results should be focused upon overcoming constraints in the decision making network of actors (will be explained in the literature review). For understanding the methods Operations research methods (QRM2a, AR3R058) will be attended. Based on the gained knowledge and results of the previous two parts, a suited method will be selected. It highly expected that this is going to be the open design approach of Binnekamp *et al.* (2006).

If possible, the end-result will be verified by an expert panel or expert interviews.

Validity and reliability

"*Validity is the ability of an instrument to measure what it is designed to measure.*" (Kumar, 2014: 213) and a research instrument can be called reliable if it is "*consistent and stable, hence predictable and accurate.*" (Kumar, 2014: 215) For qualitative research "*none of the methods of data collection provides 100 per cent accurate and reliable information.*" (Kumar, 2014: 172) Some factors are affecting the reliability in social sciences: the wording of questions, the physical setting, the mood of the respondent or interviewer, the nature of interaction and the regression effect of an instrument (Kumar, 2014). According to Robson (2011: 156) threats to validity in flexible designs can be categorized in three main types: description, interpretation and theory. In description is the main treat making a valid description, because of inaccuracy of incompleteness of data. In interpretation the main treat is imposing a framework or meaning on gathered data rather than letting this emerge or occur from what you learn. The main threat in theory is not considering alternative explanations. These three can be tackles by fully transcribing interviews, check interpretations on appropriateness (for instance by others) and actively search to data which are not consonant with your theory. (Robson, 2011) The threat of interpretation is also mentioned by Kumar (2014: 197) as "*Personal bias – Information from personal diaries, newspapers and magazines may have the problem of personal bias as these are likely to exhibit less rigour and objectively than one would expect in research reports.*"

"*There seem to be no set procedures for determining the various indicators of validity and reliability in qualitative research.*" (Kumar, 2014: 220) But he gives to advice to improve the validity and reliability in this type of research:

1. Justify your choice of research method, it is important to highlight the strength and its weaknesses, as well the relevance to the main objectives of the study. (Kumar, 2014)
2. Operationalize major concepts, and how they will be measured. (Kumar, 2014)

For the reason of validity and reliability the structure of the methods in the previous parts are first a theoretical part and then application. The theory showed the strength and weaknesses of different approaches. The operationalization will be more clear after the literature review.

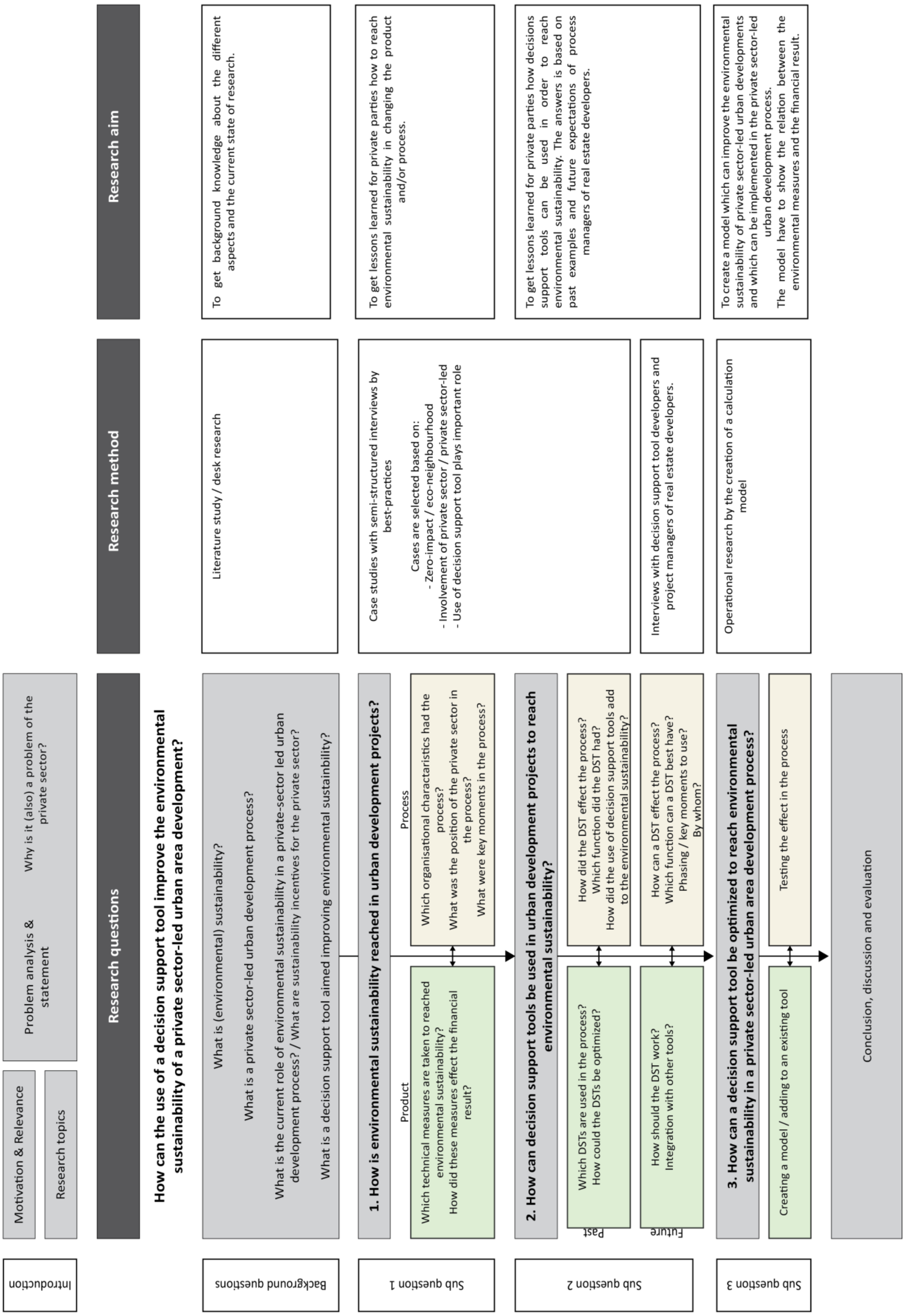


Figure 3: Research design including research methods and aims (own ill.)

Triangulation

Triangulation is "*a valuable and widely used strategy involving the use of multiple sources to enhance the rigour of the research.*" (Robson, 2011: 158) Triangulation can be reached by using more than one method for data collection (data triangulation), using more than one observer (observer triangulation), combining qualitative and quantitative approaches (methodological triangulation) and using multiple theories or perspectives (theory triangulation) (Robson, 2011).

In this research multiple cases and semi-structured interviews ensures data and observer triangulation. Theory triangulation is ensured by the use of multiple references to make a statement. This can be somewhat stronger in the end-result. Methodological triangulation is hard in this flexible research design approach. Involvement of quantitative data would make the result stronger.

2.7 Research result(s)

The research results have a product and process component.

- A model to support environmental sustainable decisions, showing the financial effect of a design (process) and how it is reducing the environmental footprint of a neighbourhood and individual buildings (product).
- An approach how this decision support tool can be best implemented in the private sector-led urban development process (process).

3. Literature Review

This literature review is the theoretical framework for this research. First a general understanding in system thinking is given. This approach is than used to give more insight in sustainability and specially the environmental component. Second, the changing urban development process is described with the change to private sector-led, the network society and the change in looking at the ground/real estate exploitation. Thirdly both topics are match with a focus on what 'the private sector' is and incentives are given why it want to involve in sustainable development. Fourth, 'tools' are explained. This consists of two major types, the Environmental Impact Assessment tools and the decision support tools.

3.1 Environmental Sustainability

Robertson (2014) believes something is going to change in the planet we call our home. The change she envisioned is from a world with the size as big as whatever culture we lived within and which felt like it were stable and unchangeable to be "*situated either at the threshold of a planetary disaster of unprecedented magnitude or at the beginning of a new sustainable era. Whatever, the outcome, the new state of the world will not be like it is today.*" (Robertson, 2014: 3)

In this part the need for environmental sustainability for our planet will be further examined. It starts with a explanation of system thinking to give a required understanding how the systems of the planet work. It continued by describing the history of awareness for sustainability an sustainable development. Then the reason why environmental sustainability is needed is in-depth explained by giving answer on why the earth gets warmer. This leads to success factors and indicators for environmental sustainability. Last, strategies and concepts for sustainable urban development are given and their functioning on different scale levels.

System thinking

"*The study of sustainability is the study of systems.*" (Robertson, 2014: 38) This implies that understanding systems is indispensable if one would tackle the need to a sustainable world. Fiksel (2006: 14) agreed upon this by asking himself the question "*Is it possible to sustain economic growth and avoid major disruptions or ecological impacts?*" His premise is as well that a system approach is required in order to effectively pursue global sustainability. There is a risk of unintended consequences if a full understanding of the system is not present. Furthermore, Robertson (2014) even state that the concept of systems is fundamental to sustainability. The example of the consequence of producing bio-based fuels is the reduction of agricultural land for food production (Fiksel, 2006). In this chapter system thinking is explained for creating a basic understanding of how the challenge of sustainability can be approached.

A system refers to a complex whole with interrelated parts, which together make the system behave in specific ways (Van Koppen, 2015), or as Meadows and Wright (2008: 2) defines it: "*A system is a set of things- people, cells, molecules or whatever – interconnected in such a way that they produce their own pattern of behaviour over time.*" If this definition is taken as granted, there are two general notions. First, the whole is

more than the sum of its parts. Investigation of how the parts together generate the specific behaviour is needed to understand the whole system. Second, irrespective of the many different kinds of systems, systems have generic features. Understanding these features is necessary to understand the behaviour of the system. These features are variables such as input, output, state and control and mechanisms such as feedback and delay. (Van Koppen, 2015)

Systems are at the root of Operations Research (Churchman, Ackoff & Arnoff, 1957). System dynamics has been developed in the 1960s by Forrester and has evolved into a widespread approach for modelling dynamics and non-linear systems (Fiksel, 2006; Townsend, 2013). The computer made fast calculation of system dynamic models possible. One of these computer models lead to the report 'Limits to Growth' by Meadows *et al.* (1972). They explain how the population growth and the need for economic growth would deplete our resources on earth. The book is seen as one of the first major steps in creating awareness in the need for sustainability. The model the researchers made had a lot of wrong assumptions, but as a tool for creating awareness it succeeded. Systems are often used in solving problems. "*The idea of 'system practice' implies a desire to find out how to use systems concepts in trying to solve problems.*" (Checkland, 1981: 125)

Two major categories of systems can be distinguished: hard and soft systems. Structured problems with clear objectives, fixed boundaries and physical variables can use the hard system approach. The soft system approach can be used if the problem has fuzzier boundaries, for instance in social systems. (Checkland, 1981)

Hard systems

"'Hard' means that they use exact mathematical system concepts as means of investigating and modelling the system." (Van Koppen, 2015: 10) Checkland (1981: 15) state that "*problems can be formulated as the making of a choice between alternative means of achieving a known end.*" This means that hard systems have a clear, hard and mostly physical boundary (for instance for energy, water, materials, etc.) alternatives can be calculated with a known end. Based on that alternatives a decision can be made. The hard system approach is useful in addressing the challenge of climate change from a product perspective.

Soft systems

Soft systems are the people, the society and organizations (De Leeuw, 2002).The soft system approach is useful in addressing the challenge of climate change from a process perspective. A focus on the people is important when using technical (hard) systems: "*[it] wasn't the biggest obstacle to building big, complex technical systems. The real challenge lay in managing the people and organizations who would use them. Humans, it turned out, were far harder to understand and control than machines.*" (Townsend, 2013: 77).

Soft vs. Hard Systems

Checkland (1981: 17) states "*The output of the [soft system] methodology is [...] very different from the output of hard systems engineering: it is learning which lead not to 'the problem' being now 'solved' but to a changed situation and new learning.*" Thus, according to him the soft systems methodology is used for learning and hard systems give clear outputs to base decision upon.

Two sides of sustainable development are described by Glasbergen (2011); the technical and governance project. The first refers to objective information and the second to social scientific knowledge and new institutional arrangements. Both descriptions fit the soft and hard systems approach. So the approach is useful for the both sides of sustainable development.

Features of system thinking

Some features of systems are inputs and outputs, processes, control processes, control inputs, open and closed systems, the black box concept, stable and instable, adaptive and non-adaptive, feedback loops and delay. The explanations are based on VAN KOPPEN.

Input and outputs. The connection of a system with its environment. Only present in open systems.
Processes. The systems behaviour.
Control processes. Feedback loops to influence the processes.
Control inputs. When control processes can be influences from the outside of the system.
Open vs. closed systems. A system related to its environment is called an open system. A closed system is an independent system without relations to its environment.
Black box concept. In a black box only input and output can be observed REF KOPPEN. The internal process are a 'black box'.
Stable / Unstable. Stable systems have a steady state and return to that state after disturbance. Instable systems can move from one equilibrium to another.

Adaptive and non-adaptive. An adaptive system can adapt to changes in its environment, the other lack this ability.

Feedback loops. Feedback loops can be positive and negative. Negative feedback loops are present when an internal control process will be triggered when a system output goes beyond some specific range to counteract the undesired output. Negative feedback loops keep systems in a stable state. Positive feedback loops reinforce the process leading to changing outputs. They make systems unstable and are often called a ' vicious cycle'.

Delay. Delay is a time lag between the output and the control processes.

Scale level of systems

Complex systems consists of subsystems, giving a hierarchy of systems. Townsend (2013) uses this to describe cities, which, according to him, can be seen as 'systems of systems'.

Urban modelling

Systems dynamics applied in an urban setting gives urban dynamic models. In the first decades of the computer system dynamics was often used in science to understand the city. But, system models have limits and have been abandoned for some time. After the development users thought to see them as oracles, but they are not. For instance, make one mistake in a formula and the output is a strange result. After these 'dark ages' urban dynamics models are now often used within the smart city concept. (Townsend, 2013)

It is important to understand why this appended. Van Koppen (2015: 3) describes the system thinking principle as "*the whole is more than the sum of its parts." And explained it as "Systems thinking rejects 'reductionism', which is the view that we can understand the behaviour of a whole system [...] by reducing it to the properties of its parts [...]. Instead, it advocates holist thinking, that is, taking into account and studying the system as a whole.*"

The urban dynamic models reduce the city to a set of top down formulas. This reductionism approach state that it is impossible to grabs all aspects into the formulas. Why are simulations currently often used? Townsend (2013) explained that computer simulations reduce the complexity of the real world, that is why they seduce precisely. Important is thus to know when applying system thinking, it is a tool to explore possible outcomes, but the more complex the system, the more uncertain the outcome will be, no matter the amount of formulas are inside the urban model. The model does not tell you why, that's often a black box.

Townsend (2013:92) used a great example between the different of the top-down Intelligent Operations Center (IOC) and two favela boys analysing the favela from bottom-up. Townsend (2013) sees the approach of the young boys as the way any community would prefer to be modelled. He compares the top-down model as a collection of objective physical measurements with the bottom-up model as a subjective story of a living and feeling organism. Two sentence are summarizing the proposed mind-set above:

- "*The computer model may tell us what is happening, but the boys' tell us why.*" (Townsend, 2013: 92)
- "*The silent watchers in the Intelligent Operations Centre [reduce] the city and their lives to set of equations, approximations and data points.*" (Townsend, 2013: 92).

Sustainable systems

Planet Earth can be seen as a self-regulating system. "*Sustainability science strives to understand the dynamics of ecological systems, social systems, and their interconnections as a framework for sustainability.*" (Robertson, 2014: 38) But an "*Integrated assessment of sustainable systems cannot be accomplished by simply linking together a collection of domain-specific models. To assess the higher-order interactions among interdependent systems requires new tools to capture the emergent behaviors and dynamics relationships that characterize complex, adaptive systems.*" (Fiksel, 2006: 17) Integral collaboration between different disciplines are needed if a sustainable system is the goal. "*The current lack of success in improving industrial sustainability, coupled with the challenges of bio complexity and resilience, indicates that sustainability is a systems problem requiring collaborative solutions [to make a step forward].*" (Fiksel, 2006: 20)

The history of sustainability

The next part focus is on the product aspect, not the process.

"*At its core, the word 'sustainability' refers to systems and processes that are able to operate and persist on their own over long periods of time.*" (Robertson, 2014: 3)

"*Sustainability is about seeing and recognizing the dynamic, cyclical and interdepend nature of all the parts and pieces of life on earth, from the soil under our feet to the whole planet we call home, from the interactions of humans with their habitats and each other to the invisible chemical cycles that have been redistributing water, oxygen, carbon and nitrogen for millions of years. [...] [Sustainability] is about the emergence*

of a new dynamic state of the world in which there is room for everyone, in which every living being can purse its right to live and to thrive, in which the great systems and cycles of the planet once again find their own state of durable yet dynamic equilibrium in patterns, form microscopic to local to global, that will endure over long periods of time." (Robertson, 2014: 3)

Sustainability is a term to bridge the gap between development and environment. Originally it came from forestry, fisheries and groundwater companies to deal with quantities, such as "maximum sustainable cut," "maximum sustainable yield" and "maximum sustainable pumping rate." (Rogers, Jalal & Boyd, 2008: 22)

The attempt is now to apply this concept of sustainability on all aspects of development (Rogers *et al.*, 2008). The first awareness of the need for sustainability was created by the report 'Limit to growth' of Meadows *et al.* (1972). These MIT systems scientists applied dynamic system modelling techniques to calculate the result of the ongoing economic growth. Results were devastating. Figure 4 shows that increasing industrial output would deplete our resources on earth and increase pollution, while in the long run population would decline as direct effect of a decrease in food production. The research was commissioned by a think tank called 'The Club of Rome'. (Meadows *et al.*, 1972; Robertson, 2014)

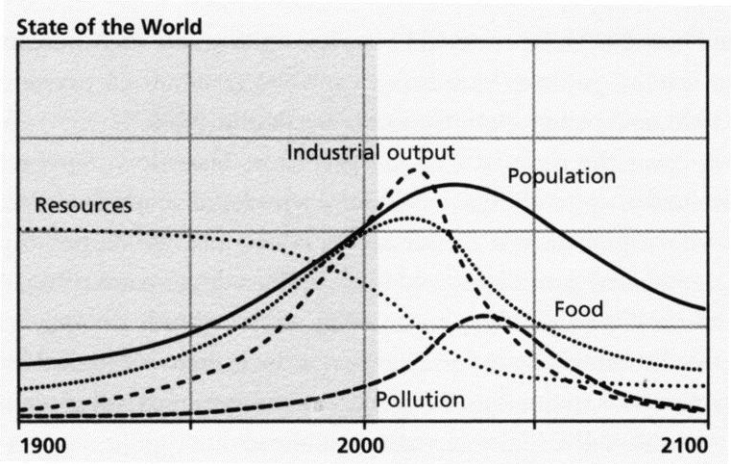


Figure 4: One of the scenarios of the report 'Limits to Growth' (Meadows *et al.*, 1972).

In the same timeframe the first in a series of international initiatives was taken to counteract the deteriorating global environment. Ghosh Roy (2011) sums up the most important ones till 2002, shown in Table 1.

Table 1: Landmarks of international initiatives in the view of the deteriorating global environment (Ghosh Roy, 2011: 6)

1972	Stockholm Conference under United Nations Environment Programme (UNEP);
1985	Montreal Protocol on depletion of Ozone layer under the Vienna Convention;
1987	Brundtland report on 'Our Common Future' under the World Commission on Environment and Development under the U.N.;
1988	Establishment of Intergovernmental Panel on Climate Change (IPCC) jointly by the UNEP and World Meteorological Office;
1992	Earth Summit at Rio de Janeiro enunciating the famous 'Agenda 21' for sustained development;
1997	Kyoto Protocol under the Framework Convention on Climate Change 1992;
2002	World Summit Johannesburg, proposing Millennium Declarations on improving the quality of life.

In 1987 the World Commission on Environment and Development (WCED, headed by Gro Harlem Brundtland of Norway, submitted a report 'Our Common Future' in 1987, popularly known as the Brundtland Report, which presented the concept of sustainable development as an alternative to the policy of only economic growth. (Ghosh Roy, 2011)

"*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*" (Brundtland report, 1987: 43)

The concepts contains two key concepts (Ghosh Roy, 2011):

1. The concept of needs in particular the essential; needs of the world's poor, to which the overriding priority should be given;

2. The idea of limitations, imposed by the state of technology and social organisation on the environment's ability to meet the present and future needs.

The concept of sustainable development merges environment and economics in decision making. "*This definition established the need for integrated decision making that is capable of balancing the economic and social needs of the people with the regenerative capacity of the natural environment." (Rogers et al., 2008: 42)* "*The core idea of sustainability is that current decisions should not impair the prospects for maintaining or improving future living standards. This implies that our economic systems should be manager so that we can live off the dividends of our resources.*" Repetto (1986) in Rogers *et al.* (2008: 22)

The Triple Bottom Line

Early in the twenty-first century the research field of sustainability focuses on interactions among different systems. Robertson (2014: 38) state that "*sustainability sciences strives to understand the dynamics of ecological systems, social systems, and their interconnections as a framework for sustainability, bringing scientific rigor to the triple bottom line.*" This is one of the most often heard ideas in discussions about sustainability, or better known as triple P: people, planet, profit or economy, ecology, equality (triple E). In the Johannesburg Treaty in 2002 profit changed to prosperity and the triple P become: People planet profit/prosperity.

Environment (ecology/planet)

"*It refers to preserving and restoring the health of living systems. All life on the planet depends on ecosystems to purify air and water, pollinate crops, provide food, recycle waste, and to circulate atmospheric gases, chemical elements and energy; these processes are sometimes referred to as ecosystem services. […] In order to create a planetary condition that is sustainable we must understand how these processes work, not just as individual pieces but as systems. We must see our own species as neither victims nor masters but as active members of the interconnected web of living being. We need to learn to live within our means ecologically, to recognize that there are built-in limits to any system know as its carrying capacity.*" (Robertson, 2014: 5)

Economics (profit/prosperity)

The Profit aspects concern about economic vitality and future values, such as local employment, flexibility and robustness. "*People need economic motivation to change. No person willingly chooses poverty if they know that other people are living comfortably and easily.*" (Robertson, 2014: 6) "*We must aim to a world that can deliver long-term prosperity to everyone, where people in every region live well.*" (Meadows *et al*, 2004: 41)

Equity (social equity or equality, people)

The people aspects are related to liveability, like air, soil contamination, safety and quality related aspects as available green and social inclusion. "*Equity includes freedom from unhealthy living conditions and equal access to food, water, employment, education and healthcare. Equity means providing opportunities for all people, not just a privileged few, to grow and flourish in their own way.*" (Robertson, 2014: 6)

Fourth pillar: Spatial

Some researchers address a fourth pillar: spatial. According to Spangenberg (2002) this is specially important in the urban and neighbourhood context, because of the various forces and entities influencing the decision making process.

Table 2: Facets of sustainable urban area development (Buskens, 2015: 27)

Facets of sustainable urban area development	
Profit / Prosperity (Economics)	Creating a favourable business climate
	Stimulate local employee ships
	Stimulate local employment
	Attract long-term investments
People (Social, Equity)	Social security
	Social interaction
	Comfort and healthy living environment
	Social cohesion
	Human scale
	Demand driven development
	Good accessibility
Planet (Environmental)	Good public transport services
	Stimulate healthy transportation options (biking, walking)

Spatial quality	Self-sufficient (circular economy)
	Renewable energy sources
	Prevent environmental pollution
	Respect ecological structures
	Varied density
	Mixed-use
	Preserve historical quality
	Place making/create an own identity
	Flexible
	Robust
	'Stewardship'

Interwoven components

3P are effecting each other. Rovers, Kimman and Ravesloot (2010) react to the importance of the 3P's. The basics for society are food, energy, water and raw materials. Without those a society cannot exists and can certainly not grow. These basics are used to create people's affluence and wellbeing. With abundance, society and culture and drive, without those resource, adaptation is need. This part is covering 2P's: people and planet. In the opinion of Rovers *et al.* (2010) the 3P of Profit only exist to facilitate and to give direction to the other Ps. They say that: "*Economy and policy can be adjusted, since they are not natural phenomena." (Rovers et al., 2010: 18)*

Environmental Sustainability

This part elaborates on environmental sustainability. First bigger understanding is giving in the reason why the earths gets warmer. What is causing climate change and how big is the effect going to be? Both answers lead to the description of environmental sustainability and its factors for success. This part ends with concepts for sustainable built environments.

Blackmore (2010) explains understandable what the causes and consequences of climate change are and starts its chapter with an quote of Professor Sir David King: "*There is no bigger problem than climate change. The threat is quite simple, it's a threat to our civilization.*" – Professor Sir David King, UK Government chief Scientific Advisor, 2000-2007 (King, 2004). Most of the answers are given by the Intergovernmental Panel on Climate Change (IPCC), which was set up in 1988 by the United Nations Environmental Programme and the World Meteorological Organization to improve understanding about global warming (Blackmore, 2010).

Why the earth gets warmer

In the history of the earth climate have been changing. In order to understand the cause of the current climate change, it is important to consider that the sun is determining the temperature of the earth at most. "*The temperature of the Earth is controlled by the balance between the energy arriving from the Sun and that radiated out to space from the Earth as heat. This balance is influenced by four important factors: the temperature of the Sun; periodic changes in the Earth's orbit which affect the distance from the Sun to the Earth; the nature of the Earth's atmosphere, and the amount of sunlight reflected away from the Earth's surface (and thus not available to warm it).*" (Blackmore, 2010: 104)

The earth's orbits are a theory of the Milankovitch cycles (Milankovitch, 1920). The theory explains how the rotation around the sun, the angle of the earth and the rotational movement of axis of the earth effects the climate of the earth. These different cycles are eccentricity (100.000 years cycle), obliquity (41.000 years cycle) and precession (26.000 year cycle). Decades later this theory got verified by Hays, Imbrie and Shackeleton (1976). Further research of Imbrie and Imbrie (1980) indicated that in the current situation orbital forcing should effect to a general cooling trend that began 6,000 years ago for the next 23,000 years. This effect is an addition to higher frequency effects like "*anthropogenic effects such as a possible warming due to an increase in carbon dioxide levels.*" (Imbrie & Imbrie, 1980: 951) The timescale of current changes in global warming does not match the timescale of the chances in temperature of the sun and changes in earth's orbits, which are over (tens of) thousands of years (Blackmore, 2010). Thus, the rising temperature must been caused by the last two important factors: the earth atmosphere and the reflection capacity of the earth. Humans are highly effecting the first one, even while the atmosphere is very important for multiple reasons.

The atmosphere of the earth makes life possible on earth. Without, temperature would be drop to 18 degrees C on average. Two main naturally occurring GHGs are carbon dioxide (CO_2) and water vapour (H_2O). However they cover a small part of the gases in the atmosphere, their impact is significant. These gases prevent solar radiation reflected by the earth to escape to outer space, warming both atmosphere as the earth

by on average 30 degrees C. Without this natural GHG-effect, life would not be possible on earth. Thus, the warming of the earth is caused by trapped heat from the sun. (Blackmore, 2010) Since the industrial revolution global emissions of GHGs have grown rapidly, mostly caused by a combination of a massive increase in world population and a growth in energy use per person, as shown in Figure 5.

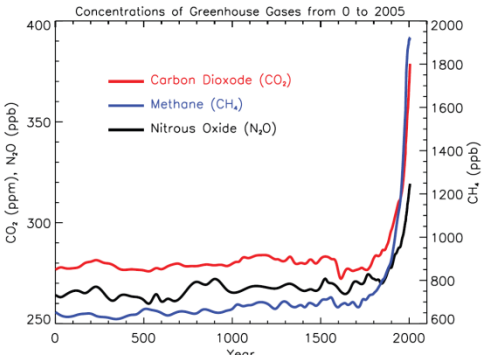


Figure 5: Concentrations of GHGs over the last 2000 years (IPCC, 2007a: 6)

As shown in the problem analysis, the energy supply, transport and building sectors have the best possibilities in reducing CO2 emissions. Together those sectors expel 45,4% of the CO2 emissions (Figure 6). This number reduces to 32,7% if the energy and heat supply of only the transport and building sector is taken into account. This indirect relationship is there because buildings are indirectly causing CO2 emissions by their electricity use and heat demand. The target has to be to get this number back to 0% in order to mitigate the greenhouse effect. Reduction of the CO2 emissions can be obtained by sustainability delivering heat and electricity to buildings. Buildings are responsible for 48% the electricity and heat demand worldwide, which is 12% of the world's total.

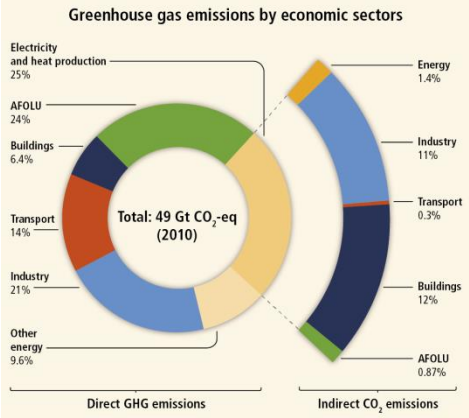


Figure 6: Earth Atmosphere effected by CO2 and built environment. (IPCC, 2013)

Unless if everybody stops expelling GHGs at this right moment, the past cannot be undone. The next paragraph describes what we can expect in the best case scenario.

Significant changes

In the last 800,000 years the CO2 concentration in the atmosphere was fluctuating between 180ppm and 300ppm and is currently with a concentration of 386ppm (measured in 2008) considerably higher (Lüthi *et al.*, 2008). Even if GHG-emissions stops, a historical peak of GHGs is already in the atmosphere. That does not indicate a carte blanche for GHG-emissions with the mind-set that the system has already been disrupted. A worse situation needs to be avoided. It can thus be expected that the effect of climate change will continue for some while. Ghosh Roy (2011: 3) names it "*unacceptable high pollution of the biosphere*", and sums up its effects, like global warming, change of weather including unpredictable floods and droughts, shrinking biodiversity from deforestation and desertification, soil erosion affecting agriculture and thus food production and demising availability of water affecting both agriculture and human health. Adaptation of the built environment is inescapable, as described by Blackmore (2010: 110): "*There is clearly a need both to reduce emissions of greenhouse gases dramatically and to prepare for an adapt to the changes already in the pipeline*."

(Blackmore, 2010: 110) This statement includes two strategies, which are also named in other literatures: mitigating and adaptation. But what does it exactly needs to tackle?

Success factors for environmental sustainability

The earth is almost a closed system. Figure 7 shows that the only input variable is solar energy and the only output variable is heat loss. Within this system an equilibrium state needs to be retained in order for us humans to continue to exist. Meadows *et al.* (2004: 9) explains this by the physical limits to growth. There are "*limits to the ability of the planetary sources to provide materials and energy and to the ability of planetary sinks to absorb the pollution and waste.*", as shown in the inner circle of Figure 7. They introduce that "*the throughput flows presently generated by the human economy cannot be maintained at their current rate for very much longer. Some sources and sinks are sufficiently stressed that they are already beginning to limit growth, by for instance, raining costs, increasing pollution burdens, and elevating the mortality rate. […] The ecological footprint could be reduced by lowering population, altering consumption norms, or implementing more resource-efficient technologies*." (Meadows *et al.*, 2004: 9) The closed system and limited 'sources' and 'sinks' are important concepts to take into account when defining the critical success factors of environmental sustainability in more depth than the definition descripted by the triple bottom line. The figure also shows that humans are extracting materials & fossil fuels from the earth into the economic system and are giving waste and pollution in return, which contaminate the air, water and soil (Meadows *et al.*, 2004: 53).

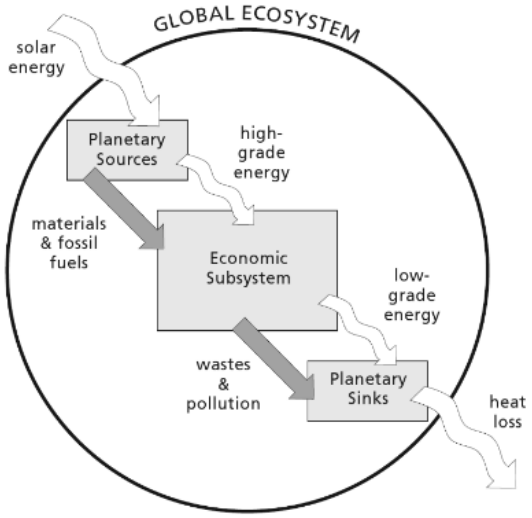


Figure 7: The Global Ecosystem (Meadows *et al.*, 2004: 53)

The sustainability part of this chapter started with a quote raising the idea that systems and processes have to be "*able to operate and persist on their own over long periods of time.*" (Robertson, 2014: 3) The environmental sustainability aspects relates to the technical (hard) systems aspect, which need to be sustainable over a long period of time. In order to reach such equilibrium state GHG-emissions and waste streams have to be stopped, or, as McDonough and Braungart (2002) and the Ellen MacArthur Foundation (2012) are stating, be re-used. In the context of the built environment sustainability is the overarching concept that acknowledges the need to protect the natural environment for future generations (Pohl, Assal & Pohl, 2011).

Critical success factors are therefore obtaining renewable sources for energy, water and materials and reduction of GHG-emissions and waste streams into the global and local environment, taking into account the soil, air and water component. Such concepts are called circular, zero-impact or eco-environments.

Most of the resource need is consumed during the operation phase of a buildings life cycle. According to the UNEP (2007) in Cheng *et al.* (2008: 8)"*Approximately 80-90 percent of the energy a building uses during its entire life cycle is consumed for heating, cooling, lighting, and other appliances. The remaining 10-20 percent is consumed during the construction, material manufacturing, and demolition phase.*" The mean focus of research will therefore be optimizing the environmental impact in the operational phase. The target is to get a closed system for the resources in that phase, with a focus on energy, water and GHG-emissions. The next part shows how these success factors can be measured in indicators.

Indicators

Indicators for these success factors are based on these energy, water and GHG-emissions. Other indicators are mentioned in the past part, but will not be the central focus.

Energy

The target is to bring the GHG-emissions of the energy supply sector and the non-renewable fuel sources back to zero. Based on this target the indicator would be the amount of energy needed in the operation phase. What are current measurement tools and how can this be reached?

Two tools are identified from the government: the EPC and EPL. The Energy Performance Coefficient (EPC) is the expression of performance requirements set in the National Building Regulations since 1995. The calculation method is laid down in Dutch standards: NEN5128 (for dwellings) and NEN 2916 (for non-residential buildings). In the base year the EPC was set on 1.4. (Rovers, 2008) The Dutch minister on Housing and National Service, Blok (2015, July 2) wrote that the policy of the Dutch national government is to lower the EPC to 0 in 2020, confirming the European EPBD directive. This implies all new buildings must be nearly zero energy buildings by 31 December 2020. The Energy Performance Location (EPL) indicator is a measurement tool on the neighborhood level, based on the assumption that an integral approach would be needed to improve the energy performance of a building. Many technical installations are more efficient in larger volumes. (Rovers, 2008) "*This EPL means that energy aspects can be introduced which are outside the scope of the house building and construction sectors, but which have a positive impact on the energy consumption of a building (e.g. energy-efficient heat and electricity generation, collective facilities, heat delivery, etc.).*" (Rovers, 2008: 25) Currently this a voluntary tool, mostly used by governments to set development targets (Rovers, 2008).

Measurements can thus be implemented on several scale levels. Based on the Trias Ecologica (explained later in more depth) it is important to first reduce the energy demand and as a next step try to supply the remaining need by renewable energy sources. Rovers (2008: 68) names a few measurements at both scale levels. For the urban fabric passive solar energy (using the sun for optimizing solar income for heat and light) and active solar energy (Solar thermal collectors for heat capturing or PV-panels) can be used. On the individual housing/building unit level several measures can be taken for lowering demand: Design measures (position and size of windows, shape of the roof, overhangs, the floor plan (cold/warm zone), building mass measures (the thermal mass of the construction material determines the reaction to differences in the outdoor climate), insulation measures (reducing thermal losses), heat recovery (from exhausted hot air and wastewater) and low energy demanding electrical appliances. Renewable energy and be supplied by PV-panels and heat pumps. In the Netherlands is solar orientation for energy the main consideration on the urban design scale. Combining windmills for electricity production with housing areas is not (yet) very popular. People are afraid of noise and stroboscopic effects with the new high tech, large windmills. (Rovers, 2008)

All those measurements have a synergy with other requirements , like the level of comfort, architectural design an organisational aspects (Rovers, 2008). All have to be taken into account.

Water

The water indicator consists of several components. Three basics issues can be thought of 1) there is to less water: drought, 2) there is to many water: floods and 3) bad quality due to pollution. Drought is less an issue in the Netherlands due to its humid climate and the position in a delta. Thus, the focus of this indicator will be on the water supply and pollution.

"*Water is increasingly used as a structuring element in urban design in the Netherlands. For several reasons: Firstly, because the Dutch love water and like to live close to it. Secondly, because local water is increasingly being used as part of the local water system, by decoupling it from the sewage grid and use local treatment. A third reason is that water management in the Netherlands as a whole is undergoing a major shift (partly due to climate change) and water buffering capacity is needed all over the country.*" (Rovers, 2008: 76)

Based on the previous quote indicators for water could be:

1. Availability of water for recreational purpose
2. Local water treatment
3. Water buffering capacity for safety reasons

Rovers (2008) mentions three water themes for sustainable local water management: Local rainwater, minimizing local water supply and local treatment and reuse of domestic water. The first theme deals with storm and rainwater. Effective storm water management requires a well-balanced design of the neighbourhood. The second theme has two strategies to minimize the water footprint: 1) Minimizing the household water use and 2) Rainwater harvesting for use in households. The third theme tries to reduce the size of the water treatment system in order to keep it local. Reducing the pressure on the environment to a

durable situation is the focus of this research. Indicators are focused on the supply level and eliminating waste streams to other subsystems of local water management, not on the water safety level. Indicators are:

1) Reduction of the water use
2) % of Rainwater used in total water supply for households
3) Local water treatment.
4) % of water reuse

Local water management is not a closed system, water is also needed downstream. The target is to get an optimal balance between demand and supply in a local area. If there is a structural surplus in a neighbouring subsystem, those water supply systems should be connected in an optimal way.

GHG-emissions

The focus of GHG-emissions in this thesis was on the energy supply sector, the building sector and the transport sector. The energy and building component are already captured by others indicators, therefor this indicator focus is on transport and green. The transport component to create a local supply in peoples' in order to reduce of need to travel by mixed use and green for purifying the air with green.

Reducing the need for travel and mobility is already been tried in other ways. "*Between 1990 and 2000 it was thought that limiting the number of parking spaces would reduce car mobility. That did not work.*" (Rovers, 2008: 77) Another solution needs to be thought of. Steen (2016) argues for the development of mixed-use neighbourhoods, which reduce travel distances. Mixed-use would create a local supply in needs of people (work, food, etc.), which reduces the need for mobility.

Other indicators

According to Rovers (2008) the indicators for urban design issues in the Netherlands are water, energy, traffic, materials, liveability and safety, affordability, good design: diversity and biodiversity and health. Liveability and safety captures the quality of life, the social aspect of sustainable design. Affordability is based on the large social housing stock in the Netherlands. Diversity captures mixed-use neighbourhoods as contrast to the separate (modernistic) neighbourhoods of the last 50 years which encouraged mobility (with the noise, pollution and accidents that it brings). Biodiversity brings nature back into the city. Health captured noise levels, air quality, indoor climate, humidity and comfort. Of the general topics, the first three are captured in this thesis. The other four are important to take into account, but are outside the scope of this thesis.

Materials. Different aspects of materials are building materials, consumption materials (goods and products) and food/nutrients. In order to optimize the closed cycle system the demand for resources need to be reduced as well as the waste production. Reuse of those materials reduces the waste production. There are not many links with urban design. "*It is rare for locally available materials to be used in the design. However, it is getting more common to integrate existing buildings and other structures into an urban plan to avoid demolition waste from the site and save virgin resource for new construction.*" (Rovers, 2008: 76) There is discussion about using metals in building construction, because lead, copper and zinc would be toxic to underwater life in water systems. Rain would carry the metal particles. (Rovers, 2008) Important principles for reducing the waste stream are 'Cradle to Cradle' by McDonough and Braungart (2002) and 'The Circular Economy' by the Ellen MacArthur Foundation (2012)

Measuring indicators

The next step is to transform the indicators to variables. Steen (2016) identified a complete list of product variables considering the future urban sustainability of an area. She did that based on literature analysis, end-user interviews and interviews with experts from practice. The part of list on environmental sustainability is shown in Table 3.

Table 3: Environmental aspects in the list of sustainability components relevant for achieving sustainable urban areas (Steen, 2016: 64)

Changeable element	Influenced sustainability component	Influenced variables	Possible values	Direction desired value from sustainability perspective
Water management measures	Water retention	Amount of water that can be retained in the area	# liters / m2	High
	Flood-resistance	Amount of measures taken to prevent flooding	No measures taken, basic measures taken, additional measures	High

			taken, all necessary measures taken	
	Drinking water provision	Amount of drinking water available	# liters / m2	High
Energy provision / generation methods	Fossil fuel consumption	Amount of fossil fuel consumption	# consumption / person	Low
	Pollution	Amount of emission of polluting substances	# pollution / person	Low
Transport choice	Fossil fuel consumption	Amount of fossil fuel consumption	# consumption / person	Low
	Pollution	Amount of emission of polluting substances	# pollution / person	Low
Amount of green / water	CO_2-absorption	Ratio amount of CO_2 absorbed in the area vs. amount of CO_2 emitted in the area	# CO_2 absorbed /# CO_2 emitted in area	High
	Heat absorption	Amount of heat absorbed	Heat absorbed / heat generated	High
	Water retention	Amount of water that can be retained in the area	# liters / m2	High

Based on the previous described indicators and the variables of Steen (2016) the variables for environmental sustainability in this thesis are shown in Table 4. This is only about the product side of this thesis.

Table 4: Summary of the successfactors, indicators, example of measurements and variables.

Success factors	Indicators	Measurements (for instance)	Variables
Energy	Energy demand	Lowering demand	# energy demand building / # energy demand required by law
		Renewable sources	#renewable supply / # total energy demand)
Water	Water demand	Lowering demand	# energy demand building / # energy demand required by law
	Rainwater harvesting	Capturing rainwater	# rainwater supply / # total water demand
	Green and local water treatment	Green treatments	# waste water treated by green / #total waste water supply
GHG-emissions	Demand for mobility / transport choice	Mixed use, close transport	# travelled miles by car per person / # average travelled miles by car per person in NL
	CO_2 absorption	Greenery	# amount of CO_2 absorbed / # amount of CO_2 exhausted

Steen (2016) also identified the core goals of sustainability from structural vision. Some of the ultimate aims are corresponding with the above indicators, namely minimizing the city's environmental impact and reducing fuel and energy consumption and CO_2 emission by transport.

Strategies against climate change

In the urban contents three strategies exist with respect to climate change:

- **Adaptation** "*(with respect to climate change) The adjusting of systems, natural or human, in response to actual or expected impacts of climate change, such as sea level rise, to reduce vulnerability or increase resilience in response to observed or expected changes in climate and associated extreme events. A distinction has been made between planned adaptation (e.g., urban planning), which is the focus of this chapter, and autonomous adaptation (e.g., by individual action such as improving housing insulation, installing air- conditioning, etc.)*" (Pauleit *et al.*, 2013: 224)
- **Mitigation** "*(with respect to climate change) Reducing greenhouse gas emissions and enhancing sinks.*" (Pauleit *et al.*, 2013: 225)
- **Resilience** "*Is the ability of a system to adapt and adjust to changing internal or external processes. Resilience is the flip side of vulnerability – a resilient system or population is not sensitive to climate variability and change and has the capacity to adapt.*" (Pauleit *et al.*, 2013: 225) "*Ecosystems are resilient because they are made of component parts at a range of scales. When a disturbance happens, small parts react and recover quickly while large, slower parts maintain the continuity of the system.*" (Robertson, 2014: 33)

Concepts for a Sustainable built environment

In the built environmental several concepts got developed to deal with environmental sustainability. It is important to know that several individual measures does not have to lead to the desired end-result. It is

important to take into account the other systems where it could have effect upon. Rovers (2008) wrote a book with a similar mind-set; he says that it is better to implement a 'concept' than a uncoordinated collection of separate measures. The reason for this is that separate of individual measures does not necessary lead to optimal solutions. He argued that sometimes even the opposite happen, known as the 'rebound effect' and gives an example: "*the introduction of energy-efficient light bulbs has led to reduced energy demand for lighting in living rooms, but also to more lights and more usage hours (and therefore more fossil-fuel energy use) in other parts of homes, like garden."* (Rovers, 2008: 9). His conceptual approach does not end at the building level, the neighbourhood needs to be incorporated in order to develop a good concept. In this part the following approaches will be described: (Human) ecological footprint, trias ecologica, 0-impact built environment, DCBA,

(Human) ecological footprint

The ecological footprint (EF) is the land area necessary to provide for the current way of life, measured in (global average) hectares. The EF also adds up the land required to absorb the carbon dioxide emitted by the population, mostly from fossil fuel use. (Meadows *et al.*, 2004: 291) "*Thus, the EF increases when humanity uses larger areas for food or fiber, or emits ore CO2.*" (Meadows *et al.*, 2004: 292) The accumulation of GHGs forces a change in human behaviour that reduces the EF. The method is developed by Wackernagel in the 1990s. (Meadows *et al.*, 2004) The result of the EF is "*the impact of an urban system on the neighbouring countryside or on other parts of the world. […] The suggestion is that a small footprint is always better and this idea has stimulated many environmentalists and architects to design and develop self-sufficient buildings or neighbourhoods.*" (Tjallingii, 2015: 76)

Trias Ecologica

Trias Ecologica is an three step approach for developing environmental sustainable concepts. Trias Ecologica is also called the 'Three Stepped Approach' or 'Trias Energetica' (Van Timmeren, 2012). The principle is described by Rovers (2008: 10): "*The first step is to reduce the need for or use of anything. The next step is to use renewable sources to meet the need. And if the first to steps are not sufficient, the third step can be applied: supply the remaining needs as efficiently as possible.*" The result is a closed cycle when all the demand is met in the first two steps. In a closed cycle non-renewables are no longer needed (Rovers, 2008). The balanced situation can be called sustainable. The Trias Ecologica approach is therefore highly useful in developing sustainable urban areas.

Trias Ecologica can be used at different scale levels to affect decisions. Rovers (2008: 10) describes a clear example about sustainable material use: "*To create balanced material use, it is necessary to consider what affects material consumption the most. On the scale of a single building, the impact is limited. The decision to build has already been taken: a building cannot be built without materials, and the builder can only choose from the materials available on the market. A combination of measures and responsibilities on different scales, involving more, different, stakeholders, will have more impact. […] [the Government Building Agency] has adopted a strategy which supports the balanced materials concepts, which state: the first option is not to build (can the need for office space be met in another way?) The next option is to renovate an existing office or to extend it, and only if these two options are unavailable will new construction be considered.*" He sees the example as the application of the Trias Ecologica at the planning level and in this sense a well-organised management for sustainable building can realize more environmental benefit than technology in every scale level, from policy development to management to design (Rovers, 2008).

0-Impact Built Environment

Rovers *et al.* (2010: 18) state that "*from now on we must maintain a closed-cycle system.*" The described indicators are based on having the least impact in an optimum setting. In the end our earth has to be a closed system, managed in a balanced way. An important question Rovers *et al.* (2010: 18) raise is: "*How do we design new buildings and districts with optimized energy and water systems, and with materials that do not deplete resources and do not create CO2-emissions?*"

Industrial Ecology

Fiksel (2006) describes industrial ecology as an approach towards sustainability. Industrial ecology is a framework of industrial systems to have a transition from a linear model to a closed-loop model. This model is based on the circular flows of natural ecosystems. In nature no waste is generated, since one creature's waste is another ones resources. Research is being done among the links between "*industrial systems (energy, transportation, manufacturing, food production), societal systems (urbanization, mobility, communication) and natural systems (soil, atmospheric, aquatic, biotic), including the flows of information, wealth, materials, energy,*

labor, and waste. The complexity, dynamics, and nonlinear nature of these interdependent systems imply that the notion of 'sustainability' as a steady-state equilibrium is not realistic. Forces of change, such as technological, geopolitical, or climatic shifts will inevitably disrupt the cycles of material and energy flows. Therefore, achieving sustainability will arguably require the development of resilient, adaptive industrial and societal systems that mirror the dynamic attributes of ecological systems." (Fiksel, 2006: 16) Industrial ecology becomes very clear in two planning concepts:

- Eco-Industrial Parks as planning concept (Desrochers, 2001).
- Circular economy (Ellen MacArthur Foundation, 2012).
- Urban Metabolism (Wolman, 1965)

DCBA

"The DCBA method is a classification model for all kinds of sustainable building measures. Materials, ideas and measures are classified in four levels:

D: The normal situation
C: Correct normal use
B: Minimize impact
A: Autonomy, the most favourable situation." (Rovers, 2008: 15)

The method can be used as tool throughout various stages in the development process, for instance as discussion tool in the early phases or as evaluation in the end-stage. The method is developed by BOOM in 1993. (Rovers, 2008) This method looks like the energy label which is currently obligated in the Netherlands. The letters from A (best) to G (worst) mark how sustainable the building is (Energielabel.nl, 2016).

Different scale levels of environmental sustainability

The success factors influence each other on different scale levels, like the building level, the neighbourhood level and the city level. In that order the scale level are discussed. Implementations for the building level and neighbourhood level are already discussed, therefore the focus is mainly on the city level.

Building level

The building level consists of the individual building design and its materials used. On the building level passive and active design options can be used like orientation to the sun, isolating materials, rainwater harvesting and re-use of materials (Rovers, 2008).

Neighbourhood level

The neighbourhood level consists of a block of buildings up till a urban district. Steen (2016) gives a clear description on how mixed-use can deliver sustainable neighbourhoods. The orientation of buildings towards the sun needs alignment in order to get the optimal situation for all buildings (Rovers, 2008). Economies of scale (financial aspect of implementation) are a valid reason to imply measures on the neighborhood level (Van Timmeren, 2012).

City level

For the city level a lot of concepts are developed. De Jong *et al* (2015) gives clear insight: "*Over the last couple of decades, metropolitan areas around the world have been engaged in a multitude of initiatives aimed at upgrading the urban infrastructure and services, with a view to creating better environmental, social and economic conditions and enhancing cities' attractiveness and competitiveness. Reflecting these developments, many new categories of 'cities' have entered the policy discourse: 'sustainable cities'; 'green cities'; 'digital cities'; 'smart cities'; 'intelligent cities'; 'information cities'; 'knowledge cities'; 'resilient cities'; 'eco cities'; 'low carbon cities'; 'liveable cities' and even combination, such as 'low carbon eco cities'.*" (De Jong *et al.*, 2015: 25) Are these categories each embodying distinct conceptual perspectives? The same writes argue that in practice policy makers, planners and developers use them interchangeably.

Table 5: Explanation of six categories of cities distinct enough to be supported by a specific body of theories (table is based on descriptions in De Jong *et al.* (2015))

Category	Explanation
Sustainable city	The sustainable city wants to meet the needs of the present without compromising the ability of future generations to meet their own needs. This category is an almost directly derivative from the Brundtland definition of sustainable development.
Eco-city	The eco-city is built according to the principles of living within the means of the environment. The population and the artefacts produced and used should remain

	within the ecological carrying capacity of the city's bioregion.
Low carbon city	The low carbon city can be seen as a direct responds to the change climate change debate and strives to minimize the human inflicted carbon footprint by reducing or even eliminating the use of non-renewable energy resources.
Smart city	In a smart city investment in human and social capital, coupled with investment in traditional (transport) and modern information and telecommunication infrastructure, generates sustainable economic development and a high quality of life while promoting prudent management of natural resources.
Resilient city	A resilient city have the ability to resist, absorb, accommodate to and recover from the effects of a hazard in timely and effective manner.
Knowledge city	Integrated cities that physically and institutionally combine the functions of a science park with civic and residential functions. In a knowledge city local developments strives to offer a platform for the city to develop in a sustainable way, coupled with a social learning process to help citizens to realize urban change.

All of them are aimed to create the impression that social, economic and environmental sustainability can go hand in hand. "*Are ecological modernization in the city and urban regenerative development safe in the hands of those who adopt any of these terms?*" (De Jong *et al.*, 2015: 35)

De Jong *et al.* (2015) research showed that the named city categories are not interchangeable. "*Rather, the research findings robustly demonstrate important conceptual differences among them, although interrelationships among the twelve categories do exists.*" (De Jong *et al.*, 2015: 35)

According to Hajer and Dassen (2014) it is fundamental to make the urban metabolism visible. If we would visualize the urban metabolism, it becomes clear what the contemporary urban life entails and we get an idea of what would be required for decoupling.

Linkages between scales

Table 6 shows linkages between scale levels. A clear urban policy and insight in the urban metabolism is requirement to give useful input on an urban neighbourhoods scale. At the same time the urban plan and building design are affecting each other on their effectiveness in the success factors.

Table 6: Linking measurements between scales

Success factors	Measurements	Tools	Scale level
Energy	Lowering energy demand	Building construction / materials	Building
	Renewable sources	Passive design	Building and neighbourhood
Water	Lowering water demand	Lowering water demand	Building
	Capturing rainwater	Capturing rainwater	Building and neighbourhood
	Green treatments	Green treatments	Neighbourhood and city
GHG-emissions	Mixed use, close transport	Close public transport	Neighbourhood and city
	Greenery	Greenery	Neighbourhood and city

Method: The Maximization Method

The Maximization Method is an approach to get the different aspects and scales together. "*The Maximization Method is a design method for urban design projects which clarifies the structuring influence of environmental and other themes in the design process.*" (Rovers, 2008: 82)

3.2 Sustainability constraints in the urban area development process

This part focus' is on the urban development process. The end result is to identify sustainability constraints in this process. First a general description of the urban area development process is given, followed by the phases and actors involved, which leads to the fragmented image of the building sector. Second, the changing practice of the process is described. Third, a basic insight in the theory of the decision making process is given. All three leading to constraints in the decision making process, which is the fourth part of this part.

Urban area development

Franzen *et al.* (2011: 9) positions urban area development as a "*part of a broad range of activities involving government intervention at various levels, from local (municipal), regional or provincial to national or even international level, and in interaction with the activities of private organisations such as property developers*" with as goal "*the development of a specific area within a town or city or the expansion of a town or city, which generally has an identity of its own.*" (Franzen *et al.*, 2011: 10) Urban area development take places on the scale

level at which contracts between local authorities and property developers are made and involved multiple disciplines, like public and private parties and disciplines needed for the planning and development or an area (Franzen *et al.*, 2011).

There is a difference between 'urban development' and 'urban area development'. According to Franzen *et al.* (2011: 17) the difference is in the aim of developing urban areas: "*Urban development manifest itself through spatial changes in various areas, which act in mutual correlation to form the urban region and shape its functioning. Urban area development is aimed at developing these particular areas.*"

Lastly, it is important to take into account that urban area development has more components than just the spatial development component: "*The process is not only concerned with spatial developments; it must take into account economic, social and various other developments.*" (Franzen et al., 2011: 18)

Phases in urban area development

The development of an urban area takes places in several successive phases. Franzen et al. (2011: 90) divides the process into four recognizable phases: Initiation phase, planning phase, realisation phase and the maintenance phase. In the first phase the ambition must be established and goals are set. "*Defining the goals must be seen in the social and political context and conditions [and] the ambition must be common ground on which all actors operate. [...] The planning phase starts after the ambition has been mutually formulated. [...] In this phase, all sectoral and facet-related aspects are integrated into a plan in such a way that they have the best possible spatial and functional quality and, moreover, that makes the plan feasible in terms of available means. [...] In the realisation phase the plan is put into effect by the relevant parties that have reached agreements in both previous phases.*" (Franzen *et al.*, 2011: 91) In the maintenance phase the operations take place.

Glumac (2012) describes a more detailed picture of the phasing. Based on Hieminga (2006) the researcher identified the following (re)development phases: **Initiative**, land acquisition, **plan development**, financing, **realization**, renting / Sale, **management / Exploitation** and demolition. The four bold phases match the phases of Franzen *et al.* (2011). "*At each phase exist a final product, defined process and actors that have different interests.*" (Glumac, 2012: 10) In these phases different actors are involved in different processes with different products as results. The focus of this research in on how a different urban strategy/design can create a 0-impact neighbourhood. The most important phases are therefore the phases up to plan development. Table 7 gives an overview of the characteristics of those phases in the mentioned aspects in quote: product, process and actors. The process aspect shows how a window of opportunity in a market get to an idea, which is applied on a location and has finally a design as result.

Table 7: (Re)Development phases and characteristics (Hieminga (2006) in Glumac (2012: 11))

Phase	Market	Actors	Process	Products
Initiative	Land market	- Developer - Owner/user - Investor - Broker - Market research company	*Market -> idea* Initiative Feasibility Definition	- Market analysis - Feasibility study - Program in brief - Project plan
Land acquisition	(Brownfield) market	- Landlord - Developer - Municipality - Notary	*Idea -> location* Location assessment	- Location analysis - Soil research - Program in brief
Plan development	Market for design services	- Urban design architect - Civil engineer - Other advisors	*Location -> design* Design Test Re-adjust design	- Sketch design - Preliminary design - Final design - Changes in zoning - Specification - Construction design - Building permission

Actors in urban area development

The definition of an actor is "*an individual or an aggregated social entity (collective actor) that has the ability to make autonomous decisions and act as a unit.*" (Pahl-Wostl (2005) in Glumac (2012: 13)). Thus, in order to be seen as separate actor one should have the ability to make own decisions. The urban area development process is shaped by the actors involved. "*A distinction can be made between actors in the public and private sectors. Additionally, local citizens and other parties involved in an area, need to be taken into account in urban area development.*" (Franzen *et al.*, 2011: 26) Those three different categories of actors are discussed below.

Public sector

The public sector consist of " *the municipal players who make decisions regarding the territory on which a specific urban development takes places. The municipality plays a role in public law (creating land-use plans, granting building permits, etc.), but it can also make use of private law by pursuing its own land development (also called active land policy). In Dutch practice, it is fairly common for municipalities to develop land or set up development companies. A municipality can also participate as partner in a development (when significant municipal interest are involved). Apart from this, the role of director to urban area development can lie with the municipality as well; in other words, the process management of the urban development.*" (Franzen et al., 2011: 26) Thus, the public sector can act in different ways in urban area development. From an active role with land development (making use of private law) to a facilitating body (making use of public law).

Private sector

The private sector consists of market parties. There are many different types of actors who participate in urban area development. Franzen *et al.* (2011: 27) named the private project developers, investors, builders, urban designers and architects, owners of land and buildings, real estate agents, housing associations and the end-users. This research focus is on the project developers. Franzen *et al.* (2011: 27) explains them in the following way: "*Private project developers play a significant role in some processes or urban area development. At their own expense and risk, they undertake projects within the context of the current market. Their investment is mostly in buildings, thus taking relatively short-term financial risks. Within the world of developers we can identify many types, including a range of combinations with investors, builders, banks, and sometimes also architects. The developers also tend to specialise in a certain sector, such as housing or retail. […] Furthermore, with greater frequency, companies that were originally builders now play an active part in more integrated area development.*"

Civil society: Citizens and interest groups

The last group is the civil society. Franzen *et al.* (2011: 29) sees them as an important category. It consist of citizens and other (current) users or representatives of the area where urban development takes place. "*The interests of these users often differ significantly. For instance, shop owners might desire car accessibility in an entirely different way to residents.*" (Franzen *et al.*, 2011: 28) "*We can also count organised civic societies (or voluntary interest groups) among the parties involved. The type of organizations can also operate at national level (e.g. pressure groups).*" (Franzen *et al.*, 2011: 29)

Interdisciplinary approach required for succeeding environmental measures.

Rovers (2008) state that an interdisciplinary approach is needed to deal with inadequately covering certain subjects. "*Accomplishing an environmentally-sound design depends on all the partners involved in the design process. They will use their influence not merely on the basis of reason, but also and more especially, on the basis of available finance and practical possibilities. To prevent the majority of environmental measures from failing during the building process, due to practical and financial objections, it is advisable to offer alternatives in an early stage in consultation with all the parties involved.*" (Rovers, 2008: 79) This can be supported with practical tools in the decision-making process. He mentions two tools: the DCBA method and the Maximization Method.

Wamelink *et al.* (2010: 401) sorts the actors according to the three categories just mentioned and the amount of influence: directly involved into the project, indirectly and the external surrounding.

Fragmentation and complexity of the construction sector

The different phases and different actors, which are not all involved from the beginning up till the end, caused a huge fragmentation of the building sector. Cheng *et al.* (2008: 18) even state that they are poorly integrated throughout the process and that this complexity of interaction is one of the greatest barriers to the development of energy efficient buildings. Figure 8 shows how the different focus of engineers within the different phases causes lots of operational islands. The figure does not include all parties involved, so in reality the sector is even more fragmented.

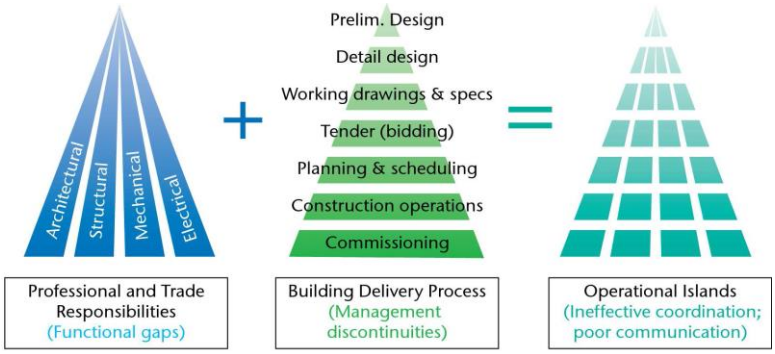


Figure 8: Complexity and fragmentation of the construction sector (WBCSD, 2007: 15)

Changing practice of urban area development

Last decennia the practice of urban area development is changing. In the next part some changes are described. The influence of sustainability is not discussed, the necessity is already discussed before.

From a (traditional) hierarchical society to network society

The introduction of ICT have introduced a new basis for organising society, which "*had led to a drastic restructuring of production processes, now characterised by greater flexibility in forms of management, decentralisation and networks between and within companies.*" (Franzen *et al.*, 2011: 37) This introduced has also increased the speed of change. "*This has happened in conjunction with an equally speedy process of globalisation. These factors have significant consequences for the functioning of societies and the cities they inhabit. In metaphorical terms, one often speaks of the 'Network society'.* [...] *Essentially, [a network society] is a society organised mainly around streams of goods, people, money and information. The scope of these networks has become so vast because of the potential offered by information technology: distance has become almost irrelevant. Network of various forms overlap, are subject to constant change, and sometimes converge to form a high concentration of networks (for example at regional level).*" (Franzen et al., 2011: 21) "*In a network society, physical proximity loses its significance: the term refers to a new situation where social, economic, as well as cultural relations are bound yet without physical ties. A network society is a society where social, economic and cultural structures are no longer determined by the shared use of a certain space.*" (Franzen *et al.*, 2011: 37) This also created non-location-bound activities, also referred as footloose industries. (Franzen *et al.*, 2011) "*These new conditions have also led to new forms of control and management, evolving to a total departure from the traditional forms of control, where in control is held by one central actor, namely the government.*" (Franzen *et al.*, 2011: 46) The difficulty of a network society (and the shift from government to governance) is that "a*ll the different visions, interest and opinions that come into play during the trajectory are streamlined into a collaborative whole – this is governance. In this trajectory, the municipality increasingly depends on private parties, other government bodies and decision making that takes places outside the realm of the municipal territory*" (Franzen *et al.*, 2011: 46) Concluding, the shift to a network society leads to the involvement of more parties on the same hierarchical level, a reduce connection to physical phase and new forms of management, called governance.

New role of the government in urban development

The role of the government is changing (Heurkens, 2012). Last 100 years the government was actively involved in urban planning. From the start of the 20th century they wanted to secure greater quality neighbourhoods and integral developments. After the World War II the governments was the leading party in making spatial visions and urban designs. In that time, extensive steering of the government in the planning and design phase was self-evidence (De Zeeuw *et al.*, 2010). The government secures the development program, which was built by real estate developers and housing associations. These developments got built with minimal design influence of inhabitants. Figure 9 and the upper left part of Figure 12 shows the government in control of urban development, mostly done by an active land policy.

Around 2000 this changed, public and private parties starting collaborating in public-private partnerships (Figure 10 and upper right part of Figure 12) and the land development was done together. Active ground policy has a major financial risk and municipal parties mixed up public and financial goals (Kam, 2007). This became clear with major financial losses for municipalities after the financial crisis (Rfv, 2015). Most municipalities shifted to a passive ground policy, shown in Figure 11 and as third step in Figure 12. In this case land development is done under the lead of private parties. In this new role the government waits for initiatives, facilitates initiators and land owners in design and development without own investments and they

determine the rules of the game. The increasing role of private parties in public policy processes is visible in that private parties are setting the agenda and in implementing policies (Franzen *et al.*, 2011). Although this shift is not new for Anglo-Saxon countries, like the United Kingdom and the United States of America, it is a great shift for the Netherlands with its strong government-driven development tradition in the 20th century (De Zeeuw *et al.*, 2010). *"In addition to these commercial organizations, there are many other organizations, companies and citizens willing to increasingly invest in spatial development projects."* (De Zeeuw *et al.*, 2010: 905) This is also a result of the emergence of the network society.

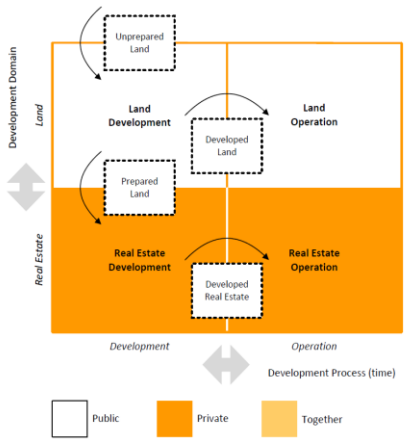


Figure 9: Public & private roles in building rights model (Heurkens, 2012: 151).

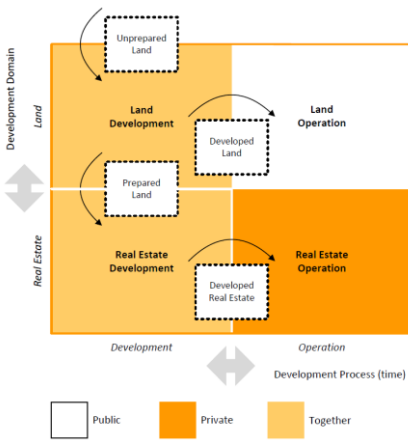


Figure 10: Public & private roles in joint venture model (Heurkens, 2012: 153).

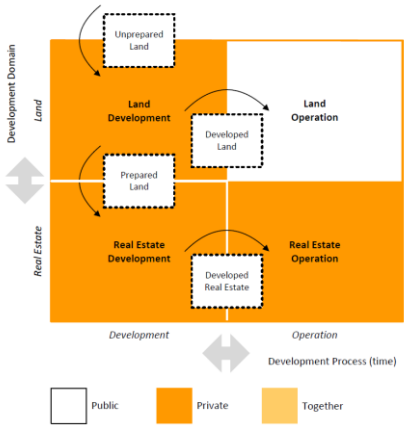


Figure 11: Public & private roles in concession model (Heurkens, 2012: 154).

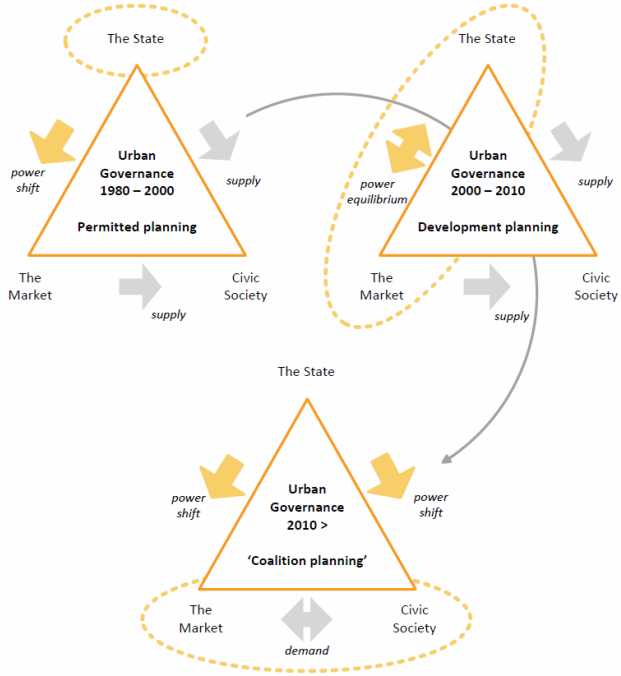


Figure 12: Dutch urban governance shifts over time (Heurkens, 2012: 140).

The result of this new playing field is that the urban area development process is getting more difficult. Instead of one party (the government) making the vision, multiple parties have to agree towards the same vision. This shift enlarges the importance of the process aspect in urban area develop over the product aspect. Besides, a different party is taking over the leading role and the responsibility and risks of land development shifts from the public sector to the private sector (Franzen *et al.*, 2011).

Glumac (2012) not totally agrees with Heurkens (2012). He state that the traditional linear planning focus of the government have been replaced by public-private collaborations, which would be Figure 10 and upper right part of Figure 12. Glumac (2012) agreed upon the major influence private parties now have in the urban development processes. This shift leads to a lack in consensus among key actors due to shared, overlapping concerns or individual conflicting interests.

Regardless of which researcher it right, currently the private sector is involved in the early phases of urban area development, creating complex multi-actor environments for decision making.

From blueprint thinking to dynamic and sustainable forms of planning

Last decades the traditional centralised master planning or blueprint approach shifted to a new concept of planning as a process (Chatterji & Soni, 2016). According to Hall (1996) the former approach assumed that the objectives were fixed from the start and in the new approach the planning process was independent of the thing that was planned. Based on Hall (1996), Chatterji and Soni (2016: 64) explained that "*master plans continually encounter several implementation difficulties and have been criticised for: lack of synergy with 5-year economic plans [and] inadequate political support after changes in governments.*" The former planning approach was inappropriate to the long process of urban area development. The new strategy reduces the risks and creates more resilience by its ability to adapt the plan in latter stages of the process. Phasing in the development strategy is becoming more important. This new approach makes it difficult to make all kind of final calculations for the final design. Flexibility and ranges needs to be incorporated.

Focus from ground exploitation to real estate exploitation

Before understanding the change, it must be said that the fragmented building sector has as result that the value chain of real estate development is scattered among a lot of parties, as shown in Figure 13. The development has to be paid back by the users. As can be seen in Figure 13 the developers play a central role in connecting all the different actors in urban area development.

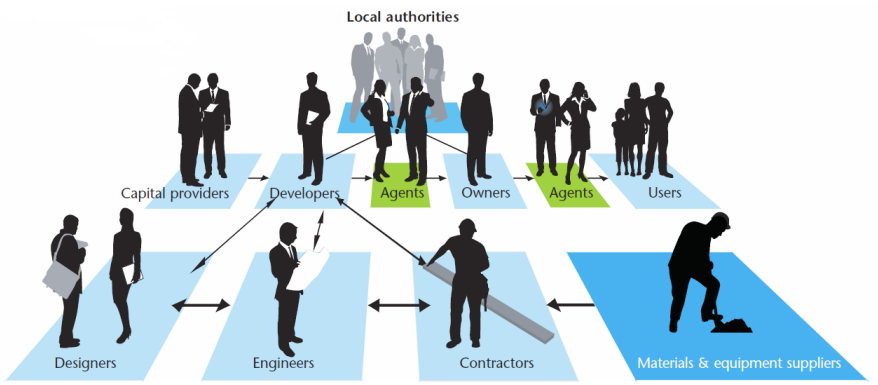


Figure 13: The complex value chain (WBCSD, 2007: 14)

There are three different financial phases in urban area development: the development of land, the development of real estate and the use of real estate (Franzen *et al.*, 2011: 183), as shown in Figure 14. The figure also shows that the investment is needed upfront and the return is in the end. Before the financial crisis of 2008 real estate developers did speculative development. They were developing land and real estate before the end-users got involved. The crisis made them aware of the risks they were facing with these kind of speculative behavior. The result was that end-users got involved in the process more earlier and a shift occurred in the creation of a business plan from the focus on land development to focus on the exploitation of real estate.

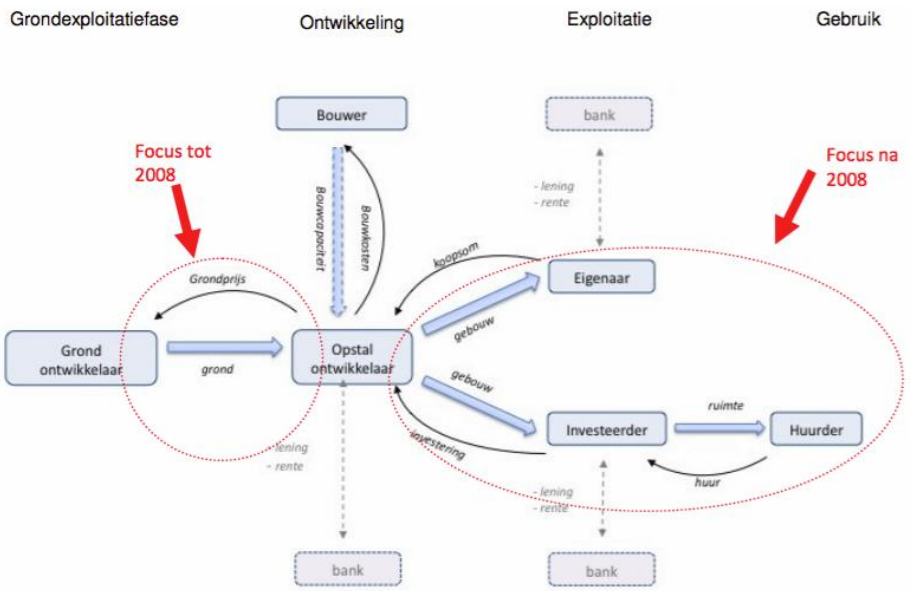


Figure 14: Shifting focus real estate developer, Putman (2010) in Buskens (2015: VIII).

Change in procurement

Since the building fraud new selection criteria for procurement are applied and to tackle the fragmentation of the sector (Figure 8) new forms of organization are introduced. In the jubilee book of Dura Vermeer BV, Dicke and Smulders (2005) are describing these changes from the viewpoint of developing constructing company.

The building fraud created enormous distrust towards the construction industry. Whereas previously the lowest price was used as selection criteria, clients shifted selection based on quality aspects. This was an incentive to set the demands of clients as a starting point in the development process. (Dicke & Smulders, 2005) This new procurement type is called a the Most Economically Advantageous Tender (Dutch: EMVI, Economisch Meest Voordeligste Inschrijving). Chao-Duivis, Koning and Ubink (2010: 144) are giving an enumeration of the criteria that could be involved, namely price, quality, technical merit, aesthetic and functional characteristics, environmental characteristics (including characteristics relating to production methods), etc. The last criteria demonstrate that involvement of the sustainability aspect could be more in this approach. Rijkwaterstaat (2014, January) confirms this by mentioning that a MEAT-tender does not only take into account the price, but also the quality. Quality includes public focus, sustainability and project management.

The second change is the formation of new organizational forms. In this case the client, building company, architects/designers and consultants have different roles and the distinction between design and construction phase is abolished (Dicke & Smulders, 2005). Chao-Duivis *et al.* (2010: 25) describes them as four building contract models: the traditional model, the design team model, the integrated model and the alliance model. In the first, the relation between client, designer and constructor are triangular. The constructor is involved after the design phase. In the second model, the constructor is involved in the design phase, also called a design and built contract. The third, the integrated contract, also management and operation of the building can be included. The execution of the contract is in the hands of a single party in relation to the client. Fourth, in the alliance model, the client and the contractor enter into a partnership and treat one other as equal. Lastly, another model is the PPP, public-private partnership. In this case the partnership covers a multiplicity of areas. The model has transformed into an umbrella term in which in a planning context a partnership between a governmental party and a private-sector organization is set up for a spatial development. (Chao-Duivis *et al.*, 2010) These integral contract forms, leading to a non-traditional form of organization, could make the fragmented building sector handling more integrated.

Greenfield to brownfield development

The last change is the emergence of brownfield development. A brownfield is a location which has already been developed before. Existing buildings have to been taken into account, which enlarges the complexity of urban area development. Glumac (2012) states it as that the scope and scale of urban redevelopment projects is increased since 1999. "*The complexity of a brownfield redevelopment results from various physical, legal and financial issues underlining the involvement of numerous parties on various levels.*" (Glumac, 2012: 5)

Conclusion

The urban area development process is getting more and more complex. In current urban area development actors are situation in a horizontal, network society. More actors are involved in the decision making. Huge masterplans are not flexible enough for the prolonged processes, which changed the project results to more flexible urban strategies. End-users are also more involved in the process for the financial feasibility. The focus is more on the final result instead of the land development. And more location factors have to be taken into account, because of the development shift from greenfield development to brownfields. In order to make the process less fragmented, which also tackles this complexity, new organizational forms are more and more used. More actors, a new process and different expected results are making the decision process more complex. The next part continues on this topic of decision making.

The decision making processes

All those changes affect the decision making process, which is currently taking place in a network approach with a facilitating government. The next part describes this process.

First and second order design

Decisions can be taken on several levels. Adams and Tiesdell (2012: 14) describes the difference for place making as a 'first-order' and 'second-order' design activity. In the first-order design consists of the physical (urban) design. The designer is responsible for this design project, which could be a building, public space or element of street furniture. "*Second-order design is about modifying the decision environments within which other development actors operate, including developers, investors, architects and surveyors. This can be achieved by means of design frameworks, plans and policies, supported where necessary by incentives and disincentives, including financial subsidies, discounted land or infrastructure provision.*" (Adams & Tiesdell, 2012: 14) Adams and Tiesdell (2012: 15) conclude that "*effective place-making thus requires second-order design to set an appropriate context for first-order design.*"

What is needed in decision making?

Harmonization and control processes are needed in order to govern the complex decision making procedures in inter-organizational networks (Franzen *et al.*, 2011). Franzen *et al.* (2011) gives two types of decision making processes. The first is a hierarchical process, in which the leader has the final call. In the second the decision power lies with several parties. Agreement between them is needed to continue, this is multi-actor decision making and in this thesis the case.

Multi-actor decision making

The interactions between actors in multi-actor decision environments can be seen as complex decision systems in the built environment. "*Characteristic for this branch is not a mere people's reaction on the given conditions in the built environment but also the interdependent decisions that people perform in relation to the other people.*" (Glumac, 2012: 17) The expected decisions of other actors thus influence individual actors' decisions. In Figure 15 the categorization of the most applied approaches can be seen (Raiffa, 2002).

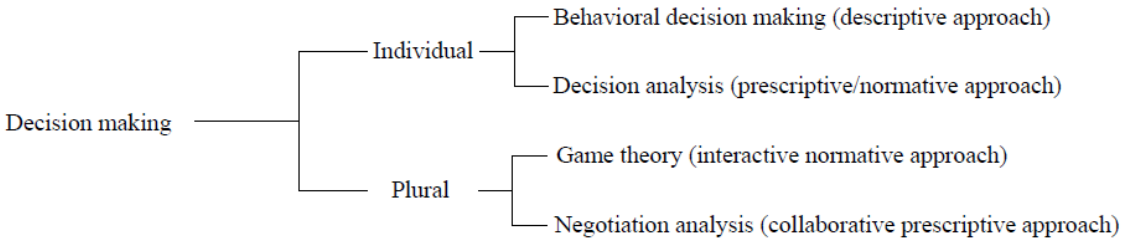


Figure 15: Four approaches in decision making (Raiffa (2002) in Glumac (2012))

The activated parts of networks are called policy arenas (Teisman, 1998). According to Heurkens (2006) within these arenas different actors, individuals, or representatives of different (types of) organisations can be found. "*Each actor individually and constantly strives to improve his part of the design, and thus to achieve his individual optimum. The project team as a whole will also continually strive to achieve the best group result possible. This is referred to as the optimum interorganisational design (Van Loon, 1998), the final product of the decision-making process.*" (Heurkens, 2006: 253)

Developers' decisions

"There are four main decisions that a developer addresses here: (1) where to build; (2) what to build; (3) when to build; (4) how to develop. These questions address the developer's perception of opportunities in an area. Understanding the questions instead of merely implementing cost-benefit analysis, potentially leads to higher urban value that is in interest of not only a developer but a municipality as well." (Glumac, 2012: 16)

An integrated development vision

According to Franzen *et al.* (2011: 57) the new governance approach that builds on individual preference makes an integrated development vision indispensable. This is a coordinated and cohesive vision of the future development, independent on the scale level. An integrated development vision is constructed through an interactive and bottom-up process.

Conclusion

In the network approach of the urban area development process multiple actors are involved in the decision making process. Every actors tries to improve his part of the plan to reach his individual optimum, they put their individual interest above the interest of the group. This makes the decision making process more complicated. An integrated development vision is needed from the started, created by an interactive and bottom-up process. By second-order design smart policy arenas can be formed to keep the development process going.

Constraints in decision making in urban area development processes

As the previous part describes, decision making is complex. This part describes the biggest constraints to take into account.

Multiple actors decision making is dealing with conflict of interest

The biggest constraint are the involvement of multiple actors in decision making and that these actors have different interests, objectives and values. Golobic and Marusic (2007: 994) even state that "m*ost of the tasks in planning involve dealing with conflicts."* According to them they result from inadequate information about the facts, and uncertainty about the outcomes. Glumac (2012) gives a clear overview of the difference between public and private parties' interests in Table 8. Franzen *et al.* (2011: 47) gives a great statement of how the urban area development process also can be seen: "*The complex interaction between parties makes urban development an exercise in relations management.*"

Table 8: Public and private parties' interests (Glumac, 2012: 25)

Party	Immaterial interests	Material interests
Public	- Employment - Vital urban economy - Spatial and environmental quality - Intensive and efficient use of space - Sustainable maintenance and management - Image of the city - Contacts with companies	- Financial feasibility of the plan / land development - Investments from companies - Higher yields from property taxes - Rising of land prices or ground rents
Private	- Improvement of the urban quality (better functioning of the company) - Sustainable maintenance and management (to guarantee the quality on the long term) - Improvement of image through a better appearance - Continuity of operational management - Image, quality and sustainability of developments represents a social responsibility further used a sales argument	- Higher value of real estate and parcel - Saving in costs through a better functioning of the company - Return / yields - Building volume / profit - Value of real estate, long-term profitable investments

From Table 8 can be distracted that the biggest difference in interest between public and private parties is the public value vs. financial value (profit).

Information gab

Besides that conflicts arise from inadequate information, conflicts can be prevented by providing information and knowledge. There is a huge information gab about sustainability. For instance, Figure 16 and Figure 17 show the underestimations people in the building industry have of the contribution of buildings to the total amount of CO_2 emissions and underestimations of the extra costs of a certified building (WBCSD, 2007: 18). Although the research is already aging, it can be expected that there is still an information gab present about sustainability issues.

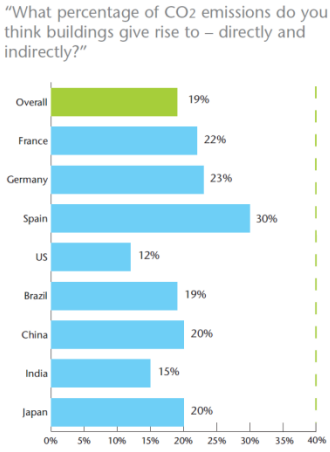


Figure 16: Estimates of buildings' contribution to total emissions (WBCSD, 2007: 18).

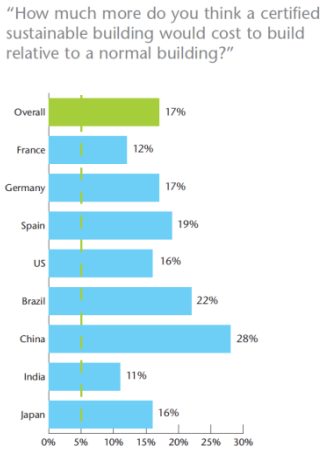


Figure 17: Estimates of cost premium for "a certified sustainable building" (WBCSD, 2007: 18)

Glumac (2012) describes the problem of the information gab for brownfield redevelopment. As example he gives is the stigma of a contaminated soil. A brownfield is mostly expected to be contaminated. That does not have to be the case.

Due to the information gab wrong arguments can be used by different parties. When provided with the correct information, another decision would probably have been made.

Fragmented value chain

The fragmentation of the value chain is causing problems. For instance, if a real estate developer would invest in energy-saving measures, he has to pay more, but the end-user is saving money. The LCTPI (2015: 1) describes this as "*non-technical barriers that hamper the uptake of energy-efficient building solutions in both new and existing buildings.*" They argue that "*solutions have to be found by engaging the full range of stakeholders across the building value chain, in local markets. Only increased coordination and collaboration in local building markets can lead to improved market acceptance of energy-efficient building practices.*" (LCTPI, 2015: 1) The WBCSD (2007: 14) comes with the same conclusion: "*The sector is characterized by fragmentation within sections of the value chain and non-integration between them. Incentives to reduce energy use are usually split between different players and not matched to those who can save the most through energy efficiency.*"

Switzer (2006, July 1) gives (already ageing) financial numbers in the 'National Real Estate Investor'. It would costs a developer 2-4% upfront to construct a green building and the payback time is often 3-5 years. So, in the long term a green building is going to save the owner more money through energy savings. A 2% investment in green building design upfront would result in 20% savings on total construction costs.

This proofs that some parts of environmental sustainability are profitable, but difficult to implement due to the fragmentation of the value chain. It is therefore important to take This fragmentation into account when calculating the financial cost-benefits of sustainability measures.

The law

As described earlier, the regulations on sustainability only gets tighter. Also an environmental impact assessment at the end of each phase is obligated (Franzen *et al.*, 2011: 111). If the authority does not accept the outcome, all parties have to go back to the drawing board.

The business case

"*A precondition for the realisation of an area development project is that there has to be a feasible business case. What this basically means is that at least all the costs that are incurred should be recovered from the yield, and*

that there are adequate safeguards against risks. […] Most importantly, many different public and private parties are involved, all of whom have to be persuaded of the soundness of the business case." (Franzen *et al.*, 2011: 181) This sounds very clear, but there is a difference between public and private parties. Franzen *et al.* (2011: 181) describes it as that "*Public-sector parties tend to look at the historic costs – i.e. they use the book value method. This can be ascribed to the fact that governmental bodies have to account for their expenditure retrospectively in great detail. From a purely commercial point of view [of the private parties], the assessment is focused solely on the value in the future; after all, that is the only thing about which it is still possible to make a decision.*" Thus, there is a difference in justification between public and private parties. Public parties have to proof there assumptions based on the past, while private parties have to proof the business case by expected revenues in the future.

"*There are also clear difference between the parties regarding their risk profiles. Commercial parties are strongly oriented towards managing and reducing risks, whereas government bodies are prepared to accept higher risks on the basis of social arguments.*" (Franzen *et al.*, 2011: 181) This would imply that with the involvement of the private parties in the urban area development process less financial risks are taken.

Conclusion: Constrains for sustainability

In the urban area development process the multiple involved parties have already a lot of different interests. For the public municipal parties it is the public value and for the private parties it is the commercial/financial value. Implementation of environmental sustainability measures into a closed business case is constraining for private parties due to the information gab on the real costs of sustainability measures, the uncertainties of future financial benefits and the fragmented value-chain (profits are for another party). Environmental sustainability is also not directly a problem of private parties, but one of the whole society. However, they are obligated by law to make an environmental assessment, but why would the invest in measures which are costly and bring more uncertainly in the business case?

Rovers (2008: 81) describes a continuing complexity to involve sustainability into the urban plan. He argued that it must be incorporated from the first step: "*Having considered all these variants and their impact on the design, costs and in terms of required skills, etc., the level of ambition of the project can be selected. Once this level has been chosen (after discussing possible conflicts between areas like energy, water, materials, etc.), the urban design phase can start. Here again, the situation is complex. How can the different levels of ambition and wishes be integrated to create a sound and sustainable area?*"

Conclusion: Viewpoint of the real estate developer

Sustainability is mostly a public value, however, for several reasons it is interesting to approach this problem from a private sector perspective. First, the real estate developer plays a central role in the development process and the financial value chain. They are a leading party. Second, somebody has to invest in those measures. Real estate developers are primarily focused on the financial aspects to close the business case. If sustainability is incorporated in the business case, the information gab is directly much lower and research findings would prove that in some way it pays off, the transition to a (environmental) sustainability would be accelerated.

3.3 (Environmental) Sustainable Private Sector-led Urban Development

This part is about identifying 'the private sector' in this thesis, incentives for the private sector / real estate developer and environmental sustainability in private sector-led urban development processes. In the final part arguments are mentioned why a decision support tool would help.

What is 'the private sector'?

The focus in this thesis is on the real estate developer as 'the private sector'. The goal of the developer is according to Putman (2010: 31) mainly on increasing its own margin. Its therefore important for the developer to control costs and increase and optimize their own value.

Investor vs. developer

Two main types of developer can be distinguished: the investor and the real estate developer.

The goal of the investor in urban area development is to improve the long term yield on their real estate portfolio (Putman, 2010). Real estate is considered a profitable long term investment (Sturm, 2014). The focus of the investor is mainly on the operating phase of the urban development process (Van Gool *et al.*, 2007). The investor can invest direct and indirect in real estate. In the first case the investor owns the building

and in the second case a collective fund owns the real estate, for instance a Real Estate Investment Trust (REIT) (Van Gool *et al.*, 2007).

According to Van Gool *et al.* (2007) the real estate developer brings together ideas, management, labor, capital and land to realize a new real estate project. The real estate developer is risk-bearing by investing in land acquisition, plan development and preparations to property development (Putman, 2010). The real estate developer is mainly focused in the first phases of urban area development.

Buskens (2015: 112) described in his master thesis that research of Sturm (2014) and Stumpel (2014) showed that investor-led development in the Netherlands is not taken for granted and not an accepted appearance. This is caused by the limited possibilities within the regulations in the Netherlands in comparison to Anglo-Saxon counties (Heurkens, 2012). Heurkens (2012) argues that because of this, it is not likely that a shift towards investor-led urban development will occur in a short time frame. For this reason, like the master thesis of Buskens (2015), the project developer will take a central role in this thesis.

Different types of real estate developers

Within the main category of real estate developers several subcategories can be distinguished. These subcategories are based on underlying reason to take part in real estate development. Table 9 shows several subcategories identified by Buskens (2015: 110) and Hieminga (2006) in Glumac (2012: 15). No final focus has been chosen.

Table 9: Characteristics of real estate developers based on goals and objectives in a more structured typology

Buskens (2015: 110)	**Hieminga (2006) in Glumac (2012: 15)**
Project developers emerged from or related to building companies	Contractor: Goal of this group of developers is to reach a high building production through project development. This group is also called developing constructors. This group is relatively large because almost all middle-sized and big construction companies have a project development unit. This group is largely represented in the development of owner-occupied houses.
Independent project developers	Independent project developer: This group of developers is not associated with other branch-related activities, like the developers that are a part of a construction company. Project development is a goal in itself. Through the project development activities, the continuity of an operational management and high returns on investments are pursued for shareholders.
Projects developers related to institutional investors	Asset investors: This type of project developer keeps the real estate in their own portfolio after development. This group considers real estate development as a mean to come to good real estate investments. Some of the big institutional real estate investors also develop real estate themselves – using the fiscally attractive status of an investment company – but this category mainly exists from wealthy particular investors.
Project developers emerged from or related to financial institutions	Financial institutions: They are also active in project development.
Others	Social housing associations: They are increasingly active and influential on the commercial real estate development market after the liberation in 1995. Project development is a mean for social housing associations to finance uneconomic social investments.
	Architects: For them, development activities are the means to perform design services. Considering the complexity of the total building process and the required (big) size of architectural companies to be able to do this, this group of project developers is relatively small.

Financial aspect vs. the natural environment

The real estate developer focus is on increasing its own margin (Putman, 2010). The (natural) environmental provides development space (land) for the developer. A part of it is the sustainability component. In Figure 18 and Figure 19 is shown that this is just a small component within the project for the real estate developer.

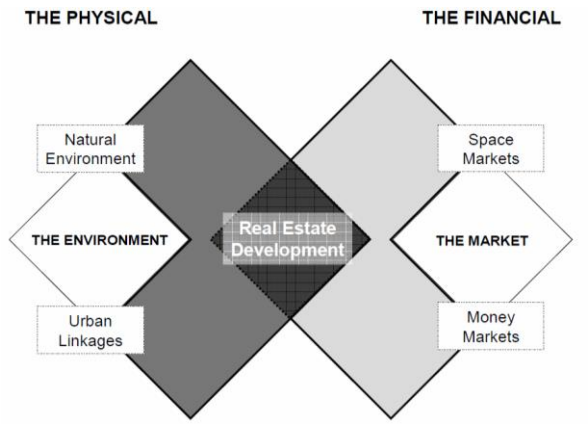


Figure 18: Real Estate Development: Synergy of Physical and Financial Dimensions (Leelarasamee, 2005: 15)

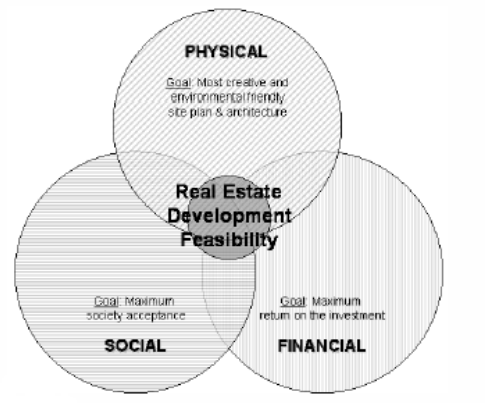


Figure 19: Real estate evelopment feasibility (Leelarasamee, 2005: 22)

Incentives for the private sector

If environmental sustainability has such a little focus of the real estate developer, what could be incentives to engage with it. Franzen *et al.* (2011: 46) named a recent shift towards a more sustainable approach, which is induced by the market since sustainability has become an economic factor. Interviews by Buskens (2015: 51) identified several motives for commitment with sustainability by real estate developers (Figure 20).

Figure 20: Mentioned motives for the commitment to sustainability, translated from Buskens (2015: 51)

Other incentives could be the increasing legislation on sustainability issues on European level and in Dutch building policies, like the EPC (Rovers, 2008), a faster process, because faster agreements into sustainable investments can be reached. A faster process saves money. And lastly, there is a market for eco-districts. Form personal communication is understood that there is a waiting list for one of the most known Dutch eco-districts; Eva-Lanxmeer. Thus, there are multiple incentives for the private sector to engage with sustainability.

Current role of sustainability in private sector-led urban area development

Sustainability is one of the factors which is making the urban area development process more complex. There are several constraints to be dealt with, as described in part 3.2. First of all, the risks and uncertainties (e.g. the knowledge gab) have to be managed and reduced, because the future value has to be known for making the business case. And second, the different interests in sustainability of public and private parties are making it complex to create a common urban development vision from the start of the project.

The LCTPI (2015: 2) state four shortcomings for sustainability in local multi-stakeholder engagements:

1. A Lack of awareness and leadership, particularly related to challenges in making the business case;
2. Workforce capacity and the need for proper skills and collaboration along the value chain to implement the right solutions;
3. Lack of adequate financing models;
4. Lack of consistent and long-term policy frameworks (national and sub-national), including regulations and incentive schemes.

According to the LCTPI (2015: 4) the first important step towards Energy Efficient Buildings is: "*Continue driving the demonstration project led by the private sector, in order to continue showing that locally led efforts can catalyse market-wide energy efficiency investment in new build and in the renovation of existing building stocks.*"

Currently, there is already a shift is occurring, mainly caused by the shift in focus from ground exploitation to real estate exploitation, as described in part 3.2. This shift changed the way of doing things for real estate developers. Buskens (2015: 36) described this change. The next two paragraphs are based on his literature search. During the financial crisis real estate developers made major losses on ground and came to the insight that developing based on power brings major financial risks. For this reason, a transition is happening, which is referred to by Beuzenberg (2012) and Van der Ven (2011) as the transition from development on the basis of power to development on the basis of strength. Within this transition quality and sustainability of developments are getting a more central role.

Formerly the funding of developments was often done for 90% by banks. Currently it is high when 65-70% of the funding comes from banks (Beuzenberg, 2012). Real estate developers are searching for new methods to operate more independent. The change from supply-driven development to demand-driven development asks for a greater market knowhow of real estate developers (Beuzenberg, 2012; Bouwfonds ontwikkeling, 2010; De Zeeuw, Franzen & Van Rheenen, 2011; Putman, 2010). This requires different abilities, knowledge and competences of their employees. Especially networking skills and option contracts are important, giving the possibility to real estate developers to reduce the necessity to own the land (De Graaf, 2011). Thus, based on this demand-driven development on the basis of strength, sustainability gets a more central role.

Future role of sustainability in the urban design process

Loftness (2013) describes sustainable design in the built environment as a collective process to reach unprecedented levels of ecological balance, focussing on the environmental context. Sustainable design merges the natural, minimum resource solutions of the past with the innovative technologies of the present. It creates an integrated and intelligent system that supports individual control with expert negotiation for resource consciousness. In the end sustainable design offers architecture of long term value through the whole life cycle instead of least-costs investments. (Loftness, 2013)

Key moments for involving sustainability

According to Rovers (2008) a conceptual approach needs to be taken. This could only be done when this is part of the central focus of the project. In the initiative phase a feasibility study is done and a program in brief and a project plan is made. Key is to incorporate sustainability from the start of the project. Glumac (2012: 10) briefly describes how the start of the process works: "*In the initiative and land acquisition phase the key actors such as market parties, users, and governmental representatives are identified, as well as their properties: internal organization, constraints, demands and power to influence and affect a development process. In the first two phases of the redevelopment, the process forwards certain market knowledge to an idea. […]. Together, these products can support the assessment of the risks and opportunities in the redevelopment process mainly related to the program in brief and location analysis.*"

Wamelink *et al.* (2010) describes the managerial paradox in a construction project. At the start of the project the project team has major influence on costs, but there is little information to base the decision upon. While during the project the amount of information increase, but the influence on costs decreases. This is shown in Figure 21. A feasibility study is therefor of major importance at the start of a project, a decision support tool could provide information to base the decision upon, for instance on the ambition in environmental sustainability. Leelarasamee (2005: 2) confirms this way of thinking: "*Decisions developers make in the predevelopment stage are very important. In many cases, the decisions affect significantly the future investment performance of the developed property.*"

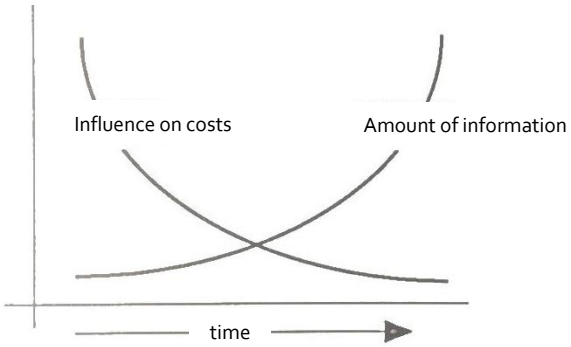


Figure 21: The managerial paradox of a construction project (translated from Wamelink *et al.* (2010: 159))

Conclusion: Where can a decision support tool help?

This part elaborates on investment decisions of real estate developers, constraints in the current and future process, the shortcomings in current tools to in the end identify the problem.

A investment decision is based upon an integral consideration between design and technical quality, function and user quality, location and ground acquisition and finance and exploitation (Wamelink *et al.*, 2010). A decision support tool can deal with the constraints for reaching environmental sustainable developments. For instance, it can provide information about the costs in environmental sustainable measures to cover the information gab.

Leelarasamee (2005) did research in decision making by real estate developers. The focus was on feasibility assessment and venture considerations during the predevelopment stage of income producing real estate. In addition this information was used the design and develop a decision support system. "*In order to reach a strategic decision, [real estate developers] have to assess many development alternatives. Often, they have to conduct analyses with limited resources and within a narrow timeframe. Developers have to put much effort in time-consuming processes, which include finding the most reliable information, and repeatedly performing comprehensive analyses.*" (Leelarasamee, 2005: 2) Based on these constraints Leelarasamee (2005: 4) named the major reasons where a decision support tool can help: "*Considering that risks are irrefutable, resources are limited, and time is essential, careful analyses during the predevelopment stage are indispensable. Under the same circumstance, developers who are equipped with the tools that facilitate the decision-making process will have competitive advantages over those who are not. Decision support systems reduce risks for investors and developers. Finally, researching and developing such systems will contribute knowledge in both real estate development and information technology fields.*" Decision support tools are thus very useful in the process. "*There are four major reasons that support use of decision support systems in income-producing real estate development, especially during the predevelopment stage: [1] Real estate market research is a non-absolute science, [2] Variations of factors often cause a chain-reaction through development and Post Development stages. [3] Program and strategy deviations are easy to evaluate during predevelopment stage. [and 4] Decisions have long-term impacts, and often incurable.*" (Leelarasamee, 2005: 51)

But there are already several tools, why is there a problem? Glumac (2012) identified scientific methods and tools for planners to support actors' decision-making in both content and context. Several techniques are visualization techniques, GIS-applications, Group Decision Support Systems, Planning Support Systems, Multi-Agent Systems and Simulation Gaming. The aim of these tools is to develop alternative solutions (plan proposals). The researcher state that "*the construction of alternative plan proposals within these models is a relative unstructured process. Little work has been down to develop models that systematically relate the characteristics of brownfield areas to the behaviour of actors thereby the insight in the actors' most important points of interest and possible sources of conflicts is still missing.*" (Glumac, 2012: 2) Just as his research this research focus on a strategic decision-making in the complex multi-actor environment to give alternative plan proposals or at least evaluate proposals, but in this research it is specially concerning environmental sustainable development to get the urban flows of water, energy and GHG-emissions in a durable situation. Unless, Glumac (2012) identified what could be lacking: insight in the actors' most important interests.

Binnekamp *et al.* (2006: 5) also identified what could be lacking: "*Urban planners, project developers, architects, construction firms, etc., all tend to stick to proven concepts and methods.*" They want to reduce risks by coping known formulas. Binnekamp *et al.* (2006: 1) argues for a new perspective "*that technical optimisation and social optimisation should not be carried out separately, but be integrated into one design process.*"

The Open Design Approach of Binnekamp *et al.* (2006) can help. "*[This] decision-making models which do incorporate differences of opinion and power imbalances, and which can cope with incomplete information.*" (Binnekamp *et al.*, 2006: 1), but "*He or she must respect and value these preferences and leave the design process really open-ended, as opposed to using that process as a means to achieve what he or she had in mind all along. Such open-minded, non- manipulative behaviour, does not come about by itself.*" (Binnekamp *et al.*, 2006: 5)

- This case is about the architect who manipulate others by fancy pictures to get their desired design.
- Same can be said for developers, who want their beloved return on investment.
- Not manipulating others

3.4 Tools for (Environmental) Sustainable Private Sector-led Urban Development

The researcher has identified three types of tools for sustainable private sector-led urban development. These tools are described in the next paragraphs.

1. Environmental Impact Assessment to comply with the law
2. Tools for recognition (BREEAM, LEED, etc)
3. Life Cycle Assessment tools
4. Tools for within the process

Environmental Impact Assessment

EIA has been a key component of environmental assessment for over the last 40 years. It "*has coincided with the increasing recognition of the nature, scale and implications of environmental change brought about by human actions*" (Morgan, 2012: 5). Related approaches to EIA are Strategic Environmental Assessment (SEA) and Sustainability Assessment (SA). First one as an attempt to extend environmental assessment to higher levels of decision making and the second one to focus more on the sustainability aspects. (Morgan, 2012)

EIA is now widely accepted and used around the world and the use of EIA at different scale levels of decision making is growing significantly. It has a rational approach of assessing the impact of a proposed policy, plan, programme or project. Morgan (2012) states in the conclusion of the article Environmental Impact Assessment: the state of the art: "*EIA should be integral to project development and design process, not left to the final legal step before project implementation.*" (Morgan, 2012: 12)

Sharifi and Murayama (2013) are describing a new, latest generation of impact assessment tools: the Neighbourhood Sustainability Assessment (NSA) tool. They give a critical review of seven NSA's, namely LEED-ND, EarthCraft Communities (EEC), BREEAM Communities, CASBEE-UD, HQE^{2}R, Ecocity and SCR. Both are divided in two categories: Plan-embedded tools and spin offs. The first category includes tools that are embedded into neighbourhood-scale plans and sustainability initiatives to assess their sustainability performance. The second category consists of third party assessment tools which are spin-offs of building assessment tools and assess the sustainability beyond a single building. The first four mentioned NSA's are spin-offs and the last three are plan-embedded tools. (Sharifi & Murayama, 2013) From the comparison of these tools is states by Sharifi and Murayama (2013) that plan-embedded tools have been more successful in reaching their objectives. This relative success brings in the significance of intertwining the assessment tools with the broader process of planning. Another advantage of this linkage is that it will be possible to establish a network of linkages among assessment systems in various geographic scales. Many problems and challenges are still to be tackled for NSA tools, but they have been successful in raising the environmental consciousness and disseminating the idea of sustainable assessment in the neighbourhood level. (Sharifi & Murayama, 2013)

For instance by BREEAM the final score is a measurement of how well a masterplan proposal and its supporting documentation have performed against the complete range of assessment criteria (BRE Global, 2011, March). However this assessment can be done in any point in time, the feedback is rather static. The researcher assumption is that a tool which can deliver real time feedback would be more useful. This would deliver a more interactive planning process.

Life Cycle Assessment

Life cycle analysis "*is currently the scientifically accepted method for environmental impact assessment.*" (Itard, 2011: 285) Also Rovers (2008: 28) agreed upon this and adds that LCA "*is an international accepted methods for accurately identifying and assessing the environmental impact that occurs in all phases of the lifecycle of a product, process, service or material. The method produces an 'environmental profile' that shows how the product scores 'from cradle to grave' in relation up to 14 environmental effects. The LCA underpins many, for the moment voluntary, tool used to compare buildings and product performances.*" While the LCA can be complex, another tool -the eco-indicator- reduces the results of the LCA to one single figure. "*This figure expresses the environmental impact caused by a product or material 'from cradle to grave'.*" (Rovers, 2008: 28)

Cellura *et al.* (2014: 130) describes a useful example how the LCA effects decision making: "*When improving the energy performance of a building, extra materials and components are required, resulting in higher embodied energy. Then, the authors apply LCA methodology in order to assess the overall impact of the proposed retrofit measures over the building lifespan.*" Thus, the relevance of the life cycle approach is apparent to perform a reliable and complete building energy and environmental assessment (Cellura *et al.*, 2014).

Focus on type of decision support tools in this thesis

In this thesis the researcher would like to search for real-time feedback systems, which deliver integral information to support the decision making at the moment. Not like the assessment tools, which are assessing at the end of a phase. In this case the development progress could be more effective. The next is therefore more focussed on support tool that deliver real time feedback. First a theoretical view on technology is given to understand the researchers standpoint towards technology.

Three theoretical views on technology in a changing social perspective over time

Technology is an umbrella term and last decades the viewpoint of society and researchers changed towards technology. Matthewman (2011) explains three theoretical views on technology and how they develop in time:

1. Anti-humanist: Technology is privileged above humans, technology can solve problems.

2. Humanist: Society is privileged above technology, technology is made by humans.
3. Post-humanist: Refuses to privilege either one of them.

Those three view can be connected to the concepts of technological determinism, the Social Construction of Technology (SCOT) and Actor Network Theory (ANT). In this research a post-humanist approach is taken. Technology cannot solve problems, it can provide information to base decision upon to solve problems. Technology collaborates with humans in a network of people and technology, the process would change if the technology is taken out. This viewpoint fits with a statement described by Matthewman (2011). Technology can be seen as an extension of ourselves. Hardware would be the extension of our body and software the extension of our mind. In this case a decision support tool would be the extension of our mind.

Intelligent technologies

Intelligent Decision Technologies are a combination between intelligent systems and intelligent technologies which enhance or improve decision making with an interdisciplinary focus. "*The field of intelligent systems is expanding rapidly. […] Networks have integrated the Internet and wireless technologies to enable communication and coordination between dispersed systems. Intelligent decision making now means that technology assists the human decision maker in everyday tasks and complex environments. The field of intelligent decision systems is interdisciplinary in nature, bridging computer science with its development of artificial intelligence, information systems with its development of decision support systems, and engineering with its development of technology.*" (Phillips-Wren *et al.*, 2010: VII)

Modelling and simulation

Next to intelligent systems can modelling and simulation tools be useful to reach decision support information at the needed moment. "*Simulation is the process of designing a model of a real or imagined system and conducting experiments with that model. The purpose of simulation experiments is to understand the behavior of the system or evaluate strategies for the operation of the system. Assumptions are made about this system and mathematical algorithms and relationships are derived to describe these assumptions – this constitutes a "model" that can reveal how the system works. Simulation is deployed when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist. It can be used to demonstrate the eventual "real" effects of a system when subjected to alternative conditions and courses of action.*" (Lam, 2013: 10197)

Supporting technologies

According to Pohl *et al.* (2011) is "*A desirable computer-aided design environment is one that assists and extends the capabilities of the human designer rather than replaces the human element. Human beings and computers are complementary in many respects. The strengths of human decision makers in the areas of conceptualization, intuition, and creativity are the weaknesses of the computer. Conversely, the strengths of the computer in computation speed, parallelism, accuracy, and the persistent storage of almost unlimited detailed information are human weaknesses. It therefore makes a great deal of sense to view a computer-based design environment as a partnership between human and computer-based resources and capabilities.*" (Pohl et al., 2011: 204)

In the computational environment Aerts *et al.* (2009) proposes it "*involves three main decision support functions: 1) Data management, integration and visualization. 2) Intelligent spatial decision analysis by the presentation of computational results using suitable outputs such as diagrams, tables and reports, surfaces, geographic maps. 3) Decision comparison by interactive evaluation of different scenarios.*" (Argiolas et al., 2010: 337)

Decision Support tools

The next part elaborates on decision support tools. Points of focus are different types, requirements of the tool and current decision support tools.

Different types

Franzen *et al.* (2011) categorizes urban management instruments in four types:

1. Urban management instruments for supporting multi-actor urban decision making
2. Urban management instruments for urban design
3. Process-oriented urban management instruments
4. Urban management instruments for design based on costs vs. benefit

The decision support tool in this research is product and process oriented, therefore it should support in the multi-actor decision making (process) and evaluate the plans (urban design product) on (financial) feasibility. It fits partly in all four categories.

How can these tools help in the process?

The decision support tool should:

- Deal with the conflicts of interests
- Give a (financial) feasibility study in the ambition for environmental sustainability
- Present the results in an understandable way to all actors

In this way the decision support tool can provide valuable information based on facts about the contribution of the plans to a sustainable environment and the cost premium. An idea is to digitalize the maximization method by use of the open design approach.

Current decision support tools

According to De Wit-Blok (2014) the most know strategic instruments in the Netherlands to assess buildings and areas on sustainability are LEED, BREEAM-NL and GPR Gebouw. All three methods use a particular scoring system that focuses on sustainability-related themes.

At the group of Urban Area Development of the Department of Real Estate and Housing (TU Delft, faculty of Architecture) several other models have been developed and applied. The Urban Decision Room and RICARDO-Model are explained by Franzen *et al.* (2011). The focus of research was on a collaborative approach to urban area development, which tackles "*the problems professionals in urban area development encounter with producing design information, quantifying design decisions and combining conflicting interest towards solutions.*" (Franzen *et al.*, 2011: 199) All kind of experiments have been done in order to answer the question of "*how and under what conditions urban developing teams should work together to achieve optimum development (Van Loon et al., 2008).*" (Franzen *et al.*, 2011: 199)

One of those tools will be discussed in more detail together with two other interesting existing models. The Urban Decision Room, CiTYMAKER and BRIDGE will be discussed.

Urban Decision Room (UDR)

The Urban Decision Room focus is on a collaborative approach to Urban Development (Franzen *et al.*, 2011: 199) and is described in the book of Van Loon *et al.* (2008). The next part is based on this source.

According to Van Loon *et al.* (2008: 10) the system works in the following way: "*The computer network enables the participants to communicate with each other about the relevant topics. The network enables also to make calculations of the 'results' of this communication and to represent it at each computer. These results may form the basis for further discussions and negotiations.*" The result is not given in alternatives or variants of the plan, but in one common solution space. In this way the UDR brings people who are engaged in the urban development process together.

For this thesis the UDR is interesting as it gives feedback about the shared solution space between actors. However, the sustainability component is lacking. A tool helping to find shared solutions and linking different alternatives to the amount of sustainability as new information to base decisions upon is the topic of this research.

CiTYMAKER

According to the creators of CiTYMAKER offers a more complete, fast and transparent tool integrating different parts of area development. The integration of all aspects makes it possible to deliver different, integral scenarios rapidly. This ensures that involved parties got more insight in the possibilities and risks of an area. (CiTYMAKER, n.d.)

The creators of CiTYMAKER identified as well a more complex urban area development process, the next part is based on the description (CiTYMAKER, n.d.). The amount of inner city projects increases, the market is changing and there is a need for sustainability. This causes bigger project teams with more parties and consultants with all their own interest and advice. How to find agreement? They decided that there is a need for a new approach in sustainable urban area development and created a tool which uses a new, smart and integral approach. The tool takes into account financial feasibility, sustainability measures, parking, existing and new program and expected inhabitants and users of an urban design. CiTYMAKER has the philosophy that in this new complex process it is important to first calculate the feasibility of starting points and program and only after agreement upon that the project team should begin with urban design. In this approach a lot of time, money and frustration can be saved. CiTYMAKER consists of a digital dashboard with different buttons to play with. All plan components are connect and insight in effects of changing something is directly visible.

All aspects of area development in one tool: finance, sustainability, inhabitants, existing program, parking and architectural program.

- Finance: Real time insight in financial consequences. This is realised by connecting the ground- and real estate exploitation to the time and scenario planning. It delivers a cash flow statement for every scenario.
- Sustainability: Achieving sustainability ambitions. This is realised by providing real time feedback on the energy need of the whole area. The tool calculates how energy can be saved and can be generated sustainable and how much that improvement costs and yield. Also the expected water consumption and waste generation is included.
- Inhabitants. The future inhabitants and users determine the demanded service level. This insight is based on their composition.
- Existing program. Increasingly, area development takes place in an existing area. The tool gives insight in possibilities like conservation, renovation, transformation and/or demolition of the existing stock.
- Parking. Real time insight in a fitting amount of parking spots.
- Architectural program. The tool makes it possible to play with different mixed-used design options in one program.

In the researchers perspective CiTYMAKER is an instrument focused on the product aspect by combining a lot of knowledge. The process aspect is incorporated in the sense that the information gab is reduced.

SustainaBle uRban plannIng Decision support accountinG for urban mEtabolism (BRIDGE)

According to the headlines of (Chrysoulakisa *et al.*, 2013) research is BRIDGE a bottom-up approach to urban metabolism based on energy, water, carbon and pollutants, which combines environmental observations and simulations with socio-economic data. The instrument has to become a Decision Support System to evaluate urban planning alternatives aiding at the evaluation of the sustainability of urban planning interventions. The researchers sees it as a step towards integration of scientific knowledge into sustainable urban planning.

This tool is thus mainly focussed on Urban Metabolism.

Others

Other interesting decision support tools, urban modelling/simulation techniques and planning support tools are 'Gebiedsontwikkelaar' of StrateGIS (Seijdel & Dullemond, n.d.), Urban Strategy (Van Lit & Kolthof, n.d.), Cigarbox (Brouwer & Erkelens, 2016), EcoDistr-ICT (ECODISTR-ICT, 2014), UrbanSIM (Waddell, 2002) and the Toolkit 'Sustainable Building' for real estate developers, municipalities and designers (Hameetman, 2005). StrateGIS and Urban Strategy are investigated by Schilder (2016) in her recent master thesis.

Conclusion

The final hypothesis is that in order to get environmental sustainability in the private sector-led urban development process a decision support tool which has the combining aspects of the urban decision room, CiTYMAKER, BRIDGE and the Open Design Approach could help the process if it is developed with insight in the actors' most important point of interests. It is important to take into account that the urban development process is a sociological process which cannot be replaced by technology, but tools can structure the design-decision process.

4. Provisional table of contents of the final P4/5 Report

This chapter shows the provisional table of contents for the final report (Figure 22).

Colophon
Foreword
Management Summary
Management Samenvatting
Table of Contents

1. Introduction
2. Research Methodology
3. Readers guide
4. Literature Review / Theoretical Framework
    a. Environmental Sustainability
    b. Private Sector-led Urban Area Development
    c. (Environmental) Sustainable Private Sector-led Urban Area Development
    d. Tools for (Environmental) Sustainable Private Sector-led Urban Area Development
5. SQ1: How is environmental sustainability reached in urban development projects?
    a. Product: Measures taken to reach environmental sustainability?
    b. Process: Characteristics of the process and decision moments
6. SQ2: How can decision support tools be used in urban development projects to reach environmental sustainability?
    a. Product: the decision support tools
    b. Process: the decision support tools in urban development
7. SQ3: How can a decision support tool be optimized to reach environmental sustainability in a private sector-led urban development process?
    a. Product: Creating a model / adding to existing model
    b. Process: Verification / testing of the model

Conclusion
Discussion
Evaluation
References
Appendices

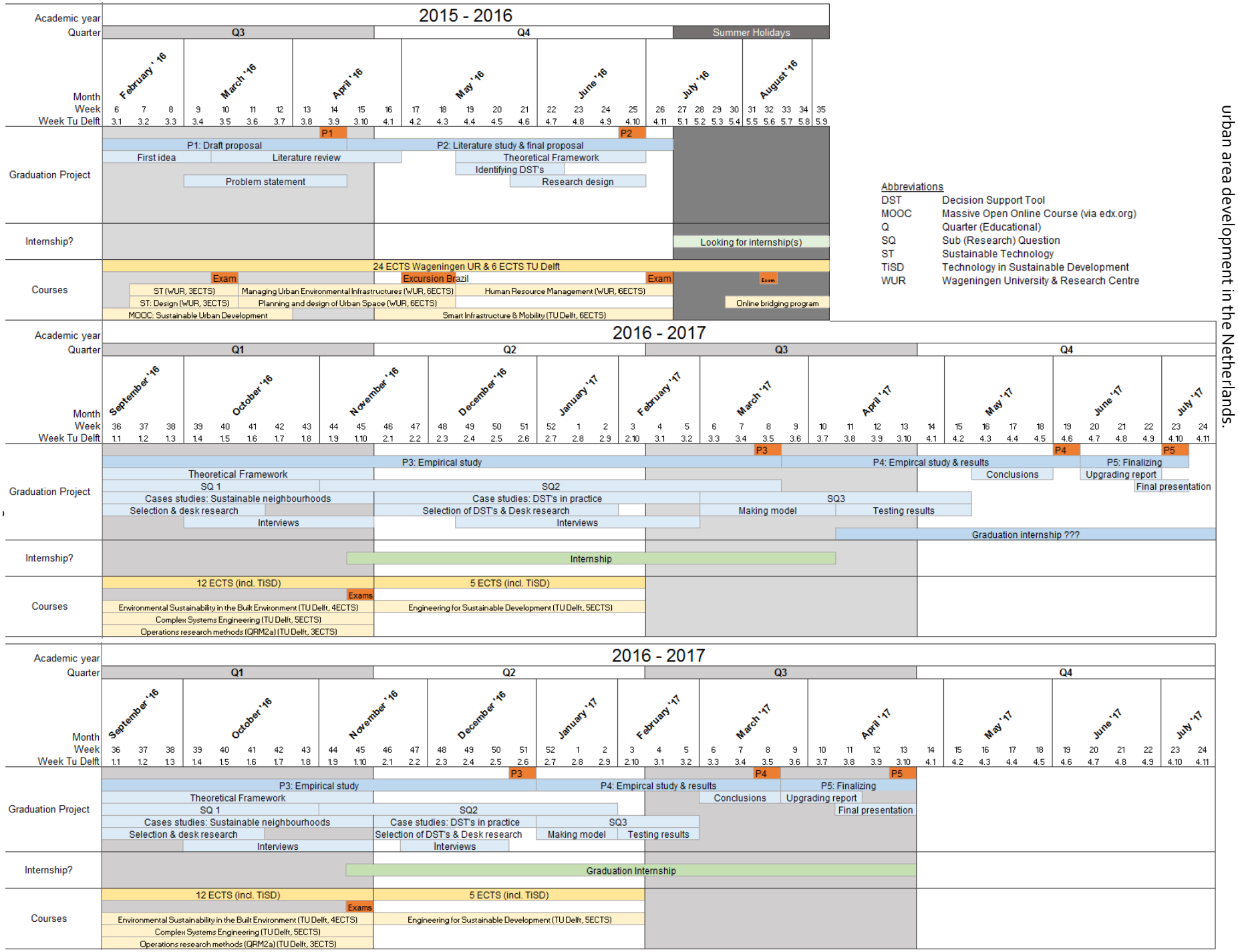
- Interview schedules
- In-depth description of cases
- In depth description of decision support tools

Figure 22: Provisional Table of Contents (own ill.)

A description of the intended content per chapter is shown by the research question, methods and aims shown in Figure 3. Only the aim of the conclusion is lacking. That chapter shall give the answers on the sub research questions, which should all partly answer the main research question. The final conclusion is the answer on the main research question.

5. Planning

The graduation schedule is shown in Figure 23. The schedule shows two options. The choice depends on the possibility to do an internship after the first quarter. This internship should give experience in the practice of urban area development in the Netherlands.



Abbreviations

DST	Decision Support Tool
MOOC	Massive Open Online Course (via edx.org)
Q	Quarter (Educational)
SQ	Sub (Research) Question
ST	Sustainable Technology
TiSD	Technology in Sustainable Development
WUR	Wageningen University & Research Centre

Figure 23: Graduation schedule (own ill.)

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Appendix 1: Data of the European Environmental Agency

All three figures are based on data of the European Environment Agency (EEA), collected by Eurostats.

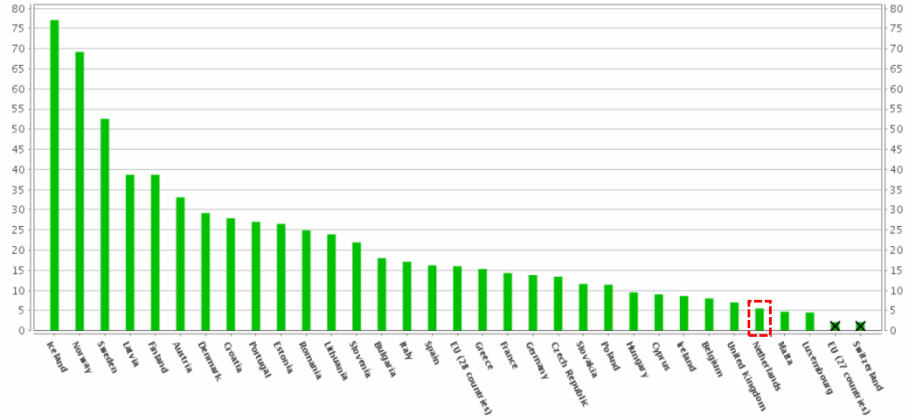

Figure 24: Share of renewable energy in gross final energy consumption in % in 2014 (EEA, 2016)[2].

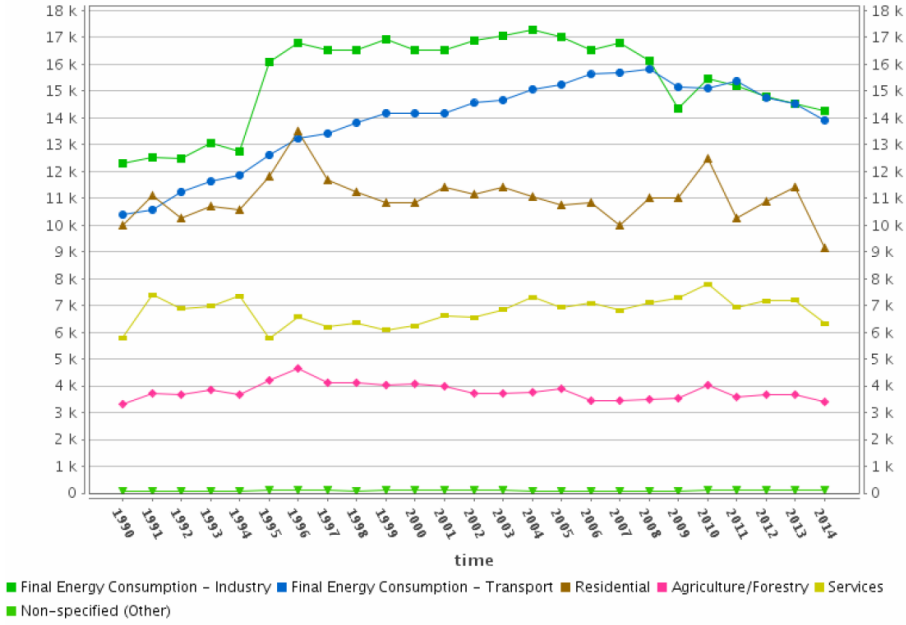

Figure 25: Final energy consumption by sector in the Netherlands (shown in 1000 tonnes of oil equivalent) (EEA, 2016)[3].

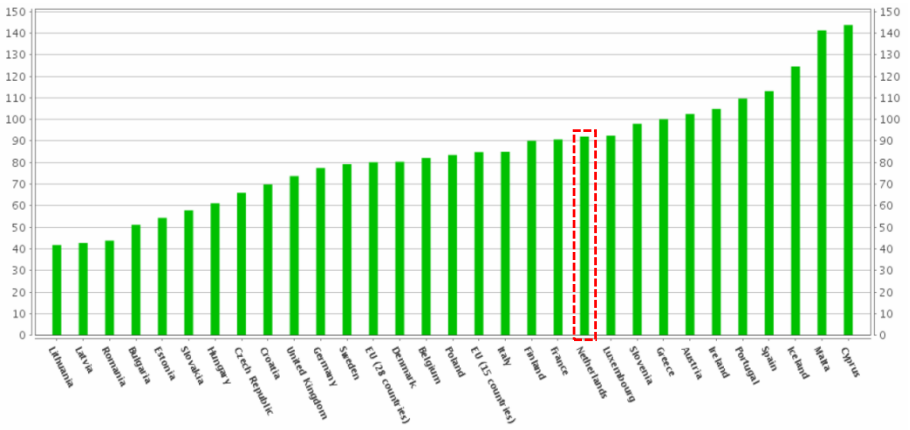

Figure 26: Greenhouse gas emissions (in CO_2 equivalent) in 2013, indexed to 1990 (EEA, 2016)[4].

[2] Image can be found by using code: t2020_31
[3] Image can be found by using code: tsdpc320
[4] Image can be found by using code: tsdcc100