THE DEVELOPMENT AND FUNCTIONALITY OF RESOURCES

A research towards the development of a framework to increase the understanding on the development and problem areas of resources

By Charlotte Roodenburg

TU Delft Delft University of Technology

Faculty Technology, policy and Management

Energy and Industry Department

Master: Systems Engineering, Policy Analysis and Management

Address: Jaffalaan 5

2628BX Delft

The Netherlands

Phone: +31(0)152788380

Webpage: www.tbm.tudelft.nl

The development and functionality of resources:

A research towards the development of a framework to increase the understanding on the development and problem areas of resources

Author

Author: Charlotte Robin Roodenburg

Student id: 1336835

Graduation committee:

Chairman: Prof. Margot Weijnen	(Energy and industry)
First supervisor: Dr. Aad Correlje	(Economics of infrastructures)
Second Supervisor: Dr. Ir. Eefje Cuppen	(Technology dynamics and Sustainable Development)
Third Supervisor: Dr. Ir. Gerard Dijkema	(Energy and industry)

Key words:

Framework, Resources, functionality, institutions, shale gas, Zimmerman

Preface

This master thesis forms the concluding element of my master *System Engineering Policy Analysis and Management.* However, this research would not have been possible without the constructive help and support of several people, who I would like to thank here. First, I want to thank Aad Correlje for his valuable comments, his insights and enthusiasm for challenging theories and his support throughout the whole process. Secondly, I want to thank Eefje Cuppen for her insights and stimulating critics and for making me aware of the different aspects and pitfalls associated with this research. Third, I want to thank Gerard Dijkema for his remarks and observations and for his help to arrive at a research subject and proposal. Fourth, I want to thank Margot Weijnen, for her enthusiasm, comments and trust that I was able to finish this research with good results. In addition, I want to thank David, Jessica and Isabel for their recommendations to improve this report. And finally, I want to thank my family and friends for supporting me throughout the year and keeping up with my 'Graduation' behavior.

Summary

With 20.000 signatures on the petition against shale gas, it can be stated that there are resistances towards the development of shale gas in the Netherlands (Schaliegasvrij Nederland, n.d.) Many people fear that in the Netherlands the same negative effects concerning the exploration of shale gas can occur as in the U.S. Though, it may be questioned if this indeed is possible. The insights which can help to answer this question can be achieved with the 'Modernized Zimmerman framework', which is developed and tested during this research. This framework is based on the theory of E.W. Zimmerman and theories on modern institutions and is developed to increase the understanding on the development and functionality of resources. The main question which is answered during this research is: *To what extent is it possible to develop an institutional framework based on the theory of E.W. Zimmerman and new institutional economists that is constructive to generate insights on the development and functionality of a resource?*

The theory of E.W. Zimmerman (1888-1961) is chosen as the basis from which the framework is developed, as it explains which factors determine why and how a substance can be developed and function as a resource. According to Zimmerman, a substance can function as a resource if it least satisfies one objective, referred to by Zimmerman as a Want. Zimmerman explains that the development and functionality of resources is a dynamic process and explains what the relations between the factors, which are of influence on the development and functionality of resources, are. In addition, his approach is selected, because it provides an uneconomic approach on why resources are developed. This can provide different and original insights, than economic approaches, which often take the profitability and the demand of a resource as the main causes why resources are developed and function as they do.

Zimmerman's theory originates from 1951 and therefore it is somewhat outdated, especially in the field of institutions. Zimmerman is not very specific on the type of institutions present, the content of these institutions and how these are related, compared to the Modern institutional theories. In addition, the terms he uses in his theory are rather complex and he uses multiple terms for the same aspects. For this reason, his theory is improved by means of Modern institutional theories. The four layered model of Williamson and the adjusted version of this model, developed by Groenewegen and Koppenjan are used to increase the insights on the different types of institutions and their interrelations. These insights are also integrated in the framework. In addition, some of the vague terms of Zimmerman are replaced by the more modern, abstract and comprehensive terms of Groenewegen and Koppenjan.

The result of the combination of the theory of Zimmerman and the Modern institutional theories, lead to the 'Modernized Zimmerman framework' provided in figure 1, which is tested with a case-study on shale gas in the U.S.

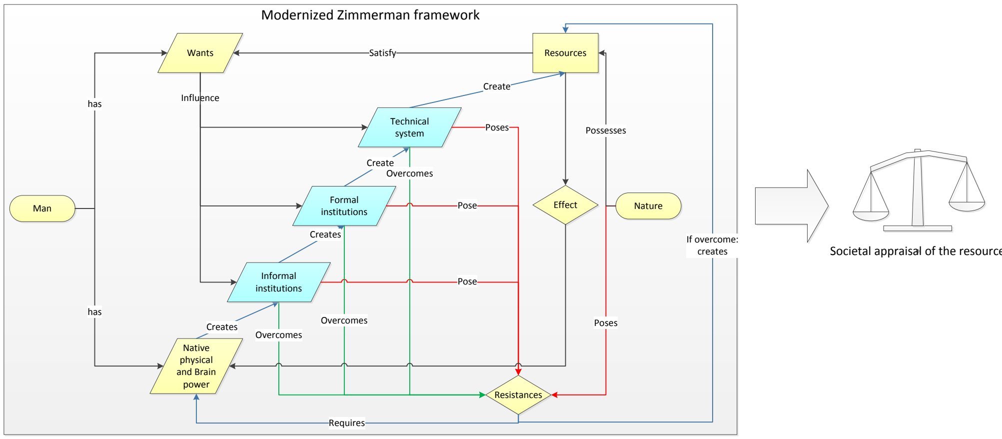


Figure 1 Modernized Zimmerman framework

The 'Modernized Zimmerman framework' provides a structured and scientific approach to analyze the development and functionality of resources and provides valuable tool to obtain important insights on the development and functionality of resources. Amongst others, it increases the understanding that it is unlikely that exactly the same effects are posed by the exploration of shale gas in the Netherlands as in the U.S. For this reason the resistances which can be expected in these countries will also be different. The reason for this difference can be found in the difference in institutions. These institutions are of strong influence on the development of the Technical system and therewith on the effect the resource will have on society. Also, the framework increases the understanding why the Technical system could evolve as it did and why there were no resistances towards shale gas in the U.S. until 2010. The case study on the shale gas development in the U.S. has also provided important insights on the development and functionality of shale gas in the U.S. These and the general insights which can be attained with the framework could be used by governments to develop an informed decision on if they want to exploit a resource, such as shale gas. By using the framework an increased understanding can be obtained on which resistances will be associated with the development of a resource and how these resistances evolve. Also, the framework can increase the understanding if, and how resistances could be overcome. Also, the framework is able to increase the understanding why a resource is developed and if it is able to meet these demands. Last, the framework provides an indication on the level of public acceptance which can be expected. When there are many resistances present, which cannot be overcome or will not be overcome for other reasons, the level of public acceptance is expected to be low. In addition, the factor Societal appraisal, the outcome of the model, also provides an indication of this public acceptance and provides guidance on which fields the resource should be improved to increase this acceptance.

Thus it was possible to develop a framework, based on the theory of E.W. Zimmerman and modern institutional economist which is constructive in generating valuable insights on the development and functionality of resources. This framework is the 'Modernized Zimmerman framework'. The framework can be used for further research towards the development and functionality of resources and the public acceptance. In addition the framework could be used to structure discussions with stakeholders. Finally, the framework could be used by governments to create more informed decision making processes on resources.

Abbreviations

Cf: cubit feet

Tcf: trillion cubic feet (10^{12} cf)

Tcm: Trillion cm (35.3 Tcf)

Mcf: Million cubic feet (10^{9} tcf)

Mcm: 1000 m^3

EIA: Energy information Administration

IEA: International Energy Agency

EIA: Environmental impact analysis

ELG: Effluent Limitation guidelines

TWDB: Texas Water Development Board

NORM: Naturally Occurring Radioactive materials

POTW: Publicly Owned Treatment Works

CWT: Centralized Waste Treatment

TDS: Total dissolved solids

TSS: Total suspended solids

PADEP: Pennsylvanian Department of Environmental Protection

SWDA: safe water drinking act

EPA: Environmental Protection Agency

RCRA: Resource Conservation and Recovery Act

CWA: clear water act

NPDES: National Pollutant Discharge Elimination System

NSPS: New Source Performance Standards

REC: reduced emissions completion

USGS: United Stated Geolological serive

VOC: Volatile Organic Compound

List of tables

List of figures

Table of Content

1. Introduction

1.1 A new resource

Due to advancements in the drilling industry it has become possible to exploit two new types of resources, namely unconventional gas and unconventional oil. Shale gas is the best known example of unconventional gas and its exploration has caused commotion in several places over the world. Shale gas is natural gas stored in shale formations. Because of the characteristics of the shale formation, shale gas could previously not be exploited, because it cannot be exploited by means of conventional vertical drilling. However, when innovations were achieved in the fields of horizontal drilling, the technology of hydraulic fracturing was developed and these two technologies were combined, it became possible to extract shale gas in a commercial manner.

According to a report of the U.S. Energy administration the world holds 6.622 tcf (188 Tcm) of recoverable shale gas reserves (U.S. Energy Information Administration, 2011). This value is better understood when compared to current proved world reserves of natural gas, which amount to 16000 tcf (453 Tcm) excluding shale gas (U.S. Energy Information Administration, 2011). Thus, the shale gas reserves increase the technically recoverable natural gas reserves of the world by more than 40 percent (U.S. Energy Information Administration, 2011). Figure 2 provides an overview of the global gas reserves.

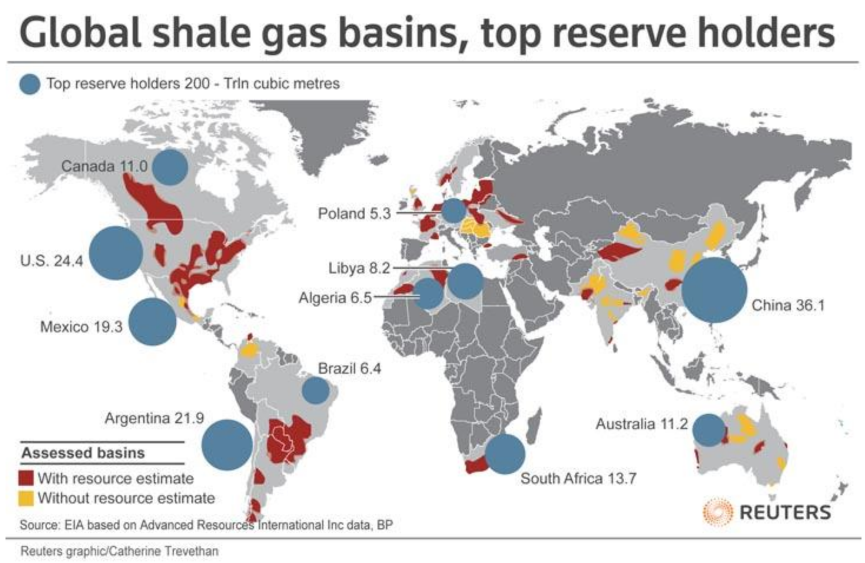


Figure 2 Global shale gas reserves (Reuters, n.d.)

Approximately thirteen percent of these technical recoverable shale gas resources are located in the U.S. It was also in this country where the shale gas evolution took off. The first horizontal wells were drilled here and the technology as used today is developed in this country.

Considering the significant reserves in some countries, it is no wonder that many governments want to exploit shale gas. The exploration of shale gas can amongst others bring economic benefits as well as energy independence to a country. However, there are also many resistances towards this energy resource. In the U.S. the level of public acceptance is significantly lowered since the release of the Movie

Gasland in 2010, in which amongst other it is claimed that the exploration of shale gas can cause contamination of water sources. Also, in other countries, such as in the Netherlands, the level of public acceptance is low. In this country, the pressure group *Schaliegasvrij Nederland* aims to prevent the exploration of shale gas. More than 20.000 people have already signed the petition of this pressure group to prevent the exploration of shale gas in the Netherlands (Schaliegasvrij Nederland, n.d.).

Even though it is understood that there are resistances against the exploration of Shale gas, it is often more challenging to understand why and how these resistances evolve. This knowledge is important, since it could provide the understanding if resistances could be overcome and if so, how. Also it can be questioned to what extent the properties of the resistances and challenges, not only in the field of public acceptance, are related to a specific country and to what extent the same resistances can be expected in different countries. In addition, it may be questioned why a resource, such as shale gas, actually is produced, especially when there are such severe resistances against it, and if this resource is actually capable to satisfy the demands for which it is developed.

To arrive at level of increased understanding on the previously described issues, the goal of this research is the development of a framework which can be used to provide these insights. The developed framework provides the factors which determine if a regular substance, such as gas, can fulfill the role of a resource; a substance which can fulfill certain benefits. It provides a dynamic vision on why and how a substance can become a resource and how the different elements within this framework interrelate.

By using the framework, insights can be attained on why resistances from the public evolve and in which areas the solutions for these resistances should be sought. In addition, the usage of the framework can lead to an increased understanding on which effects of resource can become resistances and how this could be prevented. Also, insight on the expected level of public acceptance for a resource can be attained. Furthermore, by usage of this framework it can be explained why, for instance, the evolution of shale gas started in the U.S. and why there were almost no resistances against this resource in the period until 2010, when the technical system to attain and use shale gas was developed and employed. The developed framework helps to understand if the situation in a country is supporting the development of a resource. This situation is amongst others determined by the culture in a country and the rules and regulations present. The increased understanding on the effect of the conditions in country on the technical system to produce and use the resources as well as the effect of the resource on society and on the resistances which evolve, can provide valuable insights on the resistances which can be expected in a country when a specific resource is developed.

The relevance of this research is high, since often the understanding is lacking why and how resistances against the development of a resource evolve. The framework provides a scientific and structured approach to increase amongst others the understanding on why and how resistances evolve, why a technical system for a resource evolves as it does, what the effect of conditions in a country are on the technical system, what the effects of a resource and the associated resistances can be and if and why there can be a lack of acceptance towards a resource. The insights provided by the usage of this framework can increase the understanding on the effect of a resource on society and the relation of this effect to the conditions in a country. Furthermore, increased understanding can be obtained on how resources can be developed in a way that is more acceptable to the people who are involved with or affected by this development, and which effects the resource can pose on society, the environment and possibly human health.

The following chapter presents the research problem in more detail and also presents the research questions, the research approach and the relevance of the research described in more detail. Here after, chapter three provides the theory on which the developed framework is based. Chapter four presents todays knowledge on institutions, which is necessary for the development of the framework in chapter five. Subsequently, chapter six presents a case study with the framework on the development of shale gas in the U.S. Finally, chapter seven provides the conclusion, discussion, recommendations and suggestions for further research.

2. Research and relevance

2.1 Problem description

Overall, the problems concerning the development and usage of a resource manifest in three directions; the technical problems, environmental and the institutional problems. First are the problems related to the technical system, the system used to attain the substance from the ground, make it suitable for usage and transport it etc. Second are the environmental problems. These problems are the result of the effects of the production and usage of the resource on the environment. Third are the institutional problems. These problems appear when the usage of the resource does not fit in the present institutions; it does not meet the restrictions posed by law, the resource is not congruent with the norms and values in a country, the rules and regulations are not developed for a new a resource yet or the rules and regulations are not capable of protecting the society from the negative effects of a resource. These three problem sources interact in several ways. First, the technical challenges will depend on the rules and regulations set to protect the environment and the local community. These rules will set the boundaries in which companies will have to find technical solutions. Secondly, the environmental problems depend on the technical innovations done to decrease the environmental problems and the rules and regulation set to limit the environmental problems. Since the problems in these areas deeply interact, these cannot be solved without understanding of the interrelation of these problems. Furthermore, it may even be impossible to identify the exact problems and from which ground they stem.

The described problems also account for the, already introduced, resource shale gas. Taking these problems into account, as well as the presence of resistances, as described in the introduction one can wonder why the production of shale gas is still continued in many countries. It can be questioned what Mankind expects from this substance and if this substance indeed is capable of fulfilling these desires. In addition it can be questioned why these resistances concerning shale gas exactly appear and if these can be overcome.

Often the exact reasons for the development of a resource are not known beforehand. Which function it will serve in our society is often not clear in advance, especially since not all possibilities are clear before the resource is actually developed. The same accounts for the possible side effects of the resource and the possible resistances evolving from these effects.

These issues are not unique for shale gas. According to E.W. Zimmerman these questions form the reason to determine the functionality of a resource. This functionality explains to what extent a substance can function as a resource. E.W. Zimmerman is the writer of a theory on the functionality of resources. In this theory he explains why substances, such as shale gas, are wanted and how substances are able to function as a resource. Therefore, the theory of E.W. Zimmerman could provide a valuable input in the understanding why resources such as shale gas are developed, is the substance is able to function as a resource and which problems and issues are related to the development and functionality of a resource. Several scientist, such as Thomas R. De Gregori, have also used his theory to analyze the dynamics of resources (De Gregori, 2012).

A functional approach

According to Zimmerman, a resource is not a substance or a thing, but the term resource relates to "A *function which a thing or substance may perform"(p7)* (Zimmerman, 1951). So, a substance is not a resource, though it may function as a resource. The substance will function as a resource if the substance can at least satisfy one demand or *Want*, as Zimmerman poses it. Though, this functionality is not static, it changes when conditions change. The map provided in figure 2 may create the idea that the shale gas reserves are static. It provides the idea that resources are and do not change or evolve over time. According to E.W. Zimmerman, this approach is wrong. He states that "R*esources are not, resources become"* (p15) (Zimmerman, 1951). If a substance can function as a resource depends on the conditions, institutions, relations etc. around the substance (Zimmerman, 1951). So, a resource is not static, it is dynamic.

This dynamic character of a resource is to a certain extent also acknowledged by economists. Economists of today work with the principles that the resource reserves depend on the consumption rate and the technologies present. When technologies improve, the amount of resources that can be recovered increases, while as the consumption rate increases the amount of resource available decreases. However, Zimmerman takes it further. In his book *World resource and industries*, from which the first edition was published in 1933 and the revised edition was published in 1951, he explains why substances can function as a resource. He explores the factors that have influence on this functionality and how these different factors interrelate. His theory is a valuable input to increase the understanding why substances can become resources and why substances may also lose this function.

Understanding which factors determine the development and functionality of a substance as a resource and how these factors interrelate can provide valuable insights in why resource can be developed and function in a society. By understanding the role of the factors in the development and functionality of resource it can be understood which factors can pose resistances towards the development and functionality of a resource and which factors can be supporting the development and functionality of resource. Furthermore, if it is understood which factors can pose resistances and how these factors are related with other factors, it can be understood how the resistances from these factors evolve. In addition, it may be understood in which of the relating factors a solution to overcome the resistance could be found. By understanding the factors which determine if a resource can be developed and function as a resource, it is understood which factors should be assessed to understand the conditions which enable the development and functionality of a resource in a country. These factors create the frame to understand the effect of the situation in a country on the development and functionality of a resource.

So, the increasing understanding on the factors which determine if a resource can be developed and function as a resource can increase the insights on why a resource can be developed and function as it does (in a specific country), why and how resistances against the resource evolve, which factors could pose solutions for these resistances and if there are resistances present that are not overcome (yet) by other factors. The presence of resistances can indicate that there is a lack of public acceptance for a resource, such as is the case for the resource shale gas. If a resource would function in a perfect way, there would be no resistances or hurdles to overcome left.

Theory Zimmerman

The theory of E.W. Zimmerman provides a valuable source to understand which factors determine why a substance can be developed and function as a resource. The reason why his theory was chosen as the basis of the framework is that Zimmerman explains why resource can be developed and function as a resource. He describes which factors are of influence on this development and functionality. His approach is very different from the economic approaches to understand how resources evolve. His theory is based on functional theories, and aims to understand why a resource can be developed and can function as a resource and not for which economic benefits the resource is developed. With the usage of this rather unconventional theory on the development of resources, it is aimed to develop a framework which can provide original and different insights on why resources are developed and how the associated problems evolve, different from the often attained economic insights. By usage of the theory it is aimed to provide the complete picture, instead of mostly the economic aspects, which includes the role of culture, rules and regulations and the capacities of Man on why resources and resistances evolve as they do.

However, the theory provided by E.W. Zimmerman is rather complex, unstructured and on some aspects, somewhat outdated. Therefore in order to be able to use his theory to create a better understanding of the factors and dynamics related to the functionality of a resource his theory should be systemized and structured. In addition, his theory on institutions is rather vague, limited and outdated compared to what we know today on institutions. Therefore, his theory should be improved by means new economic institutional theories. The combination of his theory with the new institutional theories can provide a theoretical understanding of why resources evolve as they do.

So, in order to be able use Zimmerman's theory to analyze why a substance can be developed and function as a resource, a framework is created of Zimmerman's theory. This framework provides more manageable form to apply Zimmerman's theory during research, than his book. This 'Zimmerman framework' is completed with the modern theories on institutions. This 'Modernized Zimmerman framework' should serve as an instrument to understand why a resource can evolve, which factors are of influence on the development and functionality of a resource, what the interrelations between these factors are and how resistances can evolve out of these factors.

The framework will offer an instrument to arrive at an increased understanding on why a substance may function as a resource and which problems and resistances may have to be overcome before the substance can be accepted by all, or the major share of, stakeholders as a resource. Stakeholders are in this research referred to as all the people who are involved in or affected by the production or usage of the resources. Therefore, the term stakeholders also includes people who use natural gas derived from shale formations, even though they may not be involved with the exploration or experience negative effects from it. Also, the framework helps identifying from which ground problems and resistance stem and in which fields they appear. With the understanding on why a substance is wanted and by who and which problems appear before this substance can function as a resource for all stakeholders, the fields in which the instruments can be found to solve these problems can be identified.

For this research the substance shale gas will be used to perform a case study to test the framework. The reason for this choice is the fact that shale gas is a relative new resource that is currently developing in several countries. For this reason, much data is present in available sources which can be used for the case study. During this case-study the development and functionality of shale gas in the U.S. will be analyzed by means of the framework. The U.S. was chosen for this case study as this country has the longest history in the development of shale gas and therefore contains the most data. After this case-study the framework will be adjusted if necessary. The framework, which will result from this study, will be able to provide a structure for the analysis on the development and functionality of a substance as a resource. Even though the development and functionality of shale gas in the U.S. is only used as a validation, the assessment with this framework can improve the understanding on the problems that have appeared in the U.S. concerning shale gas.

2.2 Goals and research questions

All in all, the following goals for this research project have been identified:

1. Analysis and systemization of the theory of E.W. Zimmerman into a 'Zimmerman framework'
2. Development of a 'Modernized Zimmerman framework' by extending and improving the 'Zimmerman framework' with modern institutional theories
3. First test of the modernized Zimmerman by means of a case study on the development and functionality of shale gas as a resource in the U.S.

Therefore the main question of this research is:

To what extent is it possible to develop an institutional framework based on the theory of E.W. Zimmerman and new institutional economists that is constructive to generate insights on the development and functionality of a resource?

The main question is divided into two sub questions. The first sub questions consider the development of the framework which will be used for the case study. The second question has the case study and the possible adjustments to framework based on this case study as its subject. These two sub questions have been divided into sub questions as well. The two sub questions and their sub questions are:

1. *What does a Modernized Zimmerman framework look like and to what extent does it help to frame and explain the functionality and development of a resource?*
    i. Which factors evolve from the analysis and systemization of the theory of E.W. Zimmerman as factors which are of influence on the development and functionality of a resource and should be included in the framework?
    ii. Which of these factors are internal and which factors are external?
    iii. How can the modern institutional theories be integrated in order to improve the 'Zimmerman framework'?

2. *To what extent can we arrive at a formal description of the development and functionality of shale gas in the U.S.?*
    i. To what extent is it possible to describe the development and functionality of shale gas in the U.S. with the use of the 'Modernized Zimmerman framework'?

ii. Should the framework be adjusted, and how, in order provide a complete view on the development and functionality of shale gas in the U.S.?

2.3 Research approach

Figure 3 presents how the research is constructed.

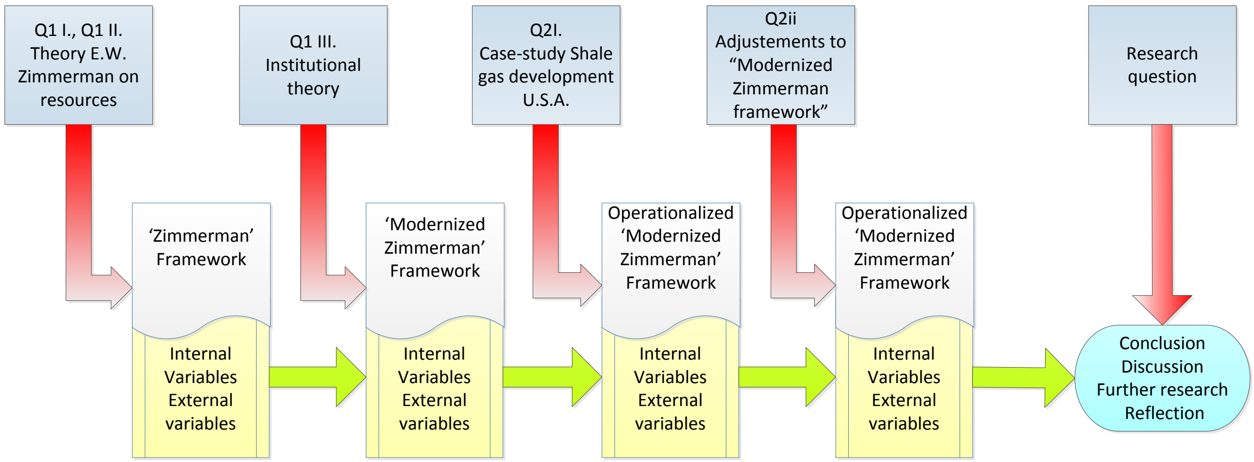


Figure 3 Research approach

In the first phase, the answer to research question 1i and 1ii will be explored. In this phase the theory of E.W. Zimmerman will be used to develop the 'Zimmerman framework' that describes which variables influence the development and functionality of a resource, according to Zimmerman. The theory will be derived from the revised edition of the book "*World resources and Industries*" from E.W. Zimmerman, published in 1951. A brief validation of this framework will be done by assessing this framework with the development and functionality of coal, which is also described by E.W. Zimmerman in the same book. This validation is described in appendix III. The result of the first phase is the 'Zimmerman framework'.

In the second phase question 1iii will be answered. Modern institutional theories will be addressed to identify how the 'Zimmerman framework' can be improved in terms of institutions. These improvements will lead to the 'Institutionalized and Modernized Zimmerman framework'. Hereafter, the 'Institutionalized and modernized Zimmerman framework', the diagrams and theory provided by Zimmerman and the important elements of the institutional theories, will together form the building blocks for the "Modernized Zimmerman framework". This 'Modernized Zimmerman framework' forms the start for phase three.

In phase three the "Modernized Zimmerman framework" is tested during a case study on the development and functionality of shale gas in the U.S. The result will form an operationalized framework that can be used to describe the functionality and development of resources.

In phase four, research question 2ii will be answered. In this phase the adjustments which can be done to the framework to improve it, based on the results of the case study are identified.

In the final phase, the conclusion, discussion, further research recommendations and reflection are presented. In this phase the contribution of the framework to the understanding of the development and functionality of resources is described. Also, the insights which can be achieved by the usage of this framework and the most important insights on the shale gas case in the U.S. that are achieved with the framework are provided. This last phase will also provide the answer to the main research question.

2.4 Method

Zimmerman framework

This research will start with the development of the ‘Zimmerman framework’. This framework is based on the theory of E.W. Zimmerman found in his book “World Resources and industries”. In order to systemize and structure Zimmerman’s theory, the first step is to develop a causal relation diagram of his theory. In this causal relation diagram, all the variables and their interrelations which are important or related to the development and functionality, according to E.W. Zimmerman are presented. After the development of the causal relation diagram the variables that have the most relations with other variables are identified, in order to extract the most important variables from his theory. These variables are expected to explain most of his theory, since they have to the most interrelations. Hereafter, the theory of E.W. Zimmerman is consulted again, to determine if these variables are indeed the most important ones. After this step these variables will be placed in the initial ‘Zimmerman framework’. This initial ‘Zimmerman framework’ will then be validated by means of the theory provided in the book *World resources and Industries* on the development and functionality of coal. The variables that appear to not be important to describe the development and functionality of a resource will then be removed. Furthermore, in this stage variables can be added by the writer that were not viewed as important during the time of Zimmerman, but which are important today. This will lead to the ‘Zimmerman framework’, which will be used in the next step of this research.

Integration of Modern institutional theories

In order to modernize the ‘Zimmerman framework’, modern institutional theories are consulted. The theories which will be used to improve the ‘Zimmerman framework’ in the field of institutions are the four layered model of Williamson and the extension of this model developed by Koppenjan and Groenewegen. These two models are explored and the institutional elements and insights that will be integrated in the final framework are extracted. These insights will be integrated in the ‘Zimmerman framework which then becomes the ‘Institutionalized and Modernized Zimmerman framework’. The ‘Institutionalized and Modernized Zimmerman framework’ forms one of the building blocks for development of the ‘Modernized Zimmerman framework’. Also some insights will be directly integrated in the ‘Modernized Zimmerman framework’, since these cannot be integrated in the ‘Institutionalized and Modernized Zimmerman framework’. An example of this can be found in insights which are related to the relations between the factors of the framework, which cannot be integrated in the ‘Institutionalized and Modernized Zimmerman framework’ without changing the whole shape of the framework. With the integration of the insights and elements from these theories in the ‘Modernized Zimmerman framework’, this framework will contain today’s knowledge on institutions.

The next step considers the development of the ‘Modernized Zimmerman framework’ from the institutional elements, the ‘Institutionalized and Modernized Zimmerman framework’ and Zimmerman’s theory and diagram. This final framework is developed to analyze the development and functionality of resources in a structured and modern way, which takes into account modern views and modern institutional ideas.

This final 'Modernized Zimmerman framework' will then be used to perform a case study on the development and functionality of shale gas in the U.S. During this case-study it will become clear to what extent the framework is capable of describing the development and functionality of a resource and which adjustments are necessary, based on this first test. Insights that may be obtained with the framework will be presented in the conclusion.

2.4.1 Research methods

The following research methods are used during this research:

2.4.1.1 Literature review

Since the theory of Zimmerman is used as the backbone for this research, his book on this subject will form a significant part of the literature. The most important book for this research is *World resources and industries* (1951, second edition). Furthermore the theories on modern institutions form an important part of the literature that will be used. Also, the literature on the development and functionality of shale gas will be used. The necessary literature will mainly concern scientific books, articles, and websites. The most important sources for this literature are the library of the TU Delft and the Scopus websites, since these both are considered reliable databases. Furthermore, literature on shale gas from oil and gas companies, operators, institutions and governments may be used; however these sources could pose the risk of subjectivity and should therefore be handled with special attention.

2.4.1.2 Case study

During this research a case study will be performed. The subject of this case study is the development and functionality of shale gas as a resource in the U.S. The development and functionality of shale gas will be analyzed by means of the "Modernized Zimmerman framework". The goal of this case-study is to perform a premier test on the developed framework and operationalize this framework. Furthermore, alterations which could be beneficial to improve the framework can come to light. These alterations may for instance be necessary to improve the usability of the framework or to improve the content which can be generated with the framework. The information that will be used will mostly be generated with a literature study and may be validated by (informal) interviews.

2.4.1.3 Conferences and hearings

During conferences and hearings new and state of the art information may be gathered. Information supplied here may not be published yet. Furthermore, direct and informal information may be retrieved from conversations with individuals. This informal information will mainly serve to determine if there are parts of the subject not yet covered and if the research done so far is correct. These events are therefore very valuable in this research, since not all information found in literature is objective.

2.4.2 Drawbacks necessary methods

The chosen methods have their drawbacks. Since the theory of Zimmerman will form the backbone of this research, it could be that the end result will be considered incomplete or subjective. Therefore, the research runs the risk of not being accepted by all stakeholders in the shale gas sector. Furthermore, the theory of E.W. Zimmerman should be handled with care and translated into the world as it is today. Also, when reading his book, it appears that he is quite a fan of the U.S. and how things are handled there. When extracting the framework, one should be careful and wise with interpreting the information he provides, since some of it may be a bit too subjective or extreme.

Secondly, a literature survey can take a significant amount of time and one can get lost in the data available. Besides this, sources may contradict each other. Therefore informal interviews and other literature should be used in order to validate the data with multiple sources.

Last, conferences and hearings may present the point of view of the organization, and may therefore not be totally objective. Also, some information and inventions may not even become published because they turn out to be wrong after a period of time. Therefore, it is important to be critical during these events of the information that is gathered.

2.5 Relevance of the research

This paragraph will briefly state the relevance of this research from a social, scientific and business perspective.

2.5.1 Social relevance

Since all human beings are dependent on substances that can be retrieved from earth, careful consideration of the exploitation and usage of these substances is important for every citizen in the world. Irresponsible usage of resources may lead to the depletion of resources. Furthermore, it may harm the ecosystem and form a danger to the human health. Therefore it is important to develop and use resources in a wise and well-considered way. This starts with a complete understanding of the effects of the production and usage of the resource. It should be understood what the exact problems are in order to be able to overcome these issues in a safe and responsible manner. The framework can increase this understanding. In addition, the framework may increase the understanding of governments how they can develop and use resources I way which is acceptable for a larger share of stakeholders.

2.5.2 Scientific relevance

The framework presents a way in which scientific institutional theories and the theory of E.W. Zimmerman on resources can be used in a practical way. Therefore it may bring a scientific aspect to the evaluation of resources. Often, the decisions if substances could be used as resources are made from an economic perspective. This may lead to a short sighted view on the functionality of a substance as resource.

This framework provides a systematic approach in determining to what extent a substance can function as a resource and which issues may be related to the usage of this resource, seen from more angles than the economic perspective. So, this framework integrates science in the decision making process in a systematic way, which may lead to a more informed decision making process.

2.5.3 Business relevance

For companies it may be challenging to determine the potential problem areas when they get involved in the development or usage of a 'new' resource. This framework could help to clarify the problem areas and the possible resistances that can be expected. This information could contribute in determining what technologies and instruments can be used and how they can be beneficial in overcoming problems and resistances. Also, it may provide them with insights which aspects they may be able to influence and which aspects they have to consider as set conditions.

Concluding, from a business perspective this framework can bring clarity in possible problems, resistances and the possible solutions.

2.6 Transition to the rest of the report

Figure 4 shows the outline and relations between the different chapters of this report. The research has started with an introduction in chapter one. Hereafter, the research problem, the research goals and questions, the relevance of the research and the research approach were presented in this chapter. In chapter three, the theory of E.W. Zimmerman on resources is explored. From this theory the 'Zimmerman framework' is constructed. Hereafter, chapter four the modern institutional theories are explored and in particular the theory of Williamson and Groenewegen and Koppenjan. The main elements of these two theories will be integrated the 'Zimmerman framework' to improve this framework in terms of comprehensiveness and institutions. The integration of these institutional elements in the 'Zimmerman framework' will happen in chapter 5. Here after, in the same chapter, the 'Modernized Zimmerman framework' is developed out of the 'Institutionalized and Modernized Zimmerman framework' , the remaining insights in the fields of institutions and the diagrams and theory provided by Zimmerman in chapter three. Chapter six describes the usage of the "Modernized Zimmerman framework" in a case study on the development and functionality of shale gas in the U.S. Finally in chapter seven, the conclusion, discussion, recommendations and possibilities for further research are provided. In this final chapter the insights which can be obtained with the framework are discussed. This research will conclude with a reflection on the research content and research process, also presented in chapter 7.

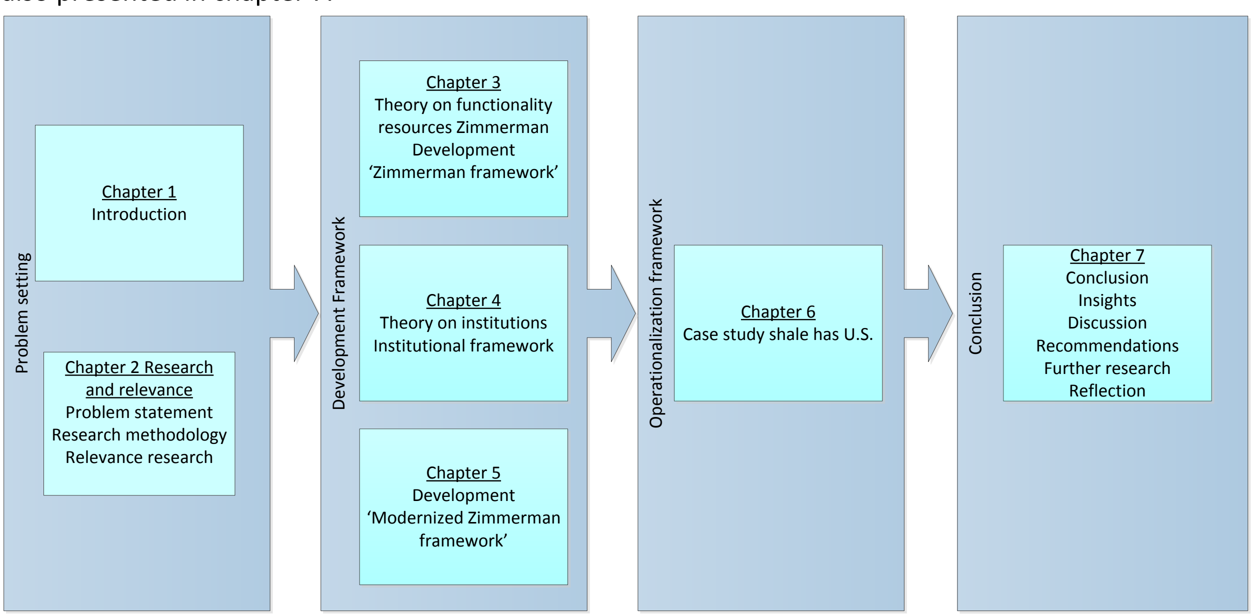


Figure 4 Reading guide

3. The Zimmerman framework

In this chapter the theory of E.W. Zimmerman, retrieved from his book *World resources and industries*, on the development and functionality of resources is explored. First, the most important elements of his theory, which are extracted by means of a causal relation model and the diagrams provided by Zimmerman, are explained in paragraph 3.1. The numbers in the developed figures represent the pages of the book *World resources and industries* from which the information on which is the figure is based, is attained. In paragraph 3.2 the steps towards the Zimmerman framework are provided and explained. In paragraph 3.3 the insights achieved with the ‘Zimmerman framework’ are presented where after the downsides and missing elements of Zimmerman’s theory are discussed in paragraph 3.4.

The main elements of Zimmerman’s theory on the functionality of resources are in this research also referred to as variables. These variables and their relations with other variables have been identified with the development of a causal relation diagram based on Zimmerman’s theory. All the variables and the relations between these variables, present in the causal relation diagram, are stated and explained in appendix I. The causal relation diagram is provided in appendix VI. The most important variables and their relations with other variables are presented and explained in paragraph 3.1.

Based on both the overview of Zimmerman’s theory in this chapter and the causal relation diagram, the ‘Zimmerman framework’, which represents the variables that play a role in the development and functionality of resources, according to Zimmerman, is developed. This framework is validated with Zimmerman’s theory on the development and functionality of coal. This validation can be found in appendix II. This validated framework will hereafter be improved with the most important elements of the modern institutional elements in chapter five.

This chapter will start with a short overview of the career E.W. Zimmerman and what his road comprised towards the book “*World resources and industries”*, that forms the backbone of this research.

Erich W. Zimmerman (1888-1961)

Erich W. Zimmerman was born in Mainz, Germany in 1888 and died in Austin Texas in 1961 (Arbingast, Ayres, & Blair, 1961). He was doctor in philosophy and specialized in political economics (Arbingast et al., 1961). During his advanced studies he travelled through England, Scotland and Wales in order to attain materials for his doctoral thesis on British coal exports (Arbingast et al., 1961). Hereafter, in 1911 he moved to the U.S. in 1911 in order to attain material for a book on the role of Great Lakes in North America. However he never completed this book but developed the foundation for his famous “Functional approach” for the study of resources (Arbingast et al., 1961). In 1922 he became an associate professor at the University of North Carolina (Arbingast et al., 1961). That was the place where wrote the book which forms the core of this research “*World resources and industries”* (Arbingast et al., 1961). In this book he integrated geographical, historical, technical, economic, social and political factors to create an understanding of resources (Arbingast et al., 1961). He ended his career with a function as Distinguished Professor of Resources in the College of Business Administration at the University of Texas (Arbingast et al., 1961).

3.1 Theory Zimmerman

3.1.1 Resources

While resources are often considered as static reserves of substances used in society, E.W. Zimmerman provides a rather unconventional view on the meaning of the term ‘Resources’. Many theories approach the definition of resources from an economic angle. From this view resources are considered to be the usable elements for production for, for example, an entrepreneur or a farmer. Thus, resources are considered the tangible, or in other words the touchable, aspects which influence both the costs of the development of a product as well as the price which can be achieved for the product (“Free Dictionary,” n.d.; Zimmerman, 1951). Moreover, these tangible aspects determine the amount of product that can be supplied (Zimmerman, 1951). The demand for the final product determines the demand for the resource (Zimmerman, 1951). In contrast, Zimmerman states the importance of the intangible aspects, such as knowledge, health, freedom, policy and education (Zimmerman, 1951). According to him, resources evolve out of the combination of both tangible and intangible aspects, not just the tangible aspects are important (Zimmerman, 1951). He states that these intangible aspects may actually be even more important than the tangible aspects (Zimmerman, 1951).

Dynamic vs. static

Next to the difference that Zimmerman considers resources the effect of both intangible and tangible aspects, instead of just the effect of tangible aspects; another difference from the common theories on resources is that Zimmerman views resources as dynamic instead of static. This is illustrated by the quote below.

“Resources are living phenomena, expanding and contracting in response to human effort and behavior. They thrive under rational harmonious treatment. They shrivel in war and strife. To a large extent, they are man’s own creation.”(p7) (Zimmerman, 1951)

This statement underlines that the human society has a strong influence on the amount of resources that are available for usage. We may either develop resources or demolish them. Often resources are handled as fixed things instead of dynamic processes and assets, which make a substance function as a resource. Therefore, Zimmerman states the following: “*Resources are not, resources become”* (p15) (Zimmerman, 1951). How tangible or intangible aspects function as a resource depends, according to Zimmerman, *“On the whole complex of substances, forces, condition, relationships, institutions, policies etc.”* (p7) (Zimmerman, 1951). For instance, a substance that may function as a resource today is not necessarily a resource in the future. If, for example, CO_2 emissions limits in Europe were lowered to such extent that the substance coal would not be used for electricity generation anymore, due to the high emissions associated with this production, it would lose its function as a resource in Europe. The same could happen if a cheaper substance with a reduced negative impact on the environment and the same qualities and characteristics as coal were to be discovered and evolved. In that case, this substance could take over the function of coal. Thus, due to changes in rules and regulations or due to inventions and discoveries, coal could lose its function as a resource to another substance and become unnecessary.

3.1.2 Basis theory Zimmerman

The diagram in figure 5 presents the simple relationship between the primitive man and his environment, according to Zimmerman. In this diagram the more complex relationships with resources are not yet presented, since these would make the diagram fairly complicated. Also, only the most important dynamics in these relations are presented. Therefore this diagram is incomplete, though it offers an image how Man, Nature, Resources and Resistances are related to each other.

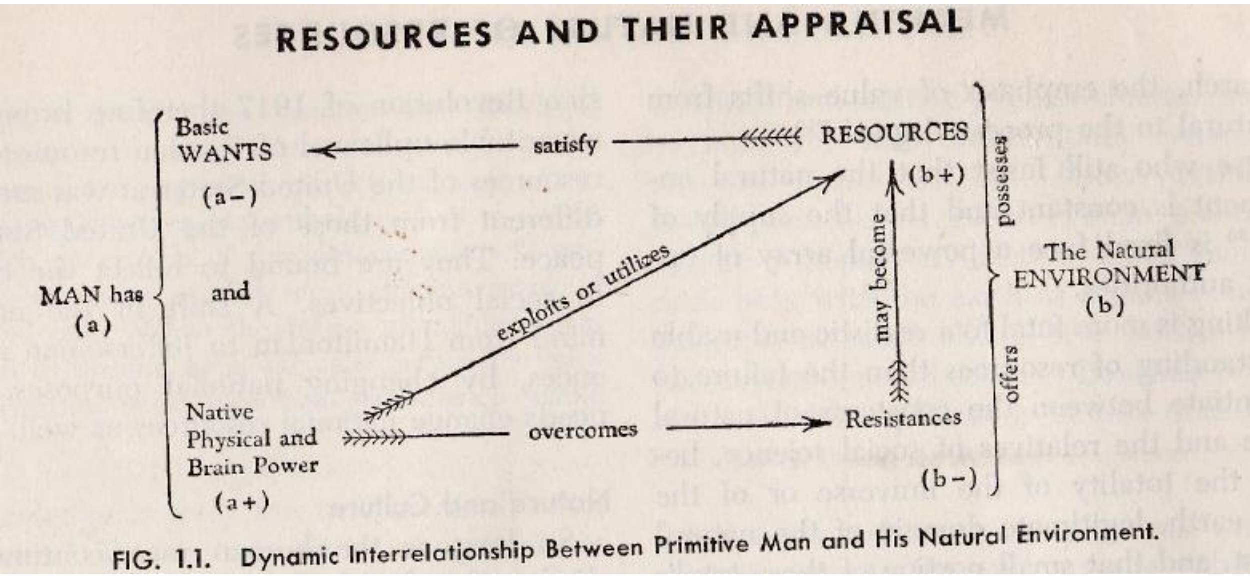


Figure 5 Dynamic interrelationship between primitive man and his natural environment ((Zimmerman, 1951)

As stated before, Zimmerman determines Resources as dynamic processes and assets which are under influence of multiple variables. According, to Zimmerman the processes start with Man and his natural environment. Man has certain Basic wants he needs to have fulfilled in order to survive. In order to fulfill these Wants, he starts exploring his natural environment to find substances which can satisfy these Wants. Some substances he will be able to pick up from the ground without effort, such as water, while for other he has to overcome resistances before he can use them. An example of this can be found in the basic want for warmth. In order to attain this warmth Man first has to attain wood, though the wood was not able to warm him. Therefore he first has to overcome the resistance of using the wood. So, by using his brain power and physical capacities Man invented a method to create fire. This fire served as his instrument to use the substance wood and satisfy his Want for warmth. This development made it possible for the substance wood to function as a resource. The variables in the diagram will be more thoroughly explored below. Furthermore, variables not present in this diagram, although important in Zimmerman's theory will also be presented after the variables offered in the diagram have been explored.

3.1.2.1 Man

In this theory Man is a general term for all human beings. It is an important element in the theory of Zimmerman. Together with the variable Nature, also referred to as the natural environment, it forms the original resource factors (Zimmerman, 1951). These variables may enable a substance to function as a resource (Zimmerman, 1951). Due to the Wants and capacities of man, substances of Nature become necessary and can be transformed into resources. Without Man, Resources would not exist, since these would not be required.

3.1.2.2 Nature

As can been seen in the figure 5 the natural environment both possesses resources and poses resistances (Zimmerman, 1951). It provides both advantages and disadvantages for man. Which opportunities Man will make use of and which resistances he will be able to overcome depends both on the Wants of Man as on his capabilities (Zimmerman, 1951). That been said, Nature does set the boundaries for Man's possibilities (Zimmerman, 1951). The following statement of Zimmerman illustrates this:

"Arts no matter how highly developed and wants no matter how urgent or sophisticated are helpless in a vacuum" (p11) (Zimmerman, 1951).

This statement implies that if only Arts or Wants are present without the variable Nature, it will be impossible to create a Resource. To have a substance function as a Resource, there should at least be a suitable substance present in Nature.

Arts can be considered as the skills and capacity of Man to alter Nature. (Further explanation of this factor will be presented in later stage of this paragraph). Arts may be developed in such a way that astonishing things could happen, but if Nature does not bring the opportunities, Arts will be useless (Zimmerman, 1951). The same accounts to the variable Wants, if the natural environment is not able to bring opportunities to satisfy these Wants, the content of these Wants is irrelevant, since they can never be fulfilled. Therefore Nature, or in other words the physical environment, is an essential link in the chain of the development of Resources.

When considering the environment, this does not only include the physical aspects. Nature cannot be seen as static physical assets, but should be considered as the dynamic context of changing affairs between trends and forces which develop nature's conditions (Zimmerman, 1951). Nature expands in reaction to increases in knowledge and improvements of Arts (Zimmerman, 1951). This implies that Nature is also dynamic, which indicates that the Resources and Resistances offered by Nature are also subject to change. When this happens secondary or derived resources and resistances are delivered by Nature.

Phantom resources are an example of the expansion of Nature due to the improvement of Arts. When improved technology makes it possible to produce more with the same amount of substance, the 'Resource' grows; more can be done with the same amount of substance (Zimmerman, 1951). Yet, the amount of substance present remains the same. This increased resource is called a phantom resource (Zimmerman, 1951).

Nature's contraction is the result of the destruction of substances or ecological processes due to ignorance of Man, a lack of knowledge, or a lack of foresight (Zimmerman, 1951). Also, inventions which make substances of Nature abundant, contract nature's contributions (Zimmerman, 1951)

3.1.2.3 Wants and human appraisal

According to Zimmerman *"The word 'Resource'* *does not refer to a thing or a substance but to a function which a thing or a substance may perform or to an operation in which it may take part, namely the function or operation of attaining a given end such as satisfying a want. In other words, the word "Resource" is an abstraction reflecting human appraisal and relating to a function or operation."* (p7) (Zimmerman, 1951)

Thus, a substance may function as a resource in order to achieve certain objectives, wanted by an individual or a group of people. This implies that if there are no desires and objectives for which that substance can function as a resource, the substance loses its resource ship.

Continuing, Zimmerman states that the word Resource reflects the Human appraisal of that substance for a certain function or operation. With this he implies, that the suitability of a substance found in the environment to fulfill a certain function depends on the human judgment of the capability of that substance, and not of the capability of the substance to fulfill that function. This indicates that there may be a difference between the capabilities of a substance as judged by man and the potential capabilities of that substance. Even more, a substance that may function as a resource may not be appraised as a resource. Therefore, the substance may not perform a possible function. However, when knowledge increases and new inventions and discoveries are done, this judgment may change. This will change what substances will function as resources.

According to Zimmerman the appraisal of resources evolves from:

1. *"The knowledge of facts of nature and culture*
2. *The determination of technical feasibility*
3. *The determination of profitability*
4. *The formulation of the grand strategy along socio-economic lines"* (p17) (Zimmerman, 1951)

Next to the factors stated above there are two interdepended criteria that influence the human appraisal of resources. These criteria are *the state of wants* and *the state of arts* (Zimmerman, 1951). These criteria express the human needs and objectives as well as the human capacities to make use of these substances and turn them into Resources (Zimmerman, 1951).

Wants

Zimmerman differentiates between two kinds of Wants; Basic wants which are also known as nature/creature/existence Wants and Cultural wants (Zimmerman, 1951). The Basic/nature/creature/existence Wants, from now on called Basic wants, present those aspects a person or group requires in order to survive. Examples of this are drinking water, warmth and food. These Basic wants often form the basis for economic processes and are of a strong influence on the human judgment of their environment during the search for useful substances, also referred to as resource appraisal (Zimmerman, 1951). These basic wants are mostly constant; they account for every person or group and are therefore recurring (Zimmerman, 1951). Also, Basic wants are related to minima and maxima, such as a minimum amount of food required and a maximum temperature which can be survived (Zimmerman, 1951).

Next to these Basic wants, there are Cultural wants. These are the more sophisticated and less urgent Wants and supplement the Basic wants (Zimmerman, 1951). The difference between Basic and Cultural wants can be found in the fact that Cultural wants are not related to limitations and that these are not constant, they can change under influence of changing conditions and time (Zimmerman, 1951). Although, Cultural wants can become physical necessities due to habituation (Zimmerman, 1951). Examples of Cultural wants are a phone and access to the Internet, which are both not necessary for survival even though it nowadays is of high importance in the Western world. The satisfaction of Cultural wants may be harder to achieve than satisfaction of Basic Wants, since there are no limitations (Zimmerman, 1951). The speed of Internet can never be too high, nor can the amount of phones possessed. Figure 6 presents these different types of Wants and their relations.

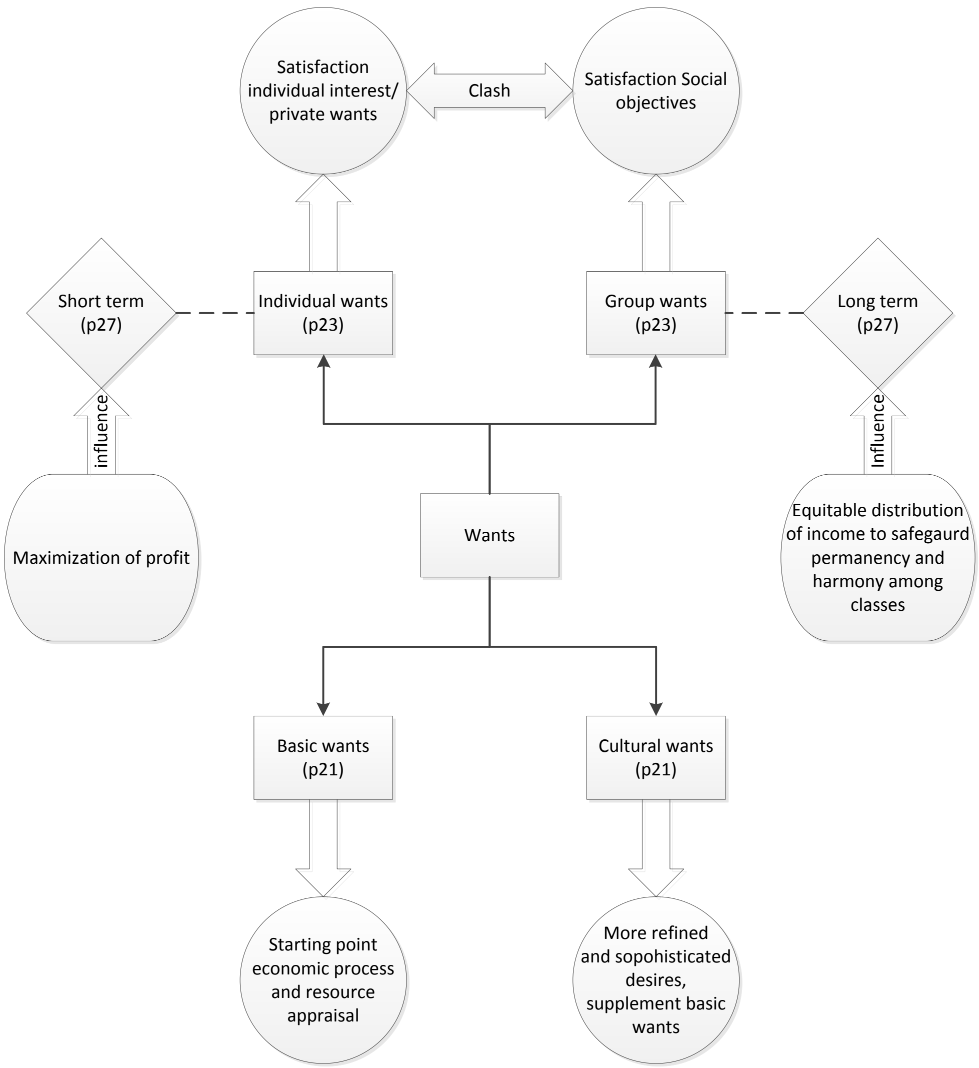


Figure 6 Wants (Figure based on Zimmerman's theory)

When considering figure 6, it appears that Zimmerman defines another division in Wants next to the Basic and Cultural wants, namely Individual and Group wants (Zimmerman, 1951). Individual wants are personal Wants, Wants belonging to one person. These Wants are often present for a short period, not longer than a lifetime of a person (Zimmerman, 1951). Group wants are also referred to as social objectives. These are the collective wants of a group of human beings. Since these objectives have to do with the survival of a population and not of a single person, these objectives often have a longer time frame (Zimmerman, 1951). These Group wants indicate the objectives that should be achieved to obtain the best situation for the group as a whole. Group wants or social objectives support or supplement the individual objectives (Zimmerman, 1951). First, because a group can only survive if individuals survive. Second, because living in a group provides safety to its members, which implies that living in a group contributes to another Basic want of individuals (Zimmerman, 1951). Last, many Group Wants are social objectives because they are desired by many individuals. Despite this, Group wants and Individual wants often clash instead of complement. The different types of objectives and their different time frames often lead to incompatible desires (Zimmerman, 1951). A reason for this can be found in the fact that it is challenging for individuals to make decisions that lead to the best situation for all human beings. Especially since human beings from other generations may have to be taken into account in these decisions (Zimmerman, 1951). Furthermore, the decisions which are best for all human beings do not necessarily bring optimal conditions for the individual (Zimmerman, 1951). Due to the conflicting interests of the group and the individual, it is hard to agree on the 'Tempo of resource development' (Zimmerman, 1951). The individual considers only the value and possibilities of a Resource in the current market and situation, while from the group view also the possibilities and values of resources of future markets are considered (Zimmerman, 1951). An example of this can be found in an individual who sells the minerals found on his land for current market prices, while these minerals may be worth more in the future (Zimmerman, 1951). Since the individual often does not have the necessary knowledge about future trends and second, since he does not know what his situation will be in the future, he often settles for a lower price in the current market instead of receiving the higher price in the future market. That been said, it is often also more beneficial for the group if the individual sells at the right time, since this lengthens the time of the Resource and may also increase the (tax and royalties) income for the government.

While private Wants are mainly influenced by a profit motive and aims for individual wealth, social objectives are influenced by a need for long term wealth, permanency and a state of harmony (Zimmerman, 1951). Therefore the social objectives have a more conserving attitude toward non-renewable resources, than individual objectives (Zimmerman, 1951). The conflict that occurs between this public interest and the individual interests, poses significant influence on which resources are used and which are not. Therefore, it strongly influences the appraisal of resources. The appraisal of resources increases in complexity due to the compromises which have to be made between the Individual and Group wants (Zimmerman, 1951).

Individual wants founded by behavior, social expectation and *sanctions* often appear to transform into living standards of a group (Zimmerman, 1951). These living standards are, once they have established, challenging to change (Zimmerman, 1951). Likewise, these living standards form an important input for the appraisal of resources (Zimmerman, 1951). If light or electricity is not considered a living standard, substances as natural gas and coal may not function as a resource, but wood may be used to fulfill the Basic want of warmth.

3.1.2.4 Resistances

"As truly as there must be shade when there is light, so also must there be resistances when there are resources" (p7) (Zimmerman, 1951).

Hence, according to Zimmerman resistances are inextricably connected to resources. One cannot be without another. Whether the Wants and objectives of man can be fulfilled, does not only depend on Resources but also on Resistances. A resource may be present though unable to function as a resource due to Resistances. An example of this can be found in oil or gas resources, which are often located in areas from which it cannot be retrieved (yet). For these substances to become Resources, the Resistances need to be overcome first.

So, if a substance cannot be attained from the ground or from another location without any effort, Resistances have to be overcome. These resistances appear in various fields and in various forms. Figure 7 presents the different kinds of resistances present according to Zimmerman.

3.1.2.4.1 Types of resistances

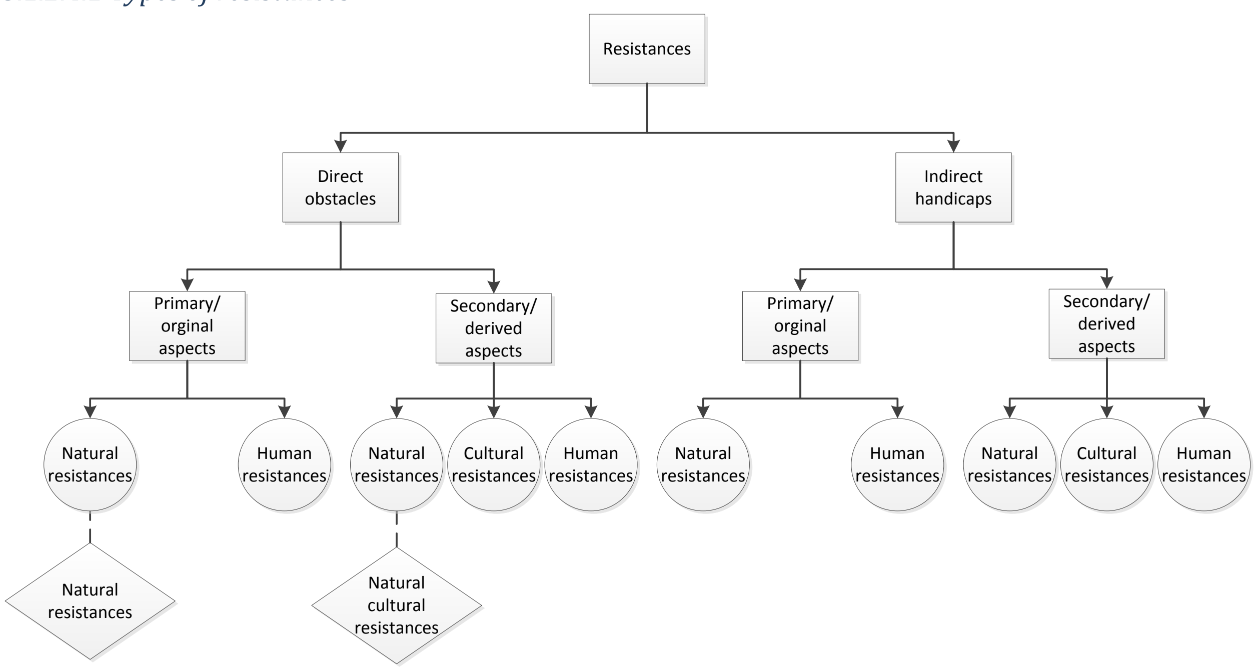


Figure 7 Resistances (Figure Based on Zimmerman's theory)

Zimmerman distinguishes between different kinds of Resistances. The first differentiation concerns the difference between those Resistances that are considered as Direct obstacles and those Resistances that are considered as Indirect handicaps. Within these two categories Zimmerman provides two subdivisions: Primary/original aspects and Secondary/derived aspects. The Primary/original aspects are those aspects that are original. The Secondary/derived aspects are those aspects that have become Resistances due to the interaction with other factors. These subdivisions are further broken down into Natural, Cultural and Human aspects. The analysis of these different resistances starts with the resistances in the form of Direct obstacles where after the indirect handicaps are presented.

Direct obstacles

In the category Primary/original aspects only Natural and Human aspects can be found. This is because Cultural aspects evolve from the reaction with the natural environment and are therefore always secondary or derived aspects. This means that it is not possible to have Primary/original Cultural aspects.

Natural aspects

Primary natural aspects which form direct obstacles are catastrophes such as floods, tidal waves, earthquakes, poisonous plants and other natural aspects which man is unable to influence (Zimmerman, 1951). These resistances are also referred to as Natural resistances (Zimmerman, 1951).

The natural obstacles of category Secondary/derived direct obstacles pose direct obstacles, though these obstacles occur due to the interference of human beings with Nature (Zimmerman, 1951). These resistances are also expressed as Natural-cultural resistances (Zimmerman, 1951). These Natural direct Secondary/ derived obstacles are for example depleted mineral resources, loss of fauna and flora and stripped mountainsides (Zimmerman, 1951).

Cultural aspects

As stated before there are no Primary cultural aspects. Secondary/derived obstacles posed by cultural aspects can, for instance, be found in capital that is not functioning as it should be or capital that is out of date but not yet written of (Zimmerman, 1951).

Human aspects

Last, are the human aspects in the category of Direct obstacles. Primary human aspects which pose direct obstacles are human's failures (Zimmerman, 1951). Examples of these failures are for example *"cussedness, lack of foresight, mismanagement, failure to comprehend complexities and multiple correlations, ignorance, stupidity and greed" (p18-19)*(Zimmerman, 1951). The secondary derived human aspects which pose direct obstacles can be found in the "*Human difficulties resulting from the complexities of modern industrial civilization and warped judgment" (p18-19)*(Zimmerman, 1951).

Indirect handicaps

The second category of resistances concerns the indirect handicaps. This category is also subdivided in primary and secondary aspects. These primary and secondary aspects are again categorized in Natural, Cultural and Human aspects.

Natural aspects

The Primary natural aspects which pose indirect handicaps are aspects such as distance, the distribution of raw materials and energy sources which is not be optimal in terms of production and consumption as well as issues posed by the climate of the country (Zimmerman, 1951). These handicaps are considered indirect since these handicaps only become handicaps in the situation that human beings want to use, for example, these raw materials. When these indirect handicaps are increased due to the impact of Man, these handicaps are categorized under the secondary natural aspects which pose an indirect handicap (Zimmerman, 1951). An example is provided by the increasing problem of climate change, which is according to some studies, the result of activities of human beings.

Cultural aspects

Again there are no Primary cultural aspects. The Secondary/derived cultural handicaps pose themselves in the form of issues from the past which are still of influence today, such as depressions, bad policies, given rights and posed threats (Zimmerman, 1951).

Human aspects

Last, there are the Human aspects that pose indirect handicaps. Examples of Primary human indirect handicaps are population densities which are not optimal for a location or an age distribution among the population which has negative influence on the overall well-being (Zimmerman, 1951). The Secondary/derived indirect handicaps can be found in the forms of conflicts between groups of human beings that may even result in war.

3.1.2.5 Arts

Zimmerman considers Arts as "*The devises or mechanism used by various groups to adapt themselves better to their specific environment and to adapt that environment to their specific needs"* (p33) *(Zimmerman, 1951).*

Thus, Arts are the human capacities that enable human beings to adapt to their environment in such a way that they can satisfy their Wants. In other words, Arts may be seen as the step following upon the brain power and physical capacity of man. Arts can be considered as the result of this capacity. As Zimmerman uses the term Arts in the rest of his theory for this capacity instead of the term Native brainpower and physical capacities, which is stated in figure 5, the variable Arts will be further explored in this paragraph instead of the variable "Native brain power and physical capacities".

Since Arts are instruments for human beings to adapt to their environment, this environment has a significant effect on the Arts present and the evolvement of new arts (Zimmerman, 1951). Secondly, the objectives and Wants of a population form a guidance for the evolvement of Arts (Zimmerman, 1951). Third, patents and laws which have evolved from the physical progress of the arts are of influence on the evolvement of new or improved Arts (Zimmerman, 1951).

Moreover Arts are of influence on the type of substances that operate as resources. When Arts improve, the function of a resource may, for instance, switch to another substance that can fulfill this function in a better way.

3.1.2.5.1 Different types of Arts

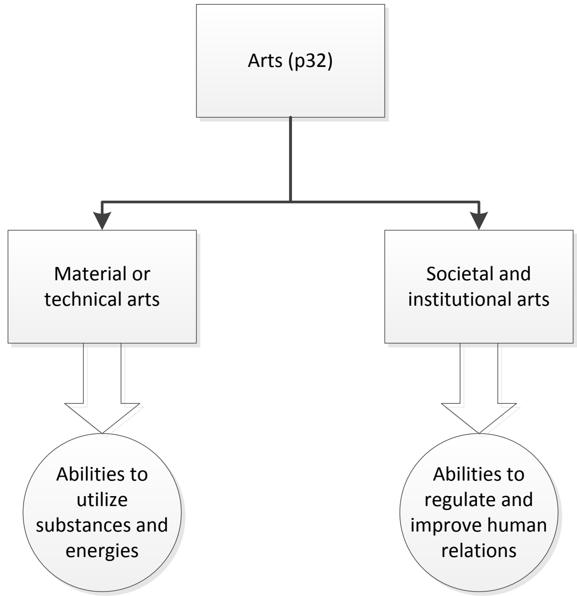


Figure 8 Arts (Figure based on theory Zimmerman)

Figure 8 presents the two types of Arts. The Material or Technical arts include Man's capacities to make use of "*substances and energies"* (Zimmerman, 1951). Examples of this kind of Arts can be found in roads and telephones (Zimmerman, 1951). The Societal and Institutional arts include the capacity of man to manage and enhance *human relations* (Zimmerman, 1951). Examples of this kind of Arts are found in the form of governments and *churches* (Zimmerman, 1951). Progress in Arts is mostly achieved in Material or Technical arts (Zimmerman, 1951). The reason for this is that Material or Technical arts can be verified and tested, while this is more complicated for Societal and Institutional Arts (Zimmerman, 1951). Due the verification and tested results, growth is easier achieved in the Material or Technical arts (Zimmerman, 1951)

Functional arts

Furthermore, Zimmerman reasons about the functionality of Arts. More specifically, he reflects on the way in which Arts are effective. Functional Arts lead to a fuller satisfaction of human Wants (Zimmerman, 1951). These Arts may be divided into two groups; *Arts which render more effective man's productive efforts* and *Arts which render the environment more amenable for these efforts* (p32) (Zimmerman, 1951). These types of functional Arts are presented in figure 9.

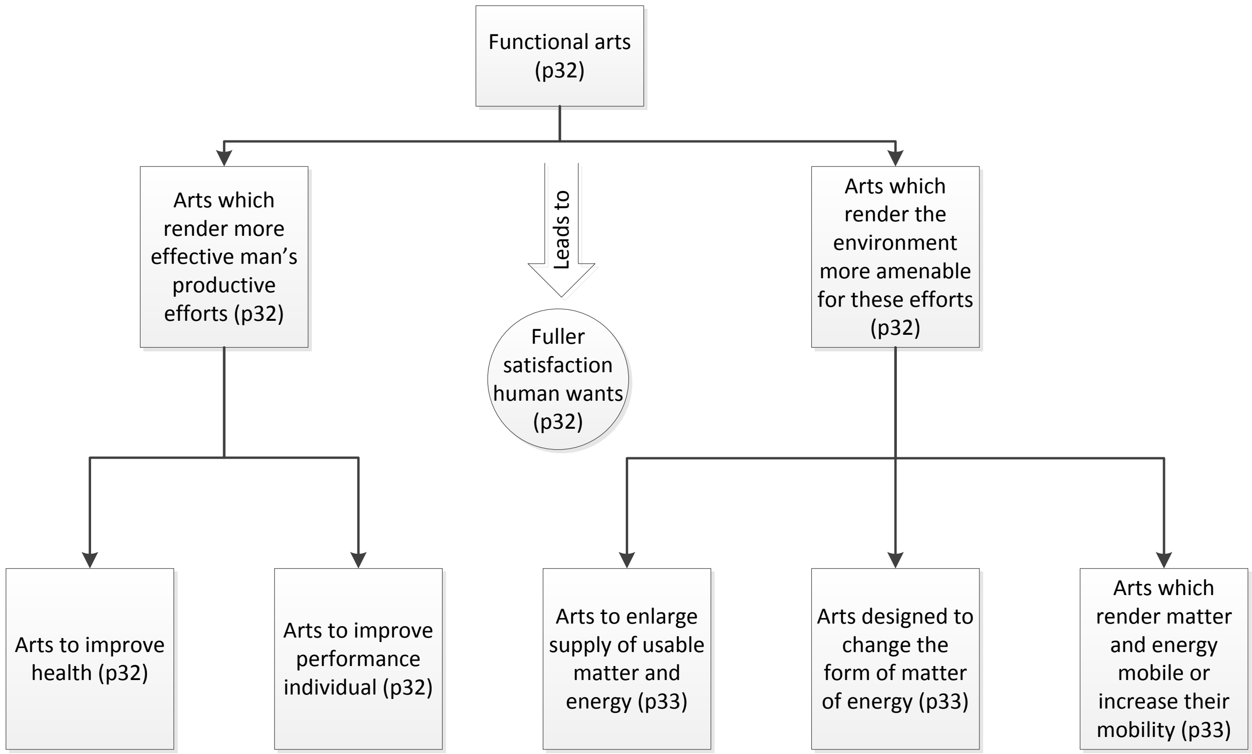


Figure 9 Functional arts (Figure based on theory Zimmerman)

3.1.2.5.2.1 Arts which increase man's productive effort

The first form of Arts that improve the productivity of human beings can be found in the form of the improvement of health of human beings (Zimmerman, 1951). These types of Arts increase the health and the duration of life and therefore increase the time in which a human being can be productive (Zimmerman, 1951). Second, in this category, are the Arts which increase the productiveness or the performance of the individual by for instance education, tools, eyeglasses and the usage of machines (Zimmerman, 1951).

Arts which increase the usability of the environment

Next, there are the Arts that increase the usability of the environment. First in this category are the Arts that enlarge the supply of usable substances and energies (Zimmerman, 1951). An example of this is formed by the techniques which make it possible to extract more oil from a well by means of air pressure (Zimmerman, 1951). Second in this category, are the Arts that change the form of the substance or the energy in such a way that it becomes usable (Zimmerman, 1951). An example of this can be found in the processes in which crude oil is processed into gasoline. Last in this category, are those Arts which make substances and forms of energy mobile, so they become suitable for transport from the location where they are abundant to the location where they are required (Zimmerman, 1951). An example of this can be found in LNG, which is easier to transport than natural gas.

3.1.2.6 Resources

Resources are those substances that are able to fulfill a function for which a Want is satisfied. If these substances are not able to fulfill a function due to for example a Resistance that cannot be overcome, the substance will not function as a resource. Resources can evolve or become depleted or demolished.

Evolvement resources

The evolvement of resources happens due to the interaction of Human, Cultural and Natural aspects or assets (Zimmerman, 1951). Man is exploring methods and means which will enable him to achieve his objectives (Zimmerman, 1951). These objectives can be achieved when Man uses his capacities to make use of the possibilities of Nature (Zimmerman, 1951). The adaptions or adjustments done by man in order to make use of his environment are the building blocks of his Culture (Zimmerman, 1951). The sum of these adaptions and adjustments together form this Culture. Due to this interaction between Man, Nature and Culture 'Neutral stuff', a substance without a resource function, can be converted into a valuable resource (Zimmerman, 1951). Often, for resources to be evolved, resistances have to be overcome. Natural resources, which are considered the free gifts of Nature are scarce, for most substances to function as a resource resistances have to be overcome (Zimmerman, 1951). Furthermore, in order to overcome the resistances associated with a substance and to have the substance evolve into a resource, an increase in knowledge, experience and/or science is necessary. Due to these factors, substances which can function as a resource can be discovered and inventions may be done that could lead to the substances becoming usable as a resource.

Depletion/demolishment

The demolishment of resources can be achieved by the physical destruction of the resources. This may happen by the consumption of the resource or by destroying the substance. Also, the substance may become unable for usage, due to new resistances which have evolved and which cannot be overcome or due to new developments which convert the resource back into neutral stuff (Zimmerman, 1951). This can happen, as stated before, when a substance is not able to fulfill his function as a resource anymore or if another substance has become more suitable for this function.

According to Zimmerman, the most significant reason for the demolishment of resources is human ignorance and cussedness (Zimmerman, 1951). This leads to destruction of Flora and fauna and other substances by means of blundering, short sightedness and a lack of knowledge (Zimmerman, 1951).

Furthermore, the conflict between the Individual wants of man, which are often short sighted, and the social objectives of the human population, which are more long term, can create problems (Zimmerman, 1951). Due to the different time frames, they cannot agree on the tempo of resource development. The way in which the Individual wants to use the resources may not always be the way in which these resources stay preserved for the next generation. Science has a positive influence on this dilemma, since it creates a better understanding what consequences the human actions of today will have for the future generation, however it does not solve the problem (Zimmerman, 1951). The conservation act is an example of the management of the Wants of individuals for the benefits of the whole society.

Additionally, destruction of substances which can function as resources may happen due to the increasing complexity of social order (Zimmerman, 1951). Zimmerman says that "*As nations increase in* *size, as economies become elaborate, and as global interdependence grows, the task of "living together well" of good neighborliness, of The Good Society, grows more difficult and the pitfalls become more numerous and deeper*" (p14) (Zimmerman, 1951). This statement was made by Zimmerman in 1951. Today, there are not many nations that still increase in size, although significant growth in economies as well as in populations in nations such as China and India is still happening. However, the communication between countries has increased and agreements and policies between countries have been established in order to overcome these problems. That been said, being a good neighbor and keeping those agreements may be hard especially when another "Neighbor" is not doing this. This could result in economic growth for the neighbor who is not producing in a way that is good for the whole society. Thus, resources can be used in ways that are best for individual countries, but which do not pose the best overall benefits and economic use of substances worldwide. Thus, even though the communication and agreements have increased, the pitfalls concerning the depletion and demolishment are still there and should not be overlooked.

Also the confidence of man in finding new energy resources, can be a factor that leads to the depletion of resources (Zimmerman, 1951). The modern man is very confident in his capabilities of finding new energy resources, which may lead to behavior in which the resources of today are not used in the most economical way (Zimmerman, 1951).

The last factor that can destroy resources is war (Zimmerman, 1951). The resources may be destroyed physically, depleted by (military) demands or may become inaccessible for the people who require these resources. Furthermore, war is of influence on inventions and discovery of new resources (Zimmerman, 1951). In times of peace more resources are available for the research towards the development of new resources.

Types of resource creating factors

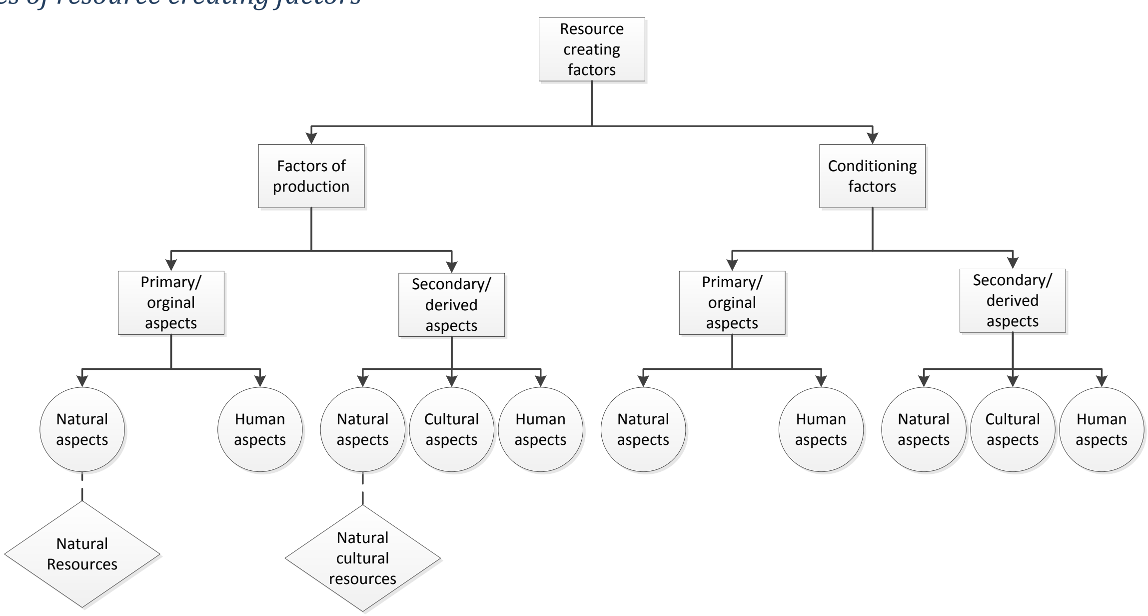


Figure 10 Resources (Figure based on theory Zimmerman)

Just as Zimmerman differentiates between kinds of resistances he provides categories for resource creating factors. The first differentiation is made between those elements that produce resources and those elements that condition resources. Within this distinction Primary/original aspects and Secondary derived/aspects can be identified. Finally, the elements are divided over the categories of Natural aspects, Cultural aspects and Human aspects. First the factors of resource production will be presented where after the conditioning factors for resources are provided.

Factors of production

The factors of production are those factor which produce resources.

Natural aspects

Those aspects of Nature for which Man does not have to overcome resistances are Natural resources (Zimmerman, 1951). These are the free gifts of nature and may be consumed by Man without putting effort in the attainment of these substances (Zimmerman, 1951). These are the Primary natural factors of production. Examples of Natural resources are fruits hanging in a tree and water present in rivers.

The Secondary/derived natural factors of production are also referred to as the Natural-cultural resources. In this category those substances are placed which are made available for Man after improvements were accomplished (Zimmerman, 1951). An example of a Natural-cultural resource can be found in natural gas, for which a drilling procedure to extract the gas and mechanism to use the gas had to be developed in order to attain the gas.

Cultural aspects

As for resistances, there are no Primary producing cultural factors, since culture can be seen as the adaption of man on his environment and is therefore always secondary. However, there are Secondary/derived cultural factors which affect the production of resources. In this category the instruments and aids to produce resources are found (Zimmerman, 1951). Examples of these cultural aspects are t*ools, engines, machines, factories, cities, telephone, radio, irrigation, ports* etc. (Zimmerman, 1951). These are the aspects which man has developed in order to make substances suitable to function as resources.

Human aspects

The Primary human aspects which relate to the production of resources are the *'Native abilities and drives'* of human beings (Zimmerman, 1951). Man's ability to think and find solutions to overcome Resistances in order to use a substance forms an example of this. The Secondary/or derived aspects are those human capacities which have been developed by *education, training, experience* etc.(Zimmerman, 1951).

Conditioning factors

Conditioning factors are those factors that make it possible for substances to function as a resource.

Natural aspects

The Primary conditioning natural factors are aspects such as climate, topography and location (Zimmerman, 1951). These aspects are only Primary conditioning aspects if they are still unaffected by

Man. When these aspect are influenced by Man, they fall into the category of Secondary/derived conditioning natural aspects (Zimmerman, 1951).

Cultural aspects

For the same reason as stated before for the absence of Primary cultural aspects, there are no Primary cultural aspects, which count as conditioning factors. The Secondary/derived conditioning cultural factors are *facilitating agencies of commerce and finance, social institutions such as governments, churches, schools, mores, state of the industrial arts, credit, accumulated knowledge, ethics, level of morals,* etc. (Zimmerman, 1951).

Human aspects

Finally, the Primary human aspects which are considered conditioning factors for resources are the 'social attitudes' which makes human beings Want to live together (Zimmerman, 1951). The Secondary/derived human conditioning factors are attitudes which generate a high amount of labor, management attitudes which create favorable conditions and the relations between the labor force and the managements (Zimmerman, 1951).

Gross resources and net resources

Those resources for which resistances still need to be overcome are called Gross resources (Zimmerman, 1951). Hence, this is not the same as Natural resources, since Natural resources concern the free gift of Nature, while Gross resources indicate both the Natural resources and those resources which could become available after Resistances have been overcome (Zimmerman, 1951). Net resources are those resources for which the resistances have been overcome and which can be used to satisfy Wants and increase the well-being of Man (Zimmerman, 1951). Since the Resistances to arrive at net resources have been overcome due to Culture, Net resources are the same as Natural-cultural resources and will be named Natural-cultural resources in the rest of this report. These kinds of Resources are also called Man's resources, which are defined as those resources created by man with the aid of knowledge, ingenuity and experience (Zimmerman, 1951).

Methods and means

Zimmerman considers resources as "*Means to attain given ends*" (Zimmerman, 1951). These ends may consider Individual wants or Group wants (Zimmerman, 1951) When these ends change, the means will also change (Zimmerman, 1951). This implies that the functionality of substances as a resource is under influence of both the Wants and objectives of individuals and society. However, this process may also be reversed, when means change, ends may become different as well. When ends or objectives are clear, means may be discovered or invented. However, this does not necessarily lead to a net progress; it may happen that while creating means to attain different or new ends, other substances will lose its function as a resource (Zimmerman, 1951).

3.1.3 Important factors not addressed in figure 5

As stated before, the diagram provided by Zimmerman in figure 5 does not include all the factors that are important to explain the development and functionality of a resource. The factors not included in figure 5 are explained in this section.

In addition to the first diagram, Zimmerman provides a second diagram. This diagram is based on the idea of "C*ulture as a spearhead which man drives deeper into the realm of nature" (p13)* creating both Resources and Resistances from neutral stuff (Zimmerman, 1951). This diagram is presented in figure 11.

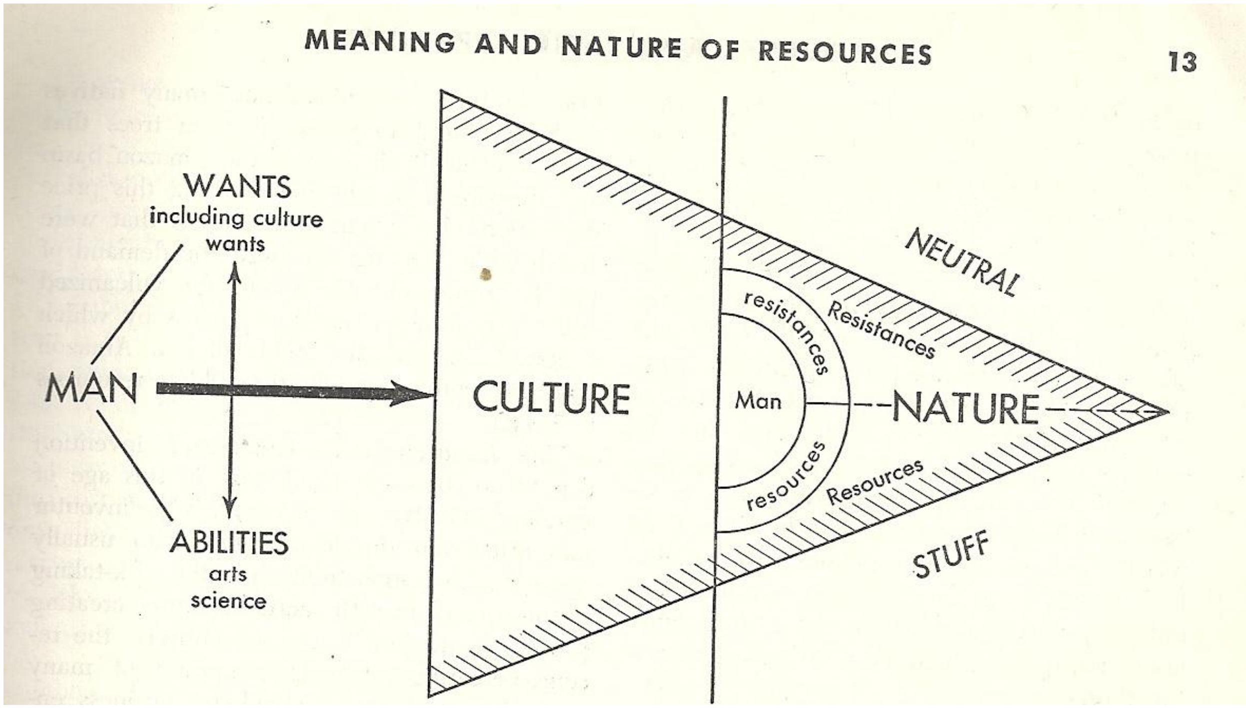


Figure 11 Meaning and Nature of resources

However, Zimmerman does not consider this diagram as complete either. In order to deliver a complete picture both diagrams should be combined, and even then it would not be possible to present all the dynamic interactions, according to Zimmerman (Zimmerman, 1951). Particularly the relation between Nature and human Wants and the relation between Nature and Arts and sciences would still be missing (Zimmerman, 1951). The factor Culture will now be more deeply explored.

3.1.4 Culture

"Culture is the sum total of all the devices produced by man, with the aid, "advice, and consent " of nature, to assist him in the attainment of his objectives" (p115) *(Zimmerman, 1951).*

According to Zimmerman culture:

- *"Permits man to imitate nature*
- *Permits man to improve on nature*
- *Enables man to create new substances nowhere found in nature*
- *Gives men the power to release energies not available in nature" (p115)* (Zimmerman, 1951)

Culture reflects those adjustments done by man to adapt to his environment. The characteristics of a Culture evolve out of the advantages and disadvantages which Nature poses to Man (Zimmerman, 1951). In order to make use of the advantages and make the best out of the disadvantages, Man choses those options concerning improvements and adjustments which will help achieve his Wants and which he is capable of fulfilling (Zimmerman, 1951) These adaptions done by man are reflected in his Culture (Zimmerman, 1951). Examples can be found in the way houses are built, the way of clothing in different areas, technologies which are used to cultivate land, and the food which is consumed over the different cultures in the world. For instance, in countries were potatoes are rare, man will either search for ways to produce these or eat something else.

Culture reflects the advantages and disadvantages posed by the relation between the population and nature's opportunities (Zimmerman, 1951). The properties and types of adjustments which are made, and which are integrated in the Culture, present which factors are scarce and which are abundant. A Factor, which is scarce, also referred to as the short factor, has a more significant influence on the Culture of a society than an abundant factor, also named the long factor. Zimmerman expresses this as:

"The equalizing function of culture may be expressed in the form of a "law"; the "long" factor (the abundant factor) tends to create culture (capital) to support the "short "factor" (p116-117) (Zimmerman, 1951).

So the 'long' factor is used for adaptions to attain or develop the 'short' factor. The adjustments made by Man to make use of his environment, is a resource creating process (Zimmerman, 1951). By making alterations, Man is able to make substances suitable to function as a resource, while these were unsuitable before these alterations. As Zimmerman states: *"Culture is bound to become increasingly important as the dynamic force in the creation of resources"* (p11) (Zimmerman, 1951). As stated before, Man and Nature are considered "*The original resource factors"* (Zimmerman, 1951). With the limitations taken, or as Zimmerman states it 'The advice and consent' of Nature, Man 'creates' Culture out of the materials and energies he achieves from nature (Zimmerman, 1951). This implies that Man chooses the most beneficial alternative which Nature provides him with. He does not aim for things that include unbeatable resistances. He may choose to develop improvements to overcome resistances. By means of Culture, Man achieves his objectives and overcomes the defects of Nature (Zimmerman, 1951). Examples of these defects of Nature are insufficient production of substances, the production of substances in the 'wrong' place, a place in which they are not required, and the production of substances at the 'wrong time, a time in which the substances are not necessary (Zimmerman, 1951) This leads to the function of Culture; to enlarge Resources and reduce Resistances (Zimmerman, 1951). This is presented in figure 12.

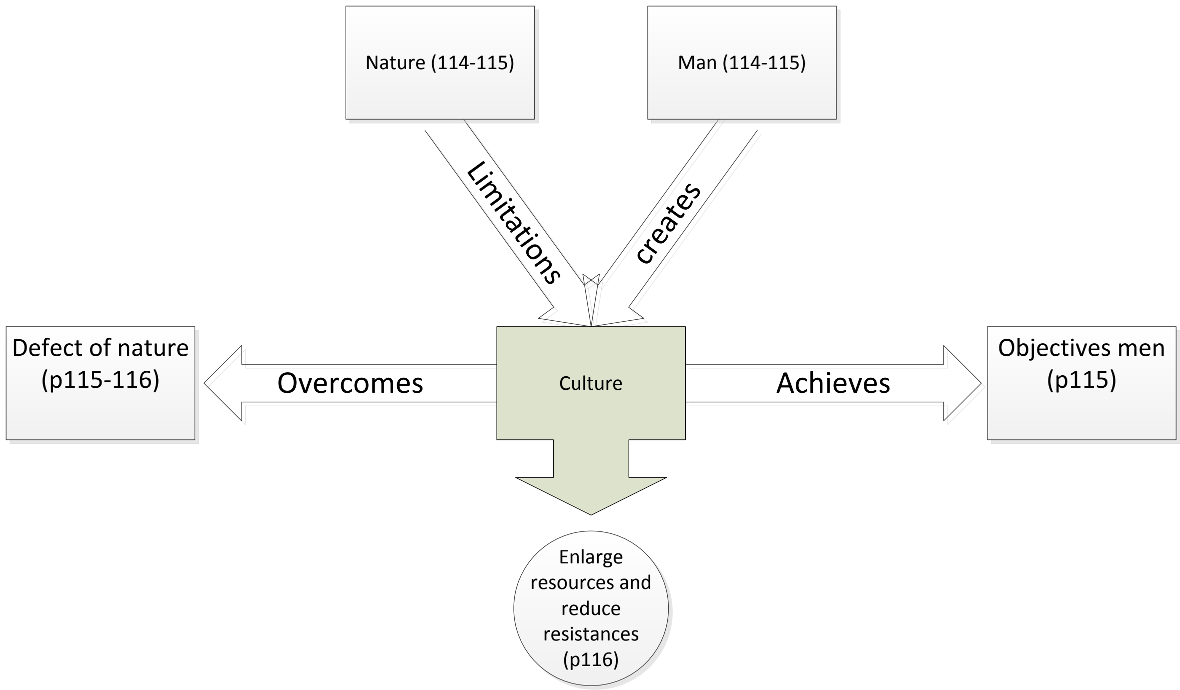


Figure 12 Interaction man, Nature and culture (Based on theory Zimmerman)

Culture is of influence on the capabilities of man in the form of *experience, education and training* (Zimmerman, 1951). Also, it is of influence on what Man Wants. A person living in New Delhi often has other desires than a person living in New York, this due to his experience, education and the way he is raised. Moreover social objectives differ per culture, what may be desired in the Netherlands may be abundant in China, because of different habits. However, this is not where the influence of Culture stops. Culture is of influence on the relations between man, organization of society and *societal institutions* such as governments, churches and schools (Zimmerman, 1951). What is important in a country is strongly affected by the Culture.

3.1.4.1 Cultural changes

In the beginning of the human race, there was not much contact between different groups, which kept Cultures isolated. Today, due to increased contact between human beings, cultures are blending which results in Enriched cultures (Zimmerman, 1951). Even though these cultures, have lost their straightness, growth in these area's is still achieved (Zimmerman, 1951). However, the blending of cultures also creates problems (Zimmerman, 1951). Since cultures have evolved from several adaptions to a specific environment and contain a certain sense of logic, parts cannot be moved without any problems to a different environment (Zimmerman, 1951). In the 'new' culture the logic of the parts of the 'old' culture may not be thoroughly understood. Furthermore, the parts or adjustments may not be as efficient or effective as the adjustments done in the 'new' culture. Here the adjustments of the 'old' culture may be abundant or inefficient.

Zimmerman states the following about Culture: *"Culture is a cumulative process, it gains momentum as it proceeds"* (p31) (Zimmerman, 1951). With this sentence it is indicated that the evolvement of Culture, and everything that it influences, never comes to an end. All adjustments and adaptions done in the past and in the future will be embedded in the Culture of a country. Cultural changes manifest themselves in three categories: the area of the effects of these changes (non-man or man), the type of change (tangible or intangible) and the directness of these changes (direct or indirect).

Area of effect of changes

The cultural adjustments and adaptions affecting the environment appear in two fields, the cultural changes which influence the non-man environment and those cultural changes which modify the human attitudes and relations, between as well as within groups (Zimmerman, 1951). The cultural adjustments and adaptions influencing the non-man environment are physical and non-physical, and include both objects and Arts (Zimmerman, 1951). The cultural changes which are of influence on the human attitudes and relations are for instance caused by governments, churches and living standards (Zimmerman, 1951). These examples are the results of the accumulation of these cultural adaptions and adjustments, which have an impact on humans. This is presented in figure 13.

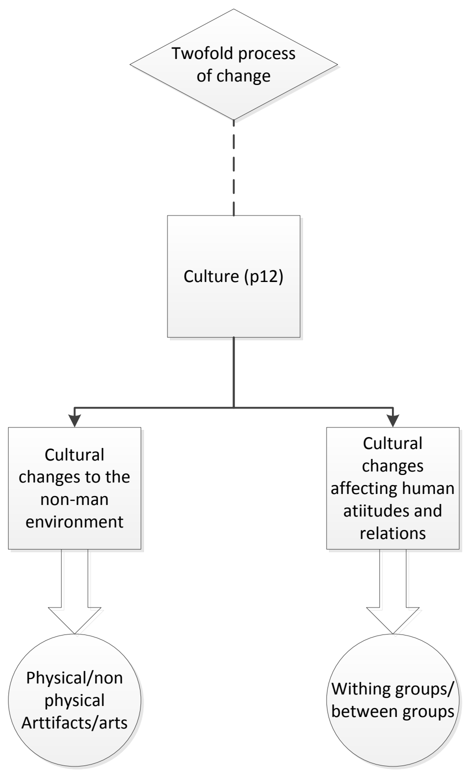


Figure 13 Cultural changes (Figure based on theory Zimmerman

Type of changes

Another distinction in culture changes can be made in the type of *Cultural improvements*. These cultural improvements can be divided in two categories: the tangible changes and the intangible changes (Zimmerman, 1951). The tangible changes include those modifications of the natural environment that lead to material issues such as waterways, roads, power facilities*, machines and churches* (Zimmerman, 1951). The intangible changes include those improvements that lead to immaterial changes, such as technologies, expertise and *knowledge* (Zimmerman, 1951). These immaterial improvements are also defined as Arts and are perceived as the *driving force* for the *capital equipment* which is seen as the material result of this driving force (Zimmerman, 1951). These Arts often function though capital equipment, in the way skills function through instruments or tools (Zimmerman, 1951). These relations are presented in figure 14. Because of this relation, the appraisal of resources depends primary on the condition of the Arts and not on the state of the capital equipment, since Arts define how and which capital equipment will be used (Zimmerman, 1951).

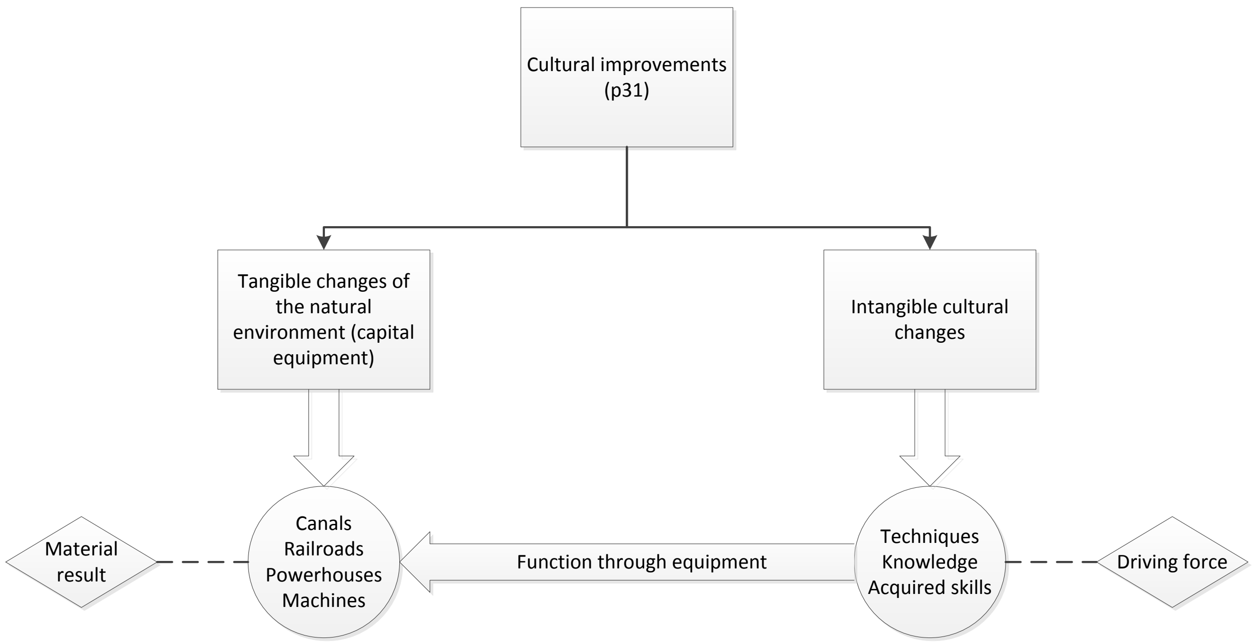


Figure 14 Cultural improvements (Figure based on theory Zimmerman)

Direct or indirect changes

The last two categories which can be distinguished in the fields of culture consider the direct and indirect adjustments to Nature, as indicated in figure 15 (Zimmerman, 1951). Direct adaptions are those improvements done by man which directly lead to results (Zimmerman, 1951). An axe to cut a tree is an example of a direct adjustment. Indirect adjustments are those improvements done by man for which the cause of the adjustment is harder to identify (Zimmerman, 1951). A machine that is built to process more wood in a certain time frame is an example of an indirect adaption. The building of the machine itself does not generate more wood, though the usage of the machine will. Another example is the development of roads and railroads, which serve to increase the optimal distribution of Resources. Societal institutions are also considered indirect adaptions (Zimmerman, 1951). These adjustments are often so indirect that it may be impossible to identify the reasons for these adjustments (Zimmerman, 1951).

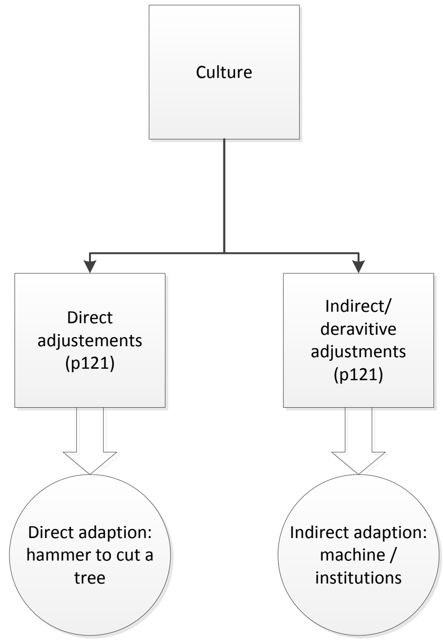


Figure 15 Environments (Figure based on theory Zimmerman)

3.1.5 Economy

As stated before, Zimmerman does not use an economic approach to determine the functionality of resources. Therefore, in his theory he does not provide calculations on turnover or profitability of resources. In his theory, these factors are not decisive, though he does state that the profitability of a substance as a resource is of influence on the appraisal of that substance as a resource. This approach is very different from many other (economic) theories in which the functionality of substances as resources is mainly based on the possible turnover and profit of these substances. However, Zimmerman does consider the effect of the Economy on the development and functionality of resources. The two main economic influences on the development and functionality of resources are provided below. These aspects are the role an individual takes when making (economic) decisions and the type of economy present in a country.

3.1.5.1 The role of the individual

As Zimmerman states it *"Modern man may be thought of as made up of many ego's"* (Zimmerman, 1951). With this he implies that Man will appraise resources in a different way, depending on which ego dominates at that moment (Zimmerman, 1951). The same Man may make different decisions, concerning resources, when placed in different situations or functions. An example provided by Zimmerman will further clarify this.

"A man is appraising a parcel of real estate; he is realtor, the father of children, the chairman of the playground committee of his community and a member appointed by the president of the United States to study national problems of land utilization. According to the particular capacity in which he thinks, speaks and acts at a given moment, he will hold widely different opinions and perhaps, advocates different policies concerning the plot of the ground in question" (p24) (Zimmerman, 1951).

What is illustrated by this example is that a person is both an individual as a participant of a group. From these different angles, he may make different decisions concerning the appraisal of resources. An example of this can be found with former CEO's of companies that are now in committees that have other purposes.

3.1.5.2 The role of the individual and the type of economy

According to Zimmermann, the economic life may be divided in three phases. This is shown in figure 16.

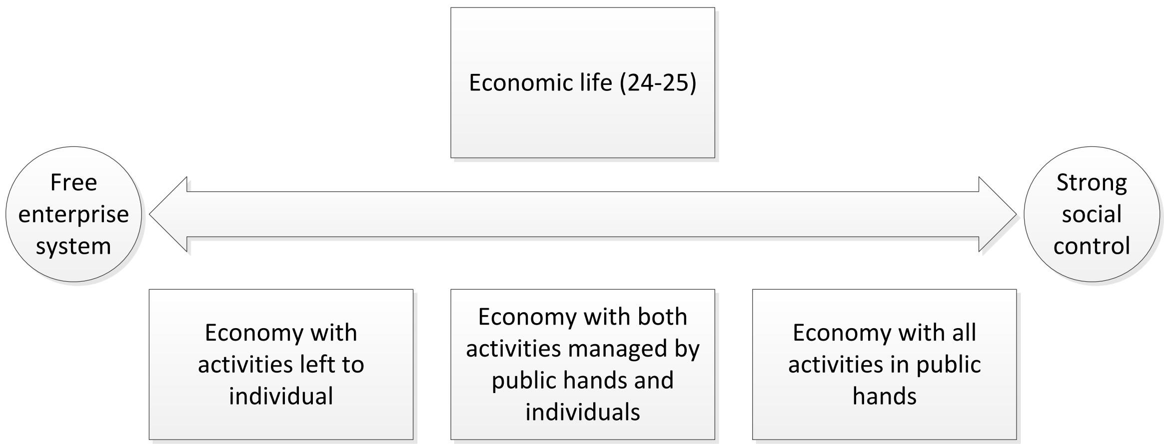


Figure 16 Economic activities

The activities belonging to an economy can be classified in three types of activities. Two extremes may be identified (Zimmerman, Spahr, Walter, & (ed.), 1936). At one extreme are the activities which are in the hand of individual initiatives and private enterprises (Zimmerman et al., 1936). On the other end, are the activities which are managed and controlled by the government (Zimmerman et al., 1936). In this type of economy, activities such as justice and supply of an army are managed by the government since they are matters of public concern (Zimmerman et al., 1936).

In between these extremes there is a 'Third economy' which preserves a mixture of activities and issues handled by both individuals and public control (Zimmerman et al., 1936). In this economy it may not be quite clear which activities are of individual interest and which are of group interest (Zimmerman et al., 1936). The power industry provides a good example of this (Zimmerman et al., 1936). The product power is a matter of public concern; everybody should have access to this. However, the production process of power is not a matter of public concern, neither is the supply of fuels for the power industry (Zimmerman et al., 1936). The production is often in the hand of private enterprises, likewise is the supply of raw materials. This does not always lead to economic use of raw materials and environmental friendly processes. The decisions made in these facilities will depend on the role of the individual when taking that decision. For example as manager of the plant, a higher profit may be the highest priority, so cheaper material that could lead to blackouts could be chosen in the plant. While as the supervisor from the government, adequate supply of power may be of higher priority and blackouts should be avoided against all costs.

Another activity which could be placed in this 'Third economy' is agriculture (Zimmerman et al., 1936). This sector provides one of the Basic wants, namely food. Yet, the production of this is often in the hands of private farmers, who use their land in a way, which is most beneficial for them. However, this does not necessary leaves the soil in a condition suitable for the production of food for the next generation (Zimmerman et al., 1936).

How countries manage those activities from the category of the third economy is different for every country and is often dependent on their *national character*, their actual situation and their history (Zimmerman et al., 1936). Certain nations leave many activities to the initiative of individuals and free enterprise, but still contain some social control, while other nations govern most economic activities. If a country is ruled in a communistic style, the way how resources are appraised and used is mostly controlled by the government. While in a country which is ruled by social or liberal parties the usage and appraisal of resources is often decided by individuals and companies. The type of governance strongly affects if a government is able to obligate a certain resource strategy such as conservation or has to leave the decisions concerning the usage of resources to the individual. Thus, the way governments manage and control these kinds of economic activities is of influence on the way resources are used, which resources are used and what their effect on society will be. These decisions are of influence on the long-term resource appraisal and the wealth of the nation.

3.1.6 Knowledge and wisdom

The following statement is made by Zimmerman considering knowledge: "*The difference between Neolithic man, who roamed the earth in misery and fear, and man today, who lives in relative comfort and security, is knowledge- knowledge of petroleum and natural gas, of sulfur and helium, of chemistry and physics, the countless wonders of modern science- and the marvelous apparatus of cultural improvements which knowledge has devised and built for its own application"* (p10) (Zimmerman, 1951).

Thus, knowledge forms the foundation of our society. Which knowledge is available for whom at which moment in time defines which substances are considered as Resources. When knowledge changes or increases this strongly affects the amount and types of substances that will function as Resources at that moment (Zimmerman, 1951).

Science

"It is one of the glories of the present age that future demands are anticipated by the systematic development of arts- which today generally means sciences- regardless of the immediate current needs" (p35) *(Zimmerman, 1951).*

Science is considered the depersonalization of Arts. The capacities of Man which could belong to a specific person become listed in formulas, expressions and books (Zimmerman, 1951). While Arts have been developed by the methods of trial and error, in which a person kept trying until he achieved the desired ends, and the method of rule of thumb, in which the past experience on a certain object is used and educated to the next generation, science is not related to a person anymore (Zimmerman, 1951). While in Arts both the teacher and student do not have to understand the physical rules if the desired result is achieved, science is aimed at knowing and understanding processes in order to attain certain ends (Zimmerman, 1951). Moreover, scientific principles may be used in more fields, while the rules of thumb are only applied in one field. Due to this characteristic, science has achieved a steep incline in the development of Arts (Zimmerman, 1951). Although, this increase manifests itself mainly in the technical field and not in the social/institutional field (Zimmerman, 1951). As stated before, the reason for this can be found in the fact that science needs verification and validation, which is hard to achieve in the social and institutional field but often is not a problem in the technical and material field (Zimmerman, 1951).

Inventions and discoveries

Inventions and discoveries are often the result of *social conditions* (Zimmerman, 1951). Looking at the development of the U.S. and Europe, different inventions were done, as different conditions were and still are present. In the U.S, the wideness of the nation, which was filled with useful substances at very broad distances, led to a low population density which resulted in problems such as labor scarcity (Zimmerman, 1951). In Europe the distances were smaller and the population density was high, so no problems appeared concerning the labor force (Zimmerman, 1951). However, Europe had significant problems with attaining the necessary raw materials (Zimmerman, 1951). Due to these different situations, different inventions were made. In the U.S. inventions were made to decrease the problem of labor scarcity by building machines that could take over the work such as tractors and plowing machines. That these machines required a lot of raw material was not a problem for a country with such an abundance of material. In Europe, which had the reversed problem inventions were done, that were labor intensive and less material intensive. Examples of these are the factories with conveyor belts in which a high amount of people worked at processes that could also be done by a machine.

The theory that inventions are the result of social conditions, is armored by the fact that similar inventions were done in places with the same social conditions (Zimmerman, 1951). *"Necessity is the mother of the invention"* appears to be a true statement (Zimmerman, 1951). This necessity evolves from the gap between Man's physical abilities and his desires and ambitions (Zimmerman, 1951). However, when initially it was the state of hopelessness which drove man to inventions and in a later stage necessity, now profit seems to be the strongest incentive for the improvements of Arts (Zimmerman, 1951).

Every invention which is done today rests on the inventions made in the past (Zimmerman, 1951). They can be based on previous inventions or may improve the inventions already done (Zimmerman, 1951). The steam turbine is an outstanding example of this. When James Watt delivered his steam engine in 1776, this invention was followed by the steam turbine, the gasoline explosion engine, the diesel engine, the gas combustion turbine, the water turbine and other inventions which have provided electricity its dominant role in the world today (Zimmerman, 1951).

3.1.7 Human actions

Human actions can either convert neutral stuff into Resources, but can also reverse this process (Zimmerman, 1951). Examples of human actions are business enterprise, technics and governmental policy (Zimmerman, 1951). Due to new technologies, substances may become suitable to function or operate as a Resource in certain processes. The same counts for changing policies and business enterprises. However, as stated before, new technologies and policies can also destroy the Resource function of a substance.

3.1.8 Energy basis

According to Zimmerman the energy basis is the foundation of a country (Zimmerman, 1951). The energy basis implies the distribution of energy sources used in a country. This basis determines which materials are used and what the size of the performance or output is (Zimmerman, 1951). The type of resources, its price and the amount available for consumption, determine the mobility in a country (Zimmerman, 1951). This mobility is of influence on the transportability of goods that may be abundant in one place and necessary in another. Also, the energy basis is of influence on the Arts which may develop. In turn these Arts can have an effect on the institutions (Zimmerman, 1951).

Thus the energy basis is an important influence on the civilization of a country and which resources it uses to generate this energy (Zimmerman, 1951). Therefore, it is the result of the functionality of various substances as resources.

3.1.9 Institutions

As can be seen in figure 8 Zimmerman considers institutions as a type of Arts (Zimmerman, 1951). Societal institutions are influenced by Culture, so cultural patterns can be found in these institutions (Zimmerman, 1951). Societal institutions can be seen as the adaptions to the environment, however these adaptions are very indirect and often the cause of this adaption is not known anymore (Zimmerman, 1951). An example can be found in the man who is attacked by wild animals and therefore wants to live in group. The generations who follow, might not know the exact reason why there are living in group anymore, for them it has become a habit. According to Zimmerman institutions and policies are of significant of influence on the development and functionality of a resource (Zimmerman, 1951). Zimmerman even states:

Institutions have as much to do with the ultimate efficacy of energy use as have engines, machines and logarithm tables (p43,44) (Zimmerman, 1951).

According to him institutions are as important for the usage and obtainment of energy as machines are (Zimmerman, 1951). Governments can be seen as the adjustments or patch-ups to make the machinery suitable for its task (Zimmerman, 1951). Furthermore, institutions can solve the problem of resource inadequacy, the problem when a resource is present though in the wrong place or in the wrong time (Zimmerman, 1951). By means of governmental policies the distribution of these resources can be improved.

The national wealth of country depends next to the presence of available and usable substances in Nature, on the institutions (Zimmerman, 1951). Especially the institutions which are of influence on the population growth are important, since institutions determine for a large extent the amount of food, clothes, water etc. which will be present per person (Zimmerman, 1951).

Which materials are used to generate and use energy, or the energy basis, strongly influences the societal and technical arts present in a country (Zimmerman, 1951). The properties of these materials determine how these materials can be attained and used and therefore what the required Arts will look like. These societal and technical arts are of influence on the development of the institutions (Zimmerman, 1951). When new developments are achieved and new substances can become resources, institutions may change; old institutions can disappear and new may evolve (Zimmerman, 1951). However, the difference of attitudes towards the usage and development of materials and resources, which is present in institutions, is again of influence on Arts (Zimmerman, 1951). Therefore, the Arts and Institutions present in a country are strongly related. Also for this reason, the way an industry to attain and use a substance is developed, strongly reflects the institutions of the country. An example is the bituminous coal industry which reflects, next to the natural properties of coal, the ideologies and institutions of the U.S (Zimmerman, 1951). Therefore it can be concluded that institutions are of influence on how resources are developed.

Finally, even though, institutions can change, this change is hard to achieve (with scientific methods). The reason for this is has already been stated; that institutional arts, unlike material arts, are hard to verify and test (Zimmerman, 1951).

3.2 The 'Zimmerman framework'

The theory of Zimmerman, briefly described in the previous paragraph, will form an important input for the development of the final framework, which will be used to develop an improved understanding of the development and functionality of a resource.

In this paragraph the development of the framework based entirely on the theory of Zimmerman, the 'Zimmerman framework', is explained. The reason that this framework is developed is to create an abstract but complete overview of which factors are important according to Zimmerman and how these are related. Therefore the framework can be considered as the next and final step done in this research to extract the core of Zimmerman's theory. The 'Zimmerman framework', will only include those variables that are of influence on the development and functionality of a resource according to Zimmerman.

3.2.1 Steps towards the 'Zimmerman framework'

In this paragraph the development of the framework based entirely on the theory of Zimmerman, the 'Zimmerman framework', is explained. All the steps that have been taken to arrive at the 'Zimmerman framework' are explained here.

3.2.1.2 Step one: creating an overview of the theory

The theory of Zimmerman provided in his book *World resources and industries,* briefly summarized in the previous paragraph, forms the backbone of the 'Zimmerman framework'. The core of this theory is extracted and converted into a framework. Since, Zimmerman elaborates on his theory in a rather unstructured and complex way, a few steps have been taken before the framework could be developed, in order to simplify and understand the theory. First, the theory is summarized into a smaller document, which only contains the essential parts of Zimmerman's theory. Second, a causal relation diagram is developed based on this summary. This causal relation diagram is used to provide an overview of all the variables and their relations presented in the theory. Since Zimmerman works in a rather unstructured way, with various names for the same variables, this diagram was useful to provide a complete overview on his theory and all the variables used. It clarifies which variables are present and how the variables are interrelated. The initial causal relation diagram consisted of 179 variables. This diagram is presented in figure 17.

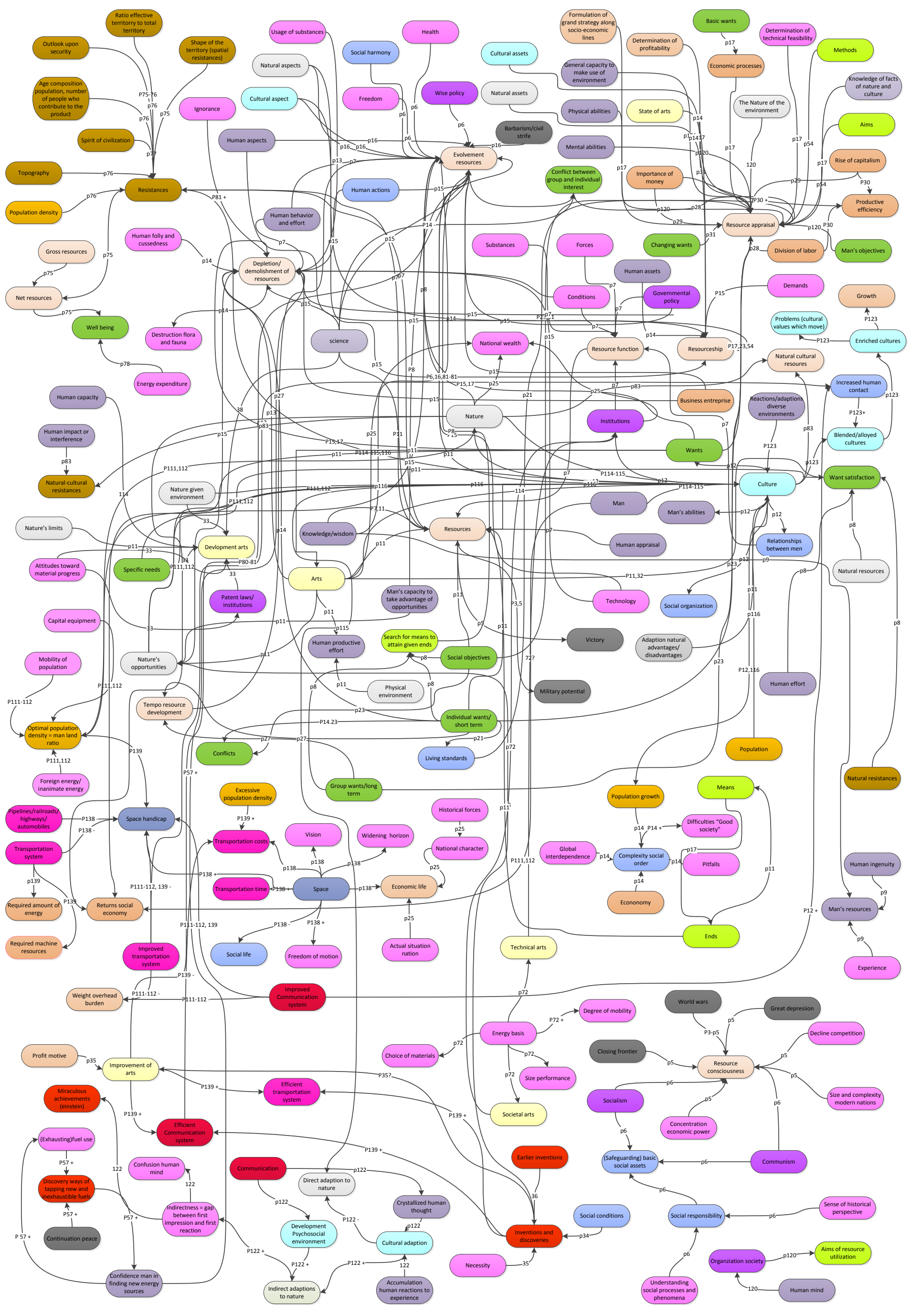


Figure 17 Initial causal relation diagram (Based on Zimmerman's theory present *World resources and industries*)

This initial causal relation diagram is only presented to provide an idea on the complexity of Zimmerman's theory and the amount of variables introduced by Zimmerman. A readable version of the variables and this diagram can be found in appendix VI.

In the initial causal relation diagram, no combinations of variables or other alterations were made. This is because it was sometimes unclear what Zimmerman implied with a variable, and it was unwanted to create combinations of variables which could be wrong according to Zimmerman. Therefore, as a step before the alterations were applied to simplify the diagram, the exact definitions and relations were explored for all the variables. This was done by the determination of the definition of every variable, which sometimes required the usage of dictionaries, and the development of tables that represented the relations of every variable. With this thorough understanding of the meanings of the variables, new, combined variables could be developed if multiple variables implied the same. The combined variables were provided with new definitions. Furthermore, tables are developed which present which 'old' variables are placed under the 'new' variable. Also, some variables were considered abundant for this research and were removed. All variables, their definitions and relations are presented in appendix I. In this appendix, paragraph 19 provides a concluding paragraph in which the definitions of the variables present in the initial causal relation diagram, the alterations to the initial causal relations diagram and the definitions of the combined variables are provided.

After this process, a simplified causal relation diagram was developed with the remaining variables. This diagram is also presented in appendix I and in appendix VI in a readable version. This diagram is still quite extensive. This was deliberately chosen in order to eliminate the risk of losing important information.

3.3.2 Step 2: The 'Zimmerman Framework'

The simplified causal relation diagram was used as the input for the 'Zimmerman framework'. However, this diagram is still quite complex and extensive. In order to define which variables are most important, another step had to be taken. For this step the amount of interrelations of the different variables is determined. This method is based on the assumption that the variables that have the most interrelations explain the largest share of the theory and are therefore the most important variables. It is understood that the amount of interrelations is also related to the lack of structure of Zimmerman's theory, therefore the theory of Zimmerman on his variables and common sense are also used to identify the most important variables. The amount of interrelations is not the decisive element.

After the variables and their number of interrelations are determined, the variables are categorized. For each category a primary factor is chosen. This primary factor is the variable that cannot be grouped under any other variable and provides a new category of variables. An example of such a primary factor is the factor Arts. This factor contains ten relations in the causal relation diagram and provides a category for other variables related to Arts. Often, these primary factors are the variables with the most relations with other variables. The other variables, which are not primary factors, are categorized under these primary variables. The process of the determination of the primary factors and the categorization of the other factors under these primary factors is presented in appendix II.

So with the primary factors identified and the factors which can be categorized under these primary factors determined, the 'Zimmerman framework' is created. This 'Zimmerman framework' is completed by the addition of the categories provided by Zimmerman for the primary factors Arts, Wants, Resistances, Economy and Culture. These categories were already presented in the previous section on the theory of Zimmerman. Due to the addition of these categories, the framework is now complete according to the theory of Zimmerman and the 'test Zimmerman framework' which will be validated in appendix III is created. These previous steps and the 'test Zimmerman framework' can be found in appendix II.

This complete framework will first be tested to determine whether the framework indeed presents the theory of Zimmerman. A brief operationalization of this framework will be performed by using Zimmerman's own theory on coal. The goal of this operationalization is to define if factors may have been overlooked in the previous steps that may be important to describe and understand the functionality and development of a substance as a Resource. Furthermore, from this operationalization it may appear that factors are not necessary for this description and may therefore be removed from the framework. The operationalization can be found in appendix III.

One note should be made. One factor has been added by the writer in this chapter, as the first attempt to modernize the framework. The reason that this is done in this chapter is that the added variable can be considered a modern factor in the human appraisal of resources, which is a variable introduced by Zimmerman. Adding of this variable in the chapter on institutions would not make sense since it is not an institutional factor, and the addition could be confusing in chapter five, where the final 'Modernized Zimmerman framework' is developed from the building blocks already present. Therefore this variable is added in this chapter as part of the Zimmerman variable "Human appraisal of resources". This added variable is the variable "Environmental feasibility", as this currently could be a factor considered important when judging the functionality of a substance as a resource. Today the environment feasibility or sustainability of an energy resource is an important factor for stakeholders, since people have become more aware of the effects of energy resources on the world and many want to limit the negative effects on the environment.

Summarizing, the steps taken to arrive at the final 'Zimmerman framework' are:

1. Development of a summary of the Zimmerman theory
2. Development of the initial causal relation diagram
3. Development of the simplified causal relation diagram
4. Identification of the most important variables
5. Construction of the initial Zimmerman framework
6. Completion of the Zimmerman framework by the categories from Zimmerman's theory provided in paragraph 3.2
7. Operationalization of the Zimmerman framework by means of Zimmerman's own theory on coal

These steps have led to the final Zimmerman framework, which is presented in figure 18. A better readable version of this framework can also be found in appendix VI.

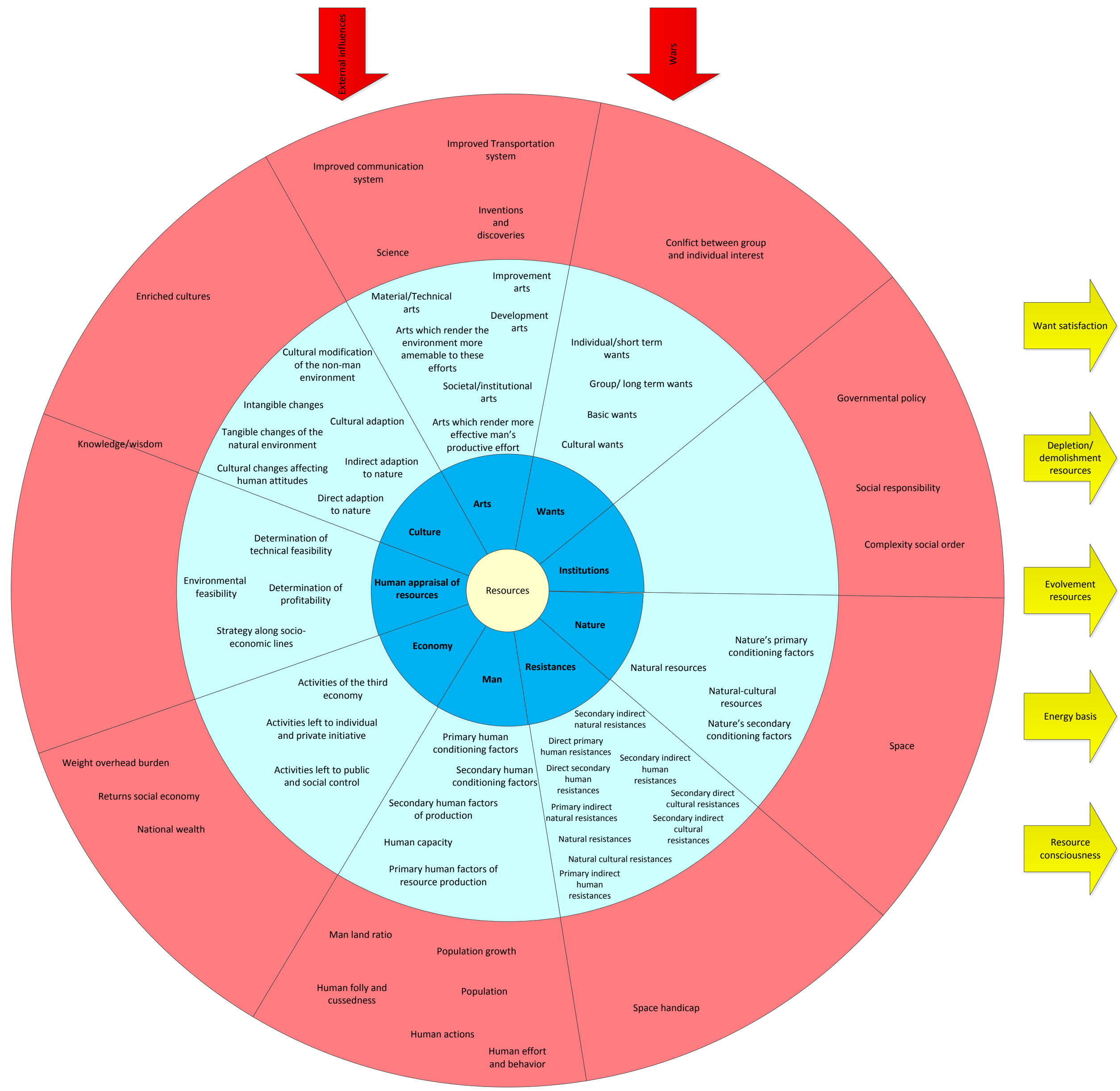


Figure 18 Operationalized Zimmerman framework

This framework is still quite extensive and too broad to describe the development and functionality of Resources. Though, it does present a complete view of the important variables according to Zimmerman, which was the goal of this framework. The improvements to narrow down this framework and make a more suitable framework in terms of usability will be done in chapter five, after the exploration of institutional theories in chapter four.

3.3.3 Explanation framework

Since this framework is developed in order to explain the functionality of a substance as a resource, the primary factor 'Resources' is placed in the middle of the first ring of the framework. All the other factors in the framework are of either of influence on this factor or are influenced by this factor.

The remaining primary factors are placed in the first ring, except for the factor 'External influences'. This factor and the factor 'War' are presented as incoming arrows in the framework. These incoming arrows represent external factors which are of influence on the development and functionality of a substance as a resource. These external factors may be of direct influence on the factor Resources, or indirect when for instance war affects the Wants of Man.

The variables categorized under the primary factors are placed in the two rings around the primary factors. The second ring contains those factors that are more specified versions of the primary factors, also referred to as the sub-factors. The factors located in the third ring are effects, products or influences of the primary factors.

The outgoing arrows present the possible effects of the interaction of the Primary factors. First, Wants can be satisfied if substances can function as a resource. Second, resources may either evolve or be destroyed due to the interaction of the primary factors. Third, certain actions and developments may lead to resource consciousness. Finally, the substances that function as resource in a specific society determine the energy basis of that society.

After the development of this framework, Zimmerman's theory was acknowledged again, in order to check if the framework indeed provides an abstract overview of Zimmerman's theory and if the variables chosen are indeed the variables which contribute to the fact whether a substance can be developed and function as a resource. As can been seen, in the presentation of the theory in paragraph 3.1, the factors in the inner circle are indeed the most important building blocks of the Zimmerman's theory.

3.3 Insights 'Zimmerman framework'

In this paragraph a summary of the main insights developed in this chapter is provided. These insights will, next to the 'Zimmerman framework', be considered and used for the development of the 'Modernized Zimmerman framework'.

- If substances can be developed and function as resources is dependent on the following factors:
    1. Arts
    2. Wants
    3. Nature
    4. Man
    5. Resistances
    6. Culture
    7. Institutions
    8. Economy
- Man has both Wants as Native physical and brain power
- Nature provides substances which can become resources (if the Natural resistances are overcome)
- Man uses his native brain power and physical power to create Arts and overcome Resistances.
- By overcoming resistances Man converts Neutral stuff into resources.
- If a substance is able to satisfy a Want, the substance functions as a Resource.

- Often the Wants of individuals and groups do not of complement but clash
- Resources are dynamic and can be created by Man as well be depleted and demolished
- War and other external influences are of influence on the functionality of substances as resources.
- Culture is the result of adaptions and alterations done by man to be able to make use of his environment and associated resources.
- The type of economy present in a country and how the activities in the third economy are regulated is of influence on way resources are used
- The role an individual has in a certain situation is of influence on his appraisal of resources
- If a substance can function as a resource is amongst other influenced by institutions and policies
- Societal institutions are examples of indirect adaptions, are influenced by Culture and present cultural patterns.
- Societal institutions can considered as adaptions to the environment, however the cause of the adaption is often unknown.
- Institutions are of influence on the functionality of a resource
- Governments can be seen as the tool to repair and make machinery suitable for its task.
- Arts are of influence on the development institutions; however institutions are also of influence on Arts.
- The human appraisal of Resources depends according to Zimmerman on the current state of Wants, the current state of Arts, the current facts of nature and culture, the technical feasibility, the profitability of resources and the way the resource fits into the socio-economic strategy. The writer has added the judgment factor Environmental feasibility.
- If all the judgment criteria of the human appraisal are rated as positive for a resource, the substance is able to function as a resource according to human beings
- The resources used in a country form the energy basis of that country

3.4 Discussion theory Zimmerman

Erich Zimmerman developed his theory in 1951 and was far ahead of his time. In his book he discusses the potential for energy sources such as wind and solar for space heating, while these energy sources were not used in those days as they are today. Furthermore, he shows that our static maps with reserves of the world are actually useless, since resources are dynamic. These maps should be adjusted to every change in the world that influences the functionality of the specific substance. In addition, he provides a different view than regular economic theories on resource development that take the view that a resource can be derived from the ground when production costs are lower than the turn-over and if a demand for the substance is present in the market. According to Zimmerman there are also other aspects which determine if substance will function as a resource in our society than just the profitability and demand for a substance. Herewith he provides a broader view and understanding on what resources are, how they evolve and diminish and how resistances concerning the usage of resources evolve.

Improvements in the field of institutions

That been said, some points of his theory leave room for improvement using the knowledge we have today. As can also be seen in the summary of the insights, Zimmerman is not very specific on the function on and content of institutions. The knowledge and frameworks available today on institutions could therefore provide significant improvements to complete his theory and improve the terms he uses for the institutional variables.

First, where Zimmerman's theory is unstructured with multiple terms for the same variables, modern institutionalists have developed comprehensive terms to describe institutional aspects. Zimmerman for example reasons about, rules and regulations and governmental policies, while using the knowledge of today, these variables can be categorized under the modern term 'Formal institutions'.

Second, Zimmerman is somewhat vague on the different types of institutions and their roles. He reasons about Societal institutions and Material and Non-material institutions. Furthermore he provides Government policy often as a part of the Societal institutions. The way he uses these different terms makes it complicated to understand what is exactly meant by these terms. In addition one can wonder if Zimmerman himself knew exactly what elements would be gathered under these terms. Therefore the usage of these terms is challenging, since it is hard to understand which elements they comprise. For this reason, it would improve the framework to use the modern terms for the different types of institutions instead of the complex and vague terms of Zimmerman.

Third, the variables which can be grouped under the primary factor institutions in his theory do not cover the content of institutions as we them know today. The terms which are used today comprehend more than just governmental policy and rules and regulations. It also covers contracts, gentlemen agreements and other aspects which determine how 'the game is played'. Also, institutions of today have a strong influence on the transaction costs between actors, which is an economic aspect. The effect of institutions on transactions costs is something which is not considered by Zimmerman.

Finally, Zimmerman does not explicitly state the relations between these different aspects of institutions. With the knowledge of today it is understood that there are relations. The integration of these relations would also improve the framework, since it can then be understood how the institutions are related to another and to the other factors.

The exact improvements possible in the field on institutions are derived in the next chapter.

Other improvements

Furthermore, there are some other aspects in Zimmerman's theory, which could be improved. First of all, the world is not the same as in 1951. Other resistances appear today, than those that were present in 1951. The world has changed, and so have the factors from which these resistances evolve. Furthermore, Zimmerman does not address the resistances that may appear after the improvements to extract the resource have been done. Today, the human appraisal of a resource will not be directly positive anymore if a resource is just economically and technical feasible and congruent with the strategy of our government. It has to fit in our institutional system and has, at least to a certain extent, to be congruent with the norms and values of the stakeholders involved to attain a level of public acceptance. Today the environmental feasibility is also an important aspect in the appraisal of a substance in its functionality as a resource. The way of exploration and the way in which the substance is used, has to have an acceptable environmental impact. When this environmental impact is considered unacceptable by the stakeholders, the appraisal or judgment on the resource will be negative. When the appraisal of resources is negative, a lack of public acceptance can be expected, since the resource is not able to score positive on all judgment factors. The substance can that still function as a resource, however not all stakeholders accept the substance in its role as resource since it does not meet all judgment criteria according to them. Also, when the (usage of the) substance is not congruent with our norms and values, a lack of public acceptance can be expected. The requirement of public acceptance is a current issue, which was not present in the days of Zimmerman.

Second, where Zimmerman does provide the link between Resistances, Arts and Resources, he does not finalize this circle. Where resistances are overcome and resources can be developed, effects of the developments of these resources will take place. If these effects are for example negative and create new Resistances, rules and regulations have to be developed in order regulate these effects and overcome these new resistances. This will lead to changes in the institutions, which again will lead to the changes in the Arts, since the technology has to meet the new requirements present in the institutions. However, Zimmerman is not very explicit on what happens from the moment the Resources are developed. He only states that resources are dependent on institutions, but not that these Resources will be of influence on the institutions again, which will again be of influence on the Arts associated with the resource. Therefore, he does not complete the dynamic relation between Resistances, Resources, Institutions and Arts. To complete the framework, this circle of relations should be closed.

Lack of structure

Due to the lack of structure, the previous steps to extract the core of Zimmerman's theory had to be taken. If these steps would not have been taken, it would be very hard to use Zimmerman's theory to provide an increased understanding in why resources develop as they do, why substances are able to function as resources and how resistances evolve.

This lack of structure can also be found in the fact that Zimmerman is not able to provide one framework of his theory; his diagrams supplement each other and then still do not provide the complete image according to Zimmerman himself. Moreover, he uses multiple terms that imply the same, which makes the line of his theory sometimes challenging to follow. In addition, these variables are not very comprehensive and clear which makes it necessary for Zimmerman to clarify these variables by means of even more variables. Furthermore, is theory is very complex, and one has to read a significant part of the book to get a feeling for his theory. Since, as beings said, Zimmerman is not able to provide a diagram which presents the (complete) core of his theory one is required to read the book in order to be able to do an analysis on the development and functionality of resources. However even with the book red, it may be hard to identify the core of his theory. The usage of a framework which represents the main elements of his book will provide more consistency for the analysis of the functionality of resource than the usage of a book; one may forget parts of the theory or different readers may interpret the content of the book in a different way which will lead to different analyses. Thus, since the theory is complex, unstructured, and extensive and presented in the form of a book, it is very hard to use his theory in a structured way and therefore the preceding steps to identify the core of Zimmerman's theory, which functions as the basis for the final framework, were necessary.

4. Institutions

4.1 What are institutions

Institutions play a major role in our everyday life. They provide structure to the way we react and behave and what we can expect from others (Ostrom, 2005). Due to these institutions we have knowledge of the do and don'ts in specific situations (Ostrom, 2005). According to Williamson, institutions set the rules of the game (Williamson, 1998). These rules may be written but they can also be unwritten, such as the rules how to behave in public. The difference between these written or formal rules and the unwritten or informal rules and their effects is explained by the following statement:

"Institutions are perfectly analogous to the rules of the game in a competitive team sport. That is, they consist of formal written rules as well as typically unwritten codes of conduct that underlie and supplement formal rules. The rules and informal codes are sometimes violated and punishment is enacted. Therefore, an essential part of the functioning of institutions is the costliness of ascertaining violations and the severity of the punishment" (North, 1990).

So, with this statement North poses that both formal and informal rules form the backbone of the game. Also, he states that the power of the rules depend on the punishment. Hence, both formal and informal rules pose some threat to the actors in the institution (Scott, n.d.). Yet, rules and regulations may also enable actors to perform actions by, for example, providing permits or by providing an incentive to innovate (Scott, n.d.).

Thus, institutions both pose the limits to behavior as the tools to pose behavior (Hodgson, 2006). Therefore, institutions define the *social infrastructure* of accepted behavior in a society (Hodgson, 2006)(Klijn & Koppenjan, 2006). The social infrastructure is a result of interaction processes between actors in order to find a solution to fulfill different stakes (Klijn & Koppenjan, 2006). It provides the guidelines how to handle interactions with other individuals (Ostrom, 2005). These institutions contain both fixed rules as well as agreements and norms and values (Klijn & Koppenjan, 2006) . Hodgson defines an institution as "*Systems of established and prevalent social rules that structure social interaction*" (Hodgson, 2006). He states that language, money, law, table manners and firms are all examples of institutions (Hodgson, 2006).

Hence, institutions provide a framework for participants how to behave in certain situations and what to expect from others (Ostrom, 2005). Next to this framework, institutions provide the cognitive framework, which is necessary for individuals in order to make sense of the information provided to them and to be able to develop behavior (Hodgson, 2005). This cognitive framework can be seen as the mental model of the environment and is of strong influence on the behavior individuals pose (Scott, n.d.). Since individuals will only understand the information provided to them when they have knowledge about the context in which the information is provided to them, this cognitive frame is necessary for individuals to understand the world (Hodgson, 2005).

So, in order to understand and explain behavior and actions, one should not only look at the environment, but also at the cognitive frame of the individual (Scott, n.d.). This cognitive frame will determine how information will be processed, how it will be interpreted and therefore how it will be evaluated, how it will be judged and which actions will follow (Scott, n.d.). This explains why individuals from a different culture may react different in the same situation; it depends on how they appraise the information according to their cognitive frame.

Culture provides models, shared by collective actors, to serve as an input for their cognitive framework. When individuals comply to the prevailing culture, they will feel confident and connected (Scott, n.d.). When they do not comply with the ruling culture, they may feel disoriented, insecure and be different than the group because of their beliefs (Scott, n.d.).

It may vary how institutionalized culture is (Scott, n.d.). When a culture is very institutionalized, it has many links with other elements in the institutions and it is embodied in routines (Scott, n.d.). Often it seems that cultures are unitary systems, however this does not have to be true (Scott, n.d.). Not all individuals have to share the same beliefs and understandings (Scott, n.d.). This could lead to conflicting ideas of what is happening and what should be done (Scott, n.d.).

4.2 Why are institutions important

If institutions would not exist, it would be impossible to accomplish the same behavior over multiple individuals (Klijn & Koppenjan, 2006). This would make it extremely difficult to solve problems that require the same or complementary actions from multiple individuals (Klijn & Koppenjan, 2006). By means of institutions behavior is steered by the rules and regulations, and practices are authorized by powers; behavior is predictable and power relations are clear (Scott, n.d.) Hence institutions bring stability and predictability (Goodin, 1996).

By the use of "nested rules" the institution provides economic benefits (North, 1990). Due to the predictability and clearness, uncertainty and its associated transaction cost costs are avoided (North, 1990)(Goodin, 1996). If these institutions would not be present it would be completely unclear what actors can expect from each other, which would lead to tremendous transaction costs (Klijn & Koppenjan, 2006). Furthermore, the clearness of expectancies and rules improves the cooperation of participants (Klijn & Koppenjan, 2006).

Since institutions pose the rules of the game and provide stability and predictability, institutions also provide continuity in the behavior of people over time. According to North: "*The major role of institutions in society is to reduce uncertainty by establishing a stable (but not necessarily efficient) structure to human interaction*"(North, 1990).

Thus, institutions enable interactions between actors in an institution, provide guidelines for behavior, provide stability and predictability and lower transactions costs (Klijn & Koppenjan, 2006). Institutions are useful to maintain a course for several years to accomplish something, since they are not easy to change and are often path dependent. However, this may also provide some downsides. Due to the embeddedness of rules, norms and values and other institutional properties, institutions may be challenging to adjust to a new development or situation. Therefore, solid institutions could slow down new developments in its arena.

4.3 Change of institutions

Even though institutions are not static, changes often develop very slow (Koppenjan & Groenewegen, 2005). Sometimes so slow, that the actors involved may not notice these changes (Koppenjan & Groenewegen, 2005). Due to this stability and predictability institutions bring increased strategic certainty and therefore reduce transaction costs (Koppenjan & Groenewegen, 2005). Groenewegen and Koppenjan present three reasons why institutions do not change easily:

1. Institutions have been developed incrementally and show the historical lessons and experiences of several parties and the rules which have established from this. They have established due to real situations, are embedded and have proved to function during time.
2. Attempts to change institutions often fail, since actors who initiate the attempt do not have the power to influence other levels than the levels they are located in.
3. Institutions are established in an environment in which not one party has made the decision but the decision has arrived from a negotiation process of several parties (Koppenjan & Groenewegen, 2005)

However, since institutions present the rules of the game, and these rules often determine who will win, and who will lose, actors often attempt to change these institutions (Groenewegen & Lemstra, 2007). Therefore the institutional (re)design is often the stage for conflicts between actors who have different interests (Groenewegen & Lemstra, 2007). Goodin states that this intentional intervention is one of the main reasons why institutions change (Goodin, 1996). The other two options are that change might happen accidently and that change may occur due to evolution (Goodin, 1996). Goodin also states that if institutions change, it is very likely to involve a combination of these three elements (Goodin, 1996).

Path dependency and lock in

Since, individuals in an institution often share the same habits, routines, beliefs, and therefore mental models, institutional change can be seen as path dependent (Groenewegen & Lemstra, 2007). The robustness, related to this path dependency, is considered an important characteristic of institutions. An institution should be able to adapt to new situations (Goodin, 1996). To be able to provide stability and continuity, the institution cannot be destroyed or severely damaged after a change in conditions (Goodin, 1996).

The first reason why institutions are hard to change, concerns the adaption of individuals and organizations (Pierson, 2000). These adaptions make it costly to exit the existing framework of informal and formal rules (Pierson, 2000). Individuals and organization may create arrangements to obey the institutional framework. Therefore these rules are embedded in the social structure and changes will have major consequences (Pierson, 2000). Therefore the previous decisions are locked in (Pierson, 2000).

The second reason why lock in and path dependence in institutions may occur are the costs which are concerned with the development of for example new technologies (Pierson, 2000). These cost give individuals and organizations a strong incentive to stick with former decisions (Pierson, 2000).

The final reason is that formal political institutions are usually hard to change. According to Pierson there are two main reasons for this. The first reason involves the restriction of the designer himself (Pierson, 2000). Literature has showed that individuals often do better if they have a limited set of options (Pierson, 2000). The second reason involves the binding of successors. Institutions have the capacity to bind actors to a certain course of action, which might be desirable at that moment (Goodin, 1996). When designing a political institution, one should keep in mind that one day his opponent may come to power (Pierson, 2000). By making institutions change resistant, successors are required to follow the chosen course of action (Goodin, 1996; Pierson, 2000). Therefore the institution is made path dependent (Pierson, 2000).

However, it is also important that institutions are able to adapt to a new situation in an appropriate way (Goodin, 1996). Therefore, reversibility of institutions may also be an important aspect in institutional design. Though the extent to which an institution is reversible should be well considered, since it may reduce the functions of institutions related to stability and predictability (Goodin, 1996). Hence, reversibility and robustness are properties of institutions which are both crucial, but which should be carefully balanced when institutions are designed.

4.4 Elements institutions

1.4.1 Theories and frameworks

In order to create an understanding of the elements which institutions comprise, the four layered model of Williamson is used. The reason for the usage of this four layered model, is that the model provides a structured and comprehensive view of the different institutional elements. Williamson uses comprehensive and abstract terms for the different types of institutions. These comprehensive terms could replace the multiple institutional terms Zimmerman uses to describe the same elements as Williamson does. Therefore the usage of these comprehensive terms of Williamson would make the 'Zimmerman framework' simpler, more comprehensive and abstracter, while not decreasing the amount of information it presents. Furthermore, the interrelations between the different layers of the four layered model, present that the elements in the model are interrelated and not static. Therefore, the usage of this model, which presents the relations between the institutional elements, increases the understanding of the different institutional elements and their dynamics and can be beneficial to create a 'Modernized Zimmerman framework' which is comprehensive, abstract and dynamic.

Also, the adjusted version of the four layered model of Williamson will be consulted. This model is developed by Groenewegen and Koppenjan to analyze complex technical systems. Their model is used to understand and design the different institutional elements around a technical system. It provides an increased understanding on how the technical system and institutional system are related and that the functionality of these systems can be improved if these systems are well adjusted to each other. Since, the 'Zimmerman framework' is developed to analyze if a substance can be developed and function as resource, the subject of this analysis will often include a technical system aimed to achieve the substance and make it useable for Man. Therefore an increased understanding of the effects of the several institutional elements on the technical system will be beneficial to improve the 'Zimmerman framework'. Also, the model of Koppenjan and Groenewegen provides additional relations between the levels of the four layered model, which makes their model more dynamic than the model of Williamson. This information can be beneficial for the creation of the final framework in which the dynamics between the several institutional elements and the technical system will be provided.

So, from these two theories and models, the elements will be extracted which can be used to develop an improved comprehensive, structured and abstract version of the 'Zimmerman framework'. First, the model of Williamson is discussed, where after the model of Koppenjan and Groenewegen is considered.

1.4.1.1. Williamson

The approach of Williamson is based on institutional economics. According to Williamson, new institutional economics can be divided in two parts (Williamson, 1998). The first part considers *the institutional environment* (Williamson, 1998). This institutional environment relates to rules of the game. The second part includes the institutions of governance; how the game is being played (Williamson, 1998). Furthermore, he divides the economics of institutions into four levels.

These levels are:

1. **The level of embeddedness**: informal institutions, customs, traditions, norms, religion
2. **The level of the institutional environment**: formal rules of the game-esp. property (polity, judiciary, bureaucracy)
3. **The level of governance**: Play of the game-contract (aligning governance structures with transactions)
4. **The level of Resource allocation and employment** (price and quantities; incentive alignment) (Williamson, 1998)

The closed arrows in the model indicate that the higher institutional level create limitations or restrictions for the level underneath (Williamson, 1998). The dashed arrows, which connect the lower levels to the higher levels indicate the feedback provided from the lower levels to the higher levels (Williamson, 1998).

The four layered model of Williamson is presented in figure 19.

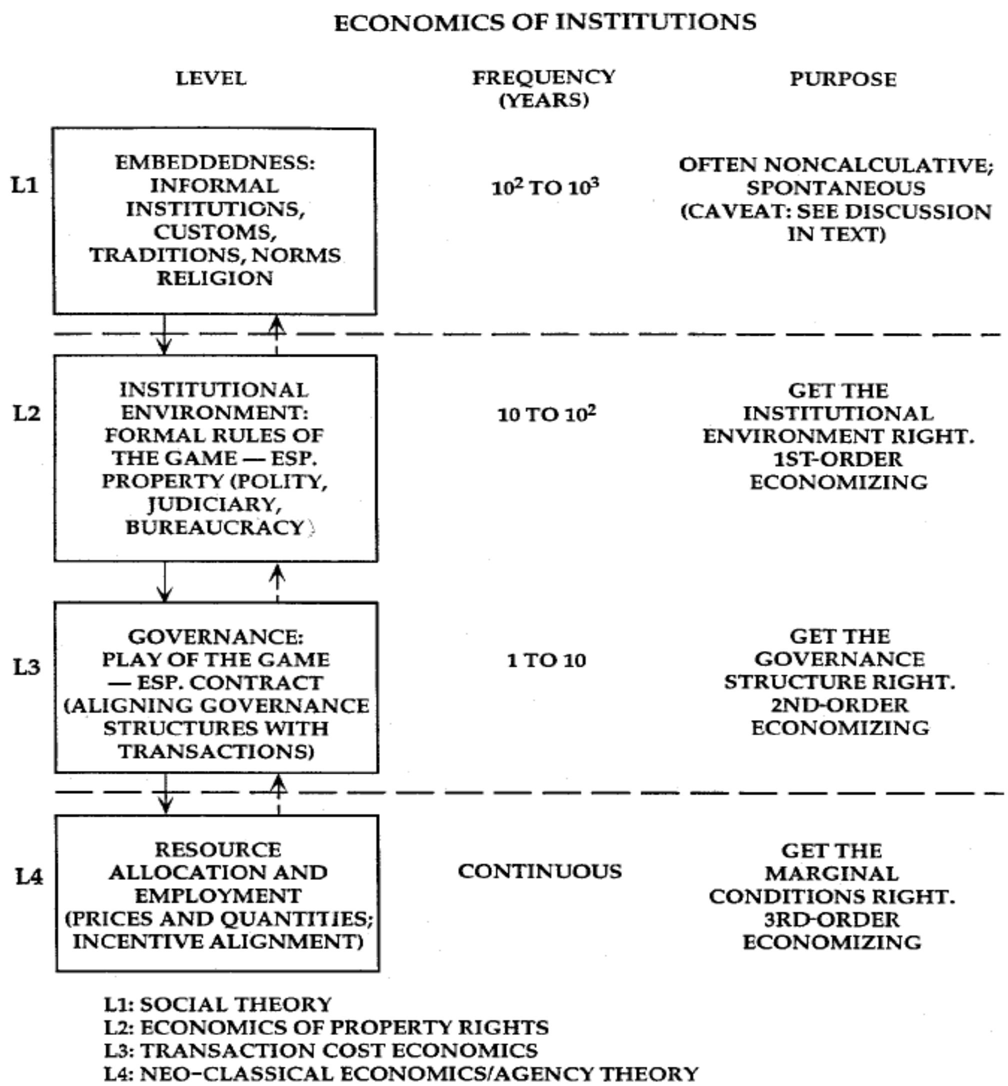


Figure 19 Four layered model Williamson ((Williamson, 1998)

Level one

The first level imposes the customs, norms, values, traditions and religions of a society (Williamson, 1998). According to Scott a value is "*A conception of the preferred or the desirable, together with the construction of standards to which existing structures of behaviors can be compared and assessed*" (Scott, n.d.). About norms Scott states: "*Norms specify how things should be done; they define legitimate means to pursue value ends*" (Scott, n.d.) Which norms and values apply to which actor in the systems, depends on the role the actor fulfills. These roles may be formal and constructed, such as roles in an organization (Scott, n.d.). Though, these roles may also be informal and emerge over time, such as the roles in a family (Scott, n.d.). The expectations which come with the different roles form guidance for the behavior (Scott, n.d.). When norms are violated, actors feel ashamed and bad about themselves (Scott, n.d.). When actors pose behavior which deserves honor, respect or admiration, they will be proud and happy (Scott, n.d.). An important difference between norms and values and rules and regulations is that actors monitor themselves, by self-evaluation of their behavior, if they are following the norms and values and also provide their own ‘Punishment’(Scott, n.d.). The normative theorists emphasize that norms and values form “ *The primary basis of the stable social order*” and have a stabilizing function (Scott, n.d.) Because of these characteristics of the informal institutions, the speed of change in this level is very low (Williamson, 1998). Some economists, consider the elements in this level therefore as given facts which cannot be changed (Williamson, 1998) Therefore, this level has a significant influence on the possibility to change institutions.

Level two

The second level presents the institutional environment or the formal rules of the game (Williamson, 1998). These are the formal rules, which can be found in laws, contracts and regulations (Williamson, 1998). These formal rules are the output of politics and negotiations and form the rules by which the game is played and how *the economic activity is organized* (Williamson, 1998).

Level three

Level three deals with “The play of the game” (Williamson, 1998). The governance structures, such as markets and firms, are located here. The game concerning economics of transaction costs is played in level three in compliance with the rules of level two (Williamson, 1998).

Level four

In level four the neo-classical economics and agency theories are present (Williamson, 1998). In the neoclassical theory the assumption is made that individuals make rational decisions based on the usefulness of a products and the benefits it will bring, the prices they want to pay for it, what the demand is and what the output is they require for this utility (Ghorbani, Ligtvoet, Nikolic, & Dijkema, n.d.). The aim of the individual is to acquire a product in marginal conditions (Ghorbani et al., n.d.). In response to changing market conditions it is possible that the price and the output of the utility change (Ghorbani et al., n.d.). In this level also the problems which can appear between a principal and an agent due to their different stakes and attitudes towards risks are located (Williamson, 1998). These problems are represented as the agency theory (Williamson, 1998).

1.4.1.2. Extension Groenewegen and Koppenjan

Groenewegen and Koppenjan use the four layered model of Williamson as a starting point for their own four layered model, developed to structure the steps in the process of an institutional design in *complex technological systems* (Koppenjan & Groenewegen, 2005). Groenewegen and Koppenjan have developed this model in order to improve the design of institutions. Even though there is a lot of data on institutions, how these institutions work and are associated with technology, there is significant less information available on the systematic approach of designing institutions for complex technical systems. Even though, this research is not aimed at the design of institutions around resources, the model of Koppenjan and Groenewegen may improve the understanding on the different institutional elements and their interrelations. Another difference between the two models is that Williamson has not taken the technical system into account, while Koppenjan en Groenewegen have included this element in their model. Therefore the model of Koppenjan en Groenewegen is more suitable for the assessment of the development and functionality of a resource such as shale gas, for which a technical system is required to attain and use it. However, since the model of Koppenjan and Groenewegen is based on Williamson, the basis of the models is the same.

A complex technical system

A technical complex system, such as an energy network, needs next to the technical design an institutional system which regulates the behavior and relations and positions of actors involved (Koppenjan & Groenewegen, 2005). According to Koppenjan and Groenewegen a complex technical system contains the following characteristics:

1. *The technical component is unruly.* This means that even though the technology is of significant importance, it does not determine how the total system will operate and work.
2. There are multiple actors involved. Many times these actors are present in the same organization.
3. Most of the time both public and private parties are involved and both public and private interest are at stake.
4. The system can both be influenced by market forces as by governmental regulation (Koppenjan & Groenewegen, 2005).

The development of a substance, such as shale gas, as a resource, can be considered as a complex technological system since all characteristics of complex technical system are present. First, the technical components such as drilling and hydraulic fracturing are important, though the way the operators and governments handle these technologies and if these technologies are used in the best way defines the impact of the technology on the total system and not the technology itself. Second, there are multiple actors involved such as operators, owners of gas fields, local governments, the federal government and the environmental protection agency. Third, both public and private parties are involved and there are public as well as private interests at stake. For instance, the government aims to keep his citizens safe, while it also aims at generating the economic benefits associated with shale gas. Fourth, the shale gas system is both influenced by the market price of natural gas, as by the regulations set by the government. For all these categories, more examples can be found. However this short list of examples already shows that the shale gas case (in the U.S.) can be considered a complex technical system.

The technical system needs *rules of the game*. These rules may be formal rules, such as laws, or informal rules such as norms and values (Koppenjan & Groenewegen, 2005). Furthermore, these rules may either be of public or private form (Koppenjan & Groenewegen, 2005). The total of these informal, formal, private and public rules form the institutions which are necessary to have the technical system operate effectively and efficient (Koppenjan & Groenewegen, 2005). However, it should be considered that an agreement or set of rules only counts as an institution when it is agreed to by the actors involved (Groenewegen & Lemstra, 2007).

In a complex technical system, multiple actors are involved, which all aim for their own benefits. This could lead to strategic uncertainty for the actors involved. Actors bring knowledge, money and time to the game in order to reach their goals (Koppenjan & Groenewegen, 2005). However, if they have to cooperate to achieve a certain goal, uncertainty may be created if the other parties will keep their agreements. This uncertainty brings both risks of being harmed by behavior of other parties and costs

(Koppenjan & Groenewegen, 2005). These costs fall under political costs for compromises and transaction costs for the interaction between parties (Koppenjan & Groenewegen, 2005). An institutional system provides transparency of what is demanded from the different actors and what they can expect (Koppenjan & Groenewegen, 2005). Furthermore it provides clarity of what the possible sanctions for certain actions will be (Koppenjan & Groenewegen, 2005). The institutional system will reduce the risks of participation. Moreover, it will reduce the transaction costs of finding the right information as well as of negotiation processes (Koppenjan & Groenewegen, 2005)

So in order to have the technical system functioning, the institutional system should also function in an effective way (Koppenjan & Groenewegen, 2005). This institutional design, will not be determined by the technical system, however the characteristics of the technical system will be of strong influence on the institutional design (Koppenjan & Groenewegen, 2005). How this process can be handled, is further described in the paper of Koppenjan and Groenewegen, though will not be further explored here, since the aim of this research is not to design institutions but to develop a framework in which the role of institutions is considered. Therefore, the understanding of relation between the technical system and the institutions will be relevant.

Four layered model of Koppenjan en Groenewegen

The four layered model of Groenewegen and Koppenjan provides four levels of institutional analysis for the functionality of the *complex technical system* (Koppenjan & Groenewegen, 2005). The model is based on the four layered model of Williamson but differs from the model of Williamson in two aspects (Koppenjan & Groenewegen, 2005). To start, where in the model of Williamson level one included the neoclassical economy and agency theory, level one in the four layered model of Groenewegen and Koppenjan includes <u>all</u> the actions of individual actors, so also strategies and games aimed influencing outcomes (Koppenjan & Groenewegen, 2005). Secondly, in the model of Groenewegen and Koppenjan interaction between the different levels is possible (Koppenjan & Groenewegen, 2005). The four layered model of Koppenjan and Groenewegen in provided in figure 20.

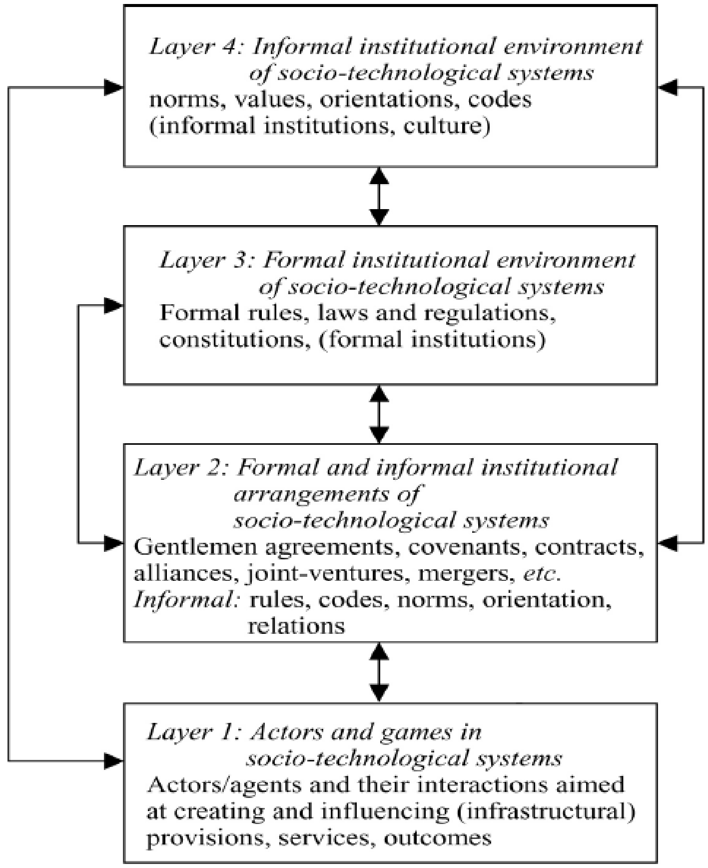


Figure 20 Four layered model Groenewegen and Koppenjan (Koppenjan & Groenewegen, 2005)

The first layer in the four layered model presents *the individual actors and their interactions in the context of a complex technological system* (Koppenjan & Groenewegen, 2005). These individual agents are for example firms or households (Koppenjan & Groenewegen, 2005) . The internal structure between these individual agents regulates the transaction done in this level (Koppenjan & Groenewegen, 2005). The second layer presents the institutional arrangements, which regulate the transactions between the different actors (Koppenjan & Groenewegen, 2005). Examples are joint ventures, contracts and vertically integrated hierarchies (Koppenjan & Groenewegen, 2005). The third levels provides the formal rules of the game, such as the law (Koppenjan & Groenewegen, 2005). Finally, the fourth layer presents the informal institutions such as culture, values, norms and attitudes (Koppenjan & Groenewegen, 2005).

Thus, a distinction in the four layered model of Koppenjan and Groenewegen is made between different kind of institutions and the actors involved. This is an important step in understanding how these institutions can be influenced (Koppenjan & Groenewegen, 2005). Furthermore, the relations between the different institutions are extended in this model. All the levels in the framework are of influence on all the levels in the framework, which is different compared to the model of Williamson where only relations were present between the levels directly above or below each other. Again, the higher level forms and limits the lower level, but the lower level has effect on the development of the higher level (Koppenjan & Groenewegen, 2005). This explains, that institutions are not static and independent, they are influenced by other layers of institutions and their surrounding conditions (Koppenjan & Groenewegen, 2005). Furthermore, since the lower institutions are constrained and shaped by the higher ones, the institutions should be compatible (Koppenjan & Groenewegen, 2005). This leads to the understanding, that one institution cannot be changed without changing the other layers (Koppenjan & Groenewegen, 2005). In order to maintain stable institutions, which can function in the aimed way, the levels have to be congruent (Koppenjan & Groenewegen, 2005). Due to the fact that these institutions are integrated in higher institutions, they can often only be changed by incremental change and are on average hard to influence (Koppenjan & Groenewegen, 2005).

4.5 Relevant information for the "Modernized Zimmerman framework"

4.5.1 Modern theories compared with Zimmerman's theory

In this chapter the modern institutional theories have been explored. Where Zimmerman understands that there are different forms of institutions and that these institutions are influenced by adaptions done to the environment, such as culture, he is not very explicit on the different types of institutions and their content. Also he does not provide argumentation how these institutions exactly evolve and how these are related. Furthermore, he acknowledges that institutions are hard to change, however the answer that he provides, that this because institutional arts are hard to verify, is not one of the reasons as defined in the modern theories. In addition, he is not that explicit as the modern theorist on the role of institutions, both economic and social. Also, even though he acknowledges that Institutions and Arts are of influence on another, he does not consider the necessity of the adjustment of the technical and institutional system to each other in order to have both systems function efficient and effectively. Finally, the fact that institutions can become unstable if these are not congruent with another, is something which is not considered in Zimmerman's theory. That being said, these modern institutional theories have been developed many years after Zimmerman's theory. As stated in Zimmerman's theory that new inventions are often based on the previous inventions, this is also the case for institutional theories. The theory of Groenewegen and Koppenjan was founded on the theory of Williamson, which was again founded on other theories, such as the theory on neoclassical economics and the agency theory. Zimmerman's theory may have formed the foundation for many other institutional theories, and is therefore still important to understand. However, as acknowledged, the framework based on his theory can be improved with the insights attained with these modern institutional theories. These insights are presented below.

4.5.2 Insights to be used in the 'Modernized Zimmerman framework'

The information provided in this chapter will be used to develop a complete, comprehensive and abstract framework to analyze the development and functionality of resources. The insights which are obtained in this chapter and which will be integrated in the 'Modernized Zimmerman framework' are:

- Institutions can be divided in four levels which are:
    - Informal institutions
    - Formal institutions
    - Institutional arrangements
    - Individual actors

- These levels are of influence on each other
- The higher levels pose restrictions towards the lower levels in the four layered model
- The lower level provides feedback for the higher level in the four layered model
- Institutions are hard to change due to the interaction between these levels
- Institutions are hard to change, because actors often appear in another level than the level they want to change
- Informal institutions may also be considered as conditions, since it takes a very long period to change these institutions
- The different levels of institutions have to be congruent in order to maintain stable
- Institutions have the function to provide stability and predictability in society
- In order to have the technical system function in an optimal way, the institutional system should be well adjusted to this system

All these insights will be used to develop the 'Modernized Zimmerman framework'; however three things in particular will be considered. The four levels of the four layered model will be used as more comprehensive and abstract terms which can replace the multiple and vague terms of Zimmerman. Furthermore, the relations between these institutional levels or elements will be used to understand the dynamics between these elements or levels. These relations will also be used to create dynamics in the 'Modernized Zimmerman framework'. Also, the understanding that the technical and institutional system should be well adjusted to another will be used to understand and present the relation between the technical and institutional system in the final framework.

The development of the 'Modernized Zimmerman framework' is presented in the next chapter.

5. Development of the final framework

In this chapter the process to develop the final framework is provided. This 'Modernized Zimmerman framework' is based the information extracted in the preceding chapters.

5.1 The Building blocks

In order to construct a framework which is complete, dynamic and provides guidance on the direction and content of the relations between the factors, the information collected in the previous chapters will serve as the building blocks for this framework. These building blocks are the 'Zimmerman framework,' the theory and diagrams provided by Zimmerman and the insights on institutions summarized in paragraph 4.5.2.

The Zimmerman framework

The 'Zimmerman framework' developed in chapter three, provides a complete view on the variables which are important according to Zimmerman. However, the framework does not provide guidance on the direction of the relations between the different factors. Furthermore, it does not provide content to these relations. In addition, the dynamics between the different factors are not clear. Moreover, the framework could be improved when it comes to the abstractness and comprehensiveness of the terms used as well as concerning the institutional elements.

The Zimmerman diagrams

Zimmerman provides two diagrams, presented in figure 5 and figure 11. The 'Resources and their appraisal' diagram, presented in figure 5, provides a simple overview on the development of resources. It is a dynamic diagram which presents how the different factors are interrelated and provides guidance on the direction of the relations as well as on the content of these relations. Since, it was acknowledged that the 'Zimmerman framework' lacks guidance on the direction and content of the relations between the (primary) variables and since the framework is not dynamic, the Zimmerman rectangle is used as the basis for the 'Modernized Zimmerman framework'.

Though, since the Zimmerman rectangle is not complete, the variables which are missing have to be integrated in this framework. That this rectangle is incomplete is stated by Zimmerman himself and follows from the fact that not all the primary variables of the 'Zimmerman framework' are present in this diagram. The variables which were not present in the rectangle, though which are identified as primary variables, and therefore important variables, in the 'Zimmerman framework' are the variables 'Institutions',' Economy', 'Culture', 'Arts' and 'Human appraisal'. However, since the rectangle presents the development of resources which are appraised by Man on their functionality, the factor "Human appraisal" is present in this diagram, though not in a factor.

The other diagram provided by Zimmerman in figure 11, is also useful to understand the role of the different factors. However, this diagram is also not considered complete, since it lacks the variables 'Institutions', 'Economy' and 'Human appraisal'. This framework will not be used for the development of the 'Modernized Zimmerman framework'. This because the shape of this diagram has to be completely changed in order to integrate the remaining factors. The integration of the remaining factors will be easier for a form such as the diagram in figure 5. Furthermore, this framework focusses mainly on the effect of culture on resources, while the final framework should have an equal focus on all the factors that enable a substance to become a resource. Also, the diagram does not add content to all the relations between the different factors. Therefore, even though the diagram helps to improve the understanding on the relations between the presented factors, the diagram is not suitable to aid in the construction of the final framework, and will therefore not be considered anymore.

Institutional insights

The insights provided in chapter four will be used to develop a framework which contains today's knowledge on institutions. The 'Modernized Zimmerman framework' will be completed with the insights on the different types or levels of institutions, the relations between these different types or levels of institutions and the relations between the institutions and the technical system. Furthermore, these insights will be used to develop more comprehensive, abstract and modern terms for the framework.

5.2 Development' Modernized Zimmerman framework'

The first step towards the' Modernized Zimmerman framework', considers the improvement of the 'Zimmerman framework' with the modern institutional theories provided in chapter four. The reason that these institutional elements are first integrated in the 'Institutionalized and Modernized Zimmerman framework' is to provide a framework which presents all the (primary) variables and their correct names, which will be integrated in the 'Modernized Zimmerman framework'. Hereafter this complete and improved 'Institutionalized and Modernized framework' is transformed into a more dynamic framework based on the form of figure 5, in which the insights on the relations and dynamics between the factors are also integrated.

Integration four layered model

First, the four layers of the four layered model are integrated in the 'Zimmerman framework'. This will provide a framework which is complete, also considering the institutional elements. The institutional levels to be integrated are:

- Informal institutions
- Formal institutions
- Institutional arrangements
- Individual actors

The integration of these institutional elements leads to four changes of the 'Zimmerman framework'.

First, the primary variable Culture can be considered to be a part of the informal institutions. This variable represents the values and norms, habits and routines and other unwritten rules in a country. Therefore, the primary variable culture will be replaced for the more comprehensive variable "Informal institutions". The decision to place Culture under the variable "Informal institutions" is also underlined by Groenewegen and Koppenjan who state that culture belongs to the level of informal institutions (Koppenjan & Groenewegen, 2005).

Second, with the Informal institutions presented as a separate primary variable, only the formal institutions are left under the primary variable ‘Institutions’. Therefore the name of the primary variable ‘Institutions’ will be changed into ‘Formal institutions’.

Third, the variable institutional arrangements may be considered a sub-factor of the Formal and Informal institutions, since it considers the rules of the game, both formal and informal, such as governance contracts, rules, gentlemen agreements and codes. Therefore the sub factor institutional arrangement is placed in the second ring, both under the primary variable ‘Formal institutions’ and under the variable ‘Informal institutions’.

Fourth, the variable which is considered as level four in the model of Williamson and Groenewegen and Koppenjan, the “Decision of the individual actor” is placed under the primary variable economy. This because the individual decides what he wants for which price and what the total demand will be. Therefore, the individual forms a part of the economy and will be placed under this primary variable.

Arts becomes Technical system

Next, to the integration of the four levels of the four layered model, the name of the variable ‘Arts’ is changed into the name ‘Technical system’. The term technical system is a more modern and functional term for the system which is used to overcome resistance. Also, it is a term which easier to understand than the term Arts. Also, Groenewegen and Koppenjan refer to the technical system as the complex system of activities, which may for example create a substance out of a resource, and therefore fulfills the same role as Arts.

These changes lead to the ‘Institutionalized and modernized Zimmerman framework”, which is presented in figure 23. This framework is also presented in a readable version in appendix VI.

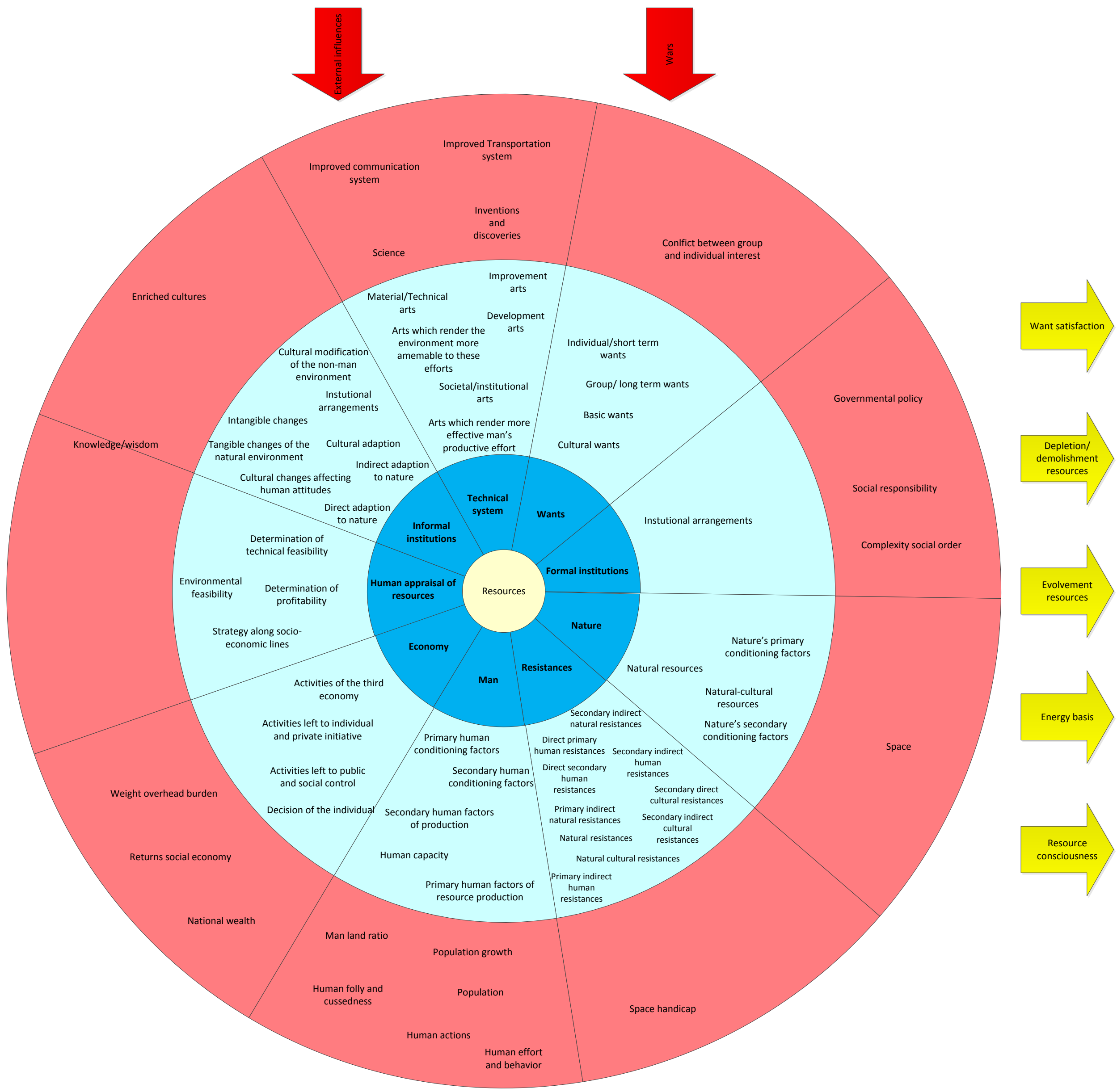


Figure 21 Institutionalized and modernized Zimmerman framework

From this framework, only the primary variables will be used to develop the 'Modernized Zimmerman framework'. The other variables would make the final framework too extended. Though, these secondary and tertiary variables may prove beneficial to provide guidance on which factors can be found under these Primary factors and what kind of information should be collected. Furthermore, these variables may pose a valuable input for further research.

One exception, towards the exclusion of secondary variables in this research is made and concerns the secondary factors of the primary factor 'Human appraisal'. The secondary factors of this primary factor are the judgment criteria for the human appraisal. The judgment criteria which have been determined are:

1 State of Wants
2 State of Arts
3 Knowledge of facts of nature and culture
4 Environmental feasibility
5 Profitability
6 Technical feasibility
7 Strategy along socio-economic lines

However, two adjustments will be made. Since the ‘State of Arts’ can be considered as the sum of skills and machines necessary to obtain and use a resource, or in other words, the Technical system to attain and use the resource, the name of this criterion should be changed into the ‘state of the Technical system’. Since the state of Technical system determines if the technical system is feasible to obtain and use the resource, the judgment criteria ‘State of the Technical system’ and ‘Technical feasibility’ would acquire the same information. For this reason, the judgment criterion ‘State of Arts/Technical system’ will be removed and only the criterion ‘Technical feasibility will be maintained. The second adjustment considers the criterion ‘Knowledge of fact of nature and culture’. Since, it can be considered that the decision to develop and use a substance as a resource also requires knowledge on the effects of, for instance, the Technical system and the Formal institutions, the criterion ‘Knowledge of facts of nature and culture’ is considered incomplete. This criterion should assess, if enough knowledge is present to make an informed decision on the development and usage of a substance as a resource in general. For this reason, the name of this criterion is changed into the more general name ‘Knowledge of facts’.

The judgment criteria for the Human appraisal of resources are not present in the final framework; however these should be used during the appraisal of the resource. For this reason, these secondary factors will be maintained for usage. However, they will not be provided in the framework, in order to keep the framework as simple as possible.

Thus, the factors that will be included in the final framework are:

1. Technical system
2. Wants
3. Formal institutions
4. Nature
5. Resistances
6. Man
7. Economy
8. Human appraisal of resources
9. Informal institutions

When these factors are integrated in the rectangle of Zimmerman, the following framework is developed. This framework is named the ‘Modernized Zimmerman framework’. The relations between the factors are based on the information provided in figure 5, Zimmerman’s theory, the theory on institutions and common sense.

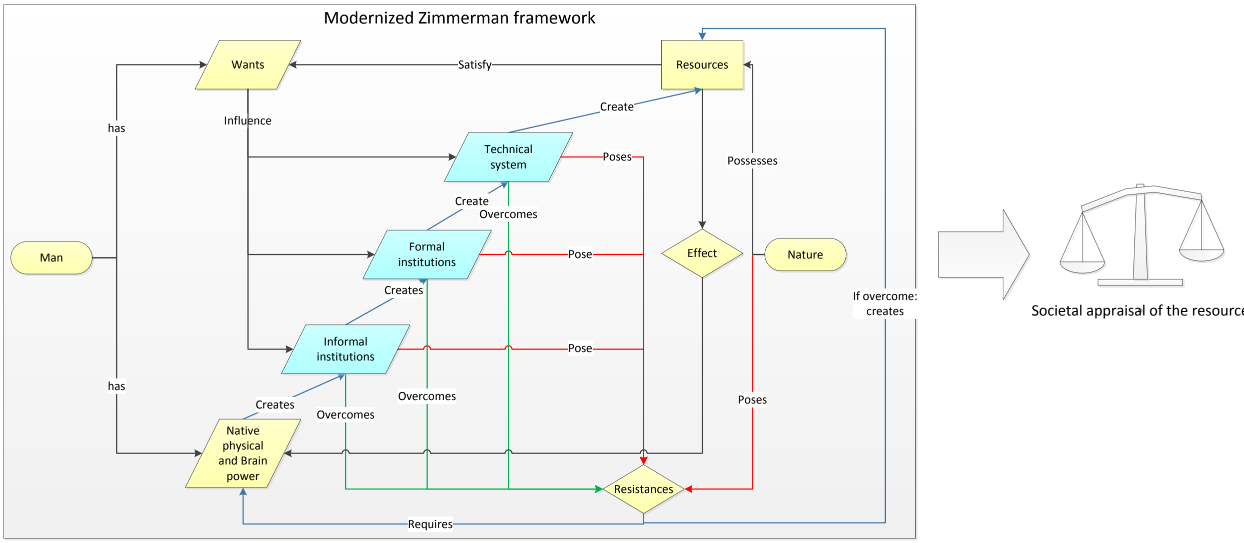


Figure 22 Modernized Zimmerman framework

Relation between the factors

The relations between the different institutional levels, as presented in the four layered model and the model of Groenewegen and Koppenjan are also integrated in this model. According to the four layered model, the Informal institutions provide limits for the Formal institutions and the Formal institutions provide feedback to the Informal institutions. In this framework these relations are presented, though slightly different. First, the Informal institutions provide limits for the Formal institutions; these limits can be considered as the boundaries of what is allowed in a society. In order to protect these boundaries, Formal institutions have to be created. Thus, with the consent of Informal institutions, the Formal institutions are developed. Therefore, in this framework, the arrow between the Informal institutions and Formal institutions presents that Formal institutions evolve out of the limits posed by the Informal institutions. Second, the feedback function of the Formal institutions towards the Informal institutions is not direct in this framework, though it is present. If a Resource is developed, it will pose certain effects on society. These effects will be evaluated according to the standards of society, present in the Informal institutions, of what can be accepted and what not. If effects are unwanted, Formal institutions can be created to mitigate these effects. This can happen with the development of rules and regulations, which pose an incentive for the Technical system to mitigate these negative effects. The effects of the resource, that are still present after the adjustments in the Formal institutions and Technical system, provide the feedback for the Informal institutions. It will represent if the Formal institutions have achieved to attain the desired result, a resource which does not create unaccepted effects. So, in order to attain feedback 'A round' within the framework has to be completed. These rounds will be more thoroughly explained in the next paragraph.

Furthermore, Koppenjan and Groenewegen explain that the functionality of a complex technical system, such as the development and functionality of a resource, is related to its surrounding institutions. This was also acknowledged by Zimmerman who stated that Arts are related to Institutions and vice versa. In order to have the whole system function in an optimal way, the institutions and Technical system should be well adjusted to each other. Though, where Koppenjan and Groenewegen, offer the idea that institutions should be designed according to the technical system, this framework only presents the influence of the institutions on the Technical system and reverse. Though, the analysis of the effects of resources could lead to design suggestions for both institutions and the Technical system. Through the feedback of the effect of the resources on the Informal institutions, institutions may be adjusted in a reaction to the Technical system. So, this framework presents that the institutions and Technical system are interrelated and may have effects on the design and content of the other system. Finally, Koppenjan and Groenewegen state that the institutional levels cannot be changed without changing the other institutional levels as well. This is also presented in the framework. If the Informal institutions would change, the formal institutions have to change as well. When this is not the case the institutions become incongruent which will lead to unstable institutions, according to Koppenjan and Groenewegen. This may lead to undesired situations such as disgruntled residents.

So, with the complete and improved framework present, the framework will now be explained.

5.3 Explanation final framework

Missing factors

In the 'Modernized Zimmerman framework', all the primary factors of the "Institutionalized and Modernized Zimmerman framework" are included, except for the factors "Human appraisal" and "Economy". The reason that the factor "Human appraisal" is also not included in this framework is the same reason as for the exclusion of this variable in figure 5; the whole diagram is related the process of the appraisal of resources. The outcome of the process in the framework is a resource which will be judged according to the criteria under the factor "Human appraisal". However, since human beings do not wander alone anymore and therefore as a society have to decide if they want to use a substance as a resource, the factor "Human appraisal" is changed into the factor "Societal Appraisal". If a substance is able to satisfy all the judgment criteria, the substance should be accepted as a resource by all stakeholders present in that society and lead to complete public acceptance. However, a substance often is not able to satisfy all criteria. In that case it is expected that not all stakeholders will accept the substance in its function as a resource.

The judgment criteria of the societal appraisal can also be extracted from the framework. This proves that these judgment criteria are logical. To start the judgment factor 'State of Wants' is the sum of the Wants present for that substance and is represented by the factor Wants. Second, the factor 'Profitability' can, for instance, be a Want for operators and therewith the incentive to start exploring a substance which can satisfy this Want. Third, the factor 'Formulation of grand strategy along socio-economic lines' can be also be found under factor Wants, since the Want of a government for a specific substance is expected to evolve from its strategy. Fourth, the factor 'Environmental feasibility' can be a Want for both citizens and the government. This Want may find its existence in the informal institutions, since people may find a safe living environment an important value, which has to be maintained. Fifth, the judgment criteria 'Technical feasibility' can be found under the factor "Technical system". If this system would not be feasible, and the resource is not a natural resource, the substance will not be able to function as a resource, which makes the rest of analysis abundant. Finally there is the judgment factor 'Knowledge of facts'. This judgment factor cannot be found as one of the factors, however this knowledge is required to be able to use the framework and be able to assess the functionality of a resource. In addition, with the usage of the framework it will become clear in which areas there may still appear a lack of knowledge.

The factor Economy is also not present in the final framework. This variable is represented by the relation between Wants and Resources. A Want can be seen as a demand for a substance and the Resource as the product which can satisfy this Want or in other words, the supply. Therefore, the relation between Wants and Resources represents an economic relation. The factor Economy could also be included as a factor, though in order to keep the model as simple as possible; the factor is now presented in the relation between 'Wants' and 'Resources'.

Institutions

In this final framework Man both has Native physical and brain power and Wants. The Native physical and brain power form the basis from which the Informal institutions in the head of Man are created. Often, institutions are unstructured and not 'consciously' present in the head of Man. In most cases, people do not know which norms and values they are following. It is a 'gut feeling' of what is wrong and what is right. This gut feeling can also be seen as the cognitive frame people use to understand and handle situations. From these unstructured Informal institutions, more structured and sophisticated Formal institutions can be developed. The development of these institutions happens in consciousness and thoughtful way, people are aware of why they are creating which rules and regulations and what these rules and regulations should protect. These consciously created 'written rules' protect the elements of the Informal institutions. These Formal institutions provide the boundaries for the Technical system. The technical system is the system which contains all the (physical) improvements done to overcome the resistances related to the analyzed substance. An example of (one aspect) of the Technical system can be found in drilling equipment to extract natural gas from the ground.

Explaining additions to the framework

So, the block 'Native physical and brain power' does not provide a new factor. It helps to understand how the factors 'Informal institutions', 'Formal institutions' and 'Technical system' evolve. The same accounts for the block 'Effect'. This block was added to create the understanding, that it is not the resource itself that leads to resistances in the factors 'Informal institutions', 'Formal institutions' and 'Technical system', but the effects of the resource on society do. If resources do not have an effect, there will be no resistances, since nobody will notice the resources. However, if there are effects and these are perceived negative in the Informal institutions, or if these effects do not comply with the Formal institutions, the Informal institutions, the Formal institutions or the Technical system of the resource have to be adjusted to overcome these resistances.

Resistances

The factors Nature, Informal institutions, Formal institutions and the technical system can all pose resistances. The resistances derived from Nature relate to the hurdles which appear when the substance should be extracted from Nature and the alterations which should be done to use the substance. The resistances derived from the Informal institutions are for instance, a lack of public acceptance, due to the fact that the development and functionality of certain substance as resources does not comply with the norms and values of citizens. The resistances evolving from the Formal institutions are for instance rules and regulations which limit the possibilities in the Technical system. Finally, the Technical system can pose resistances, such as an unprofitable technology or technologies which lead to negative side effects. However, the resistances of the technical system are in most cases only resistances if these issues they are perceived as problems in the Informal institutions or if the Technical system does not comply with the rules and regulations present in the Formal institutions.

The factors Informal institutions, Formal institutions and the Technical system are also able to overcome resistances. Nature is not able to overcome resistances; since it has no 'creating power' it is only able to offer resources, not to create them. That being said if, for instance, Informal institutions would change to such extent that the Technical system does not violate the norms and values of a population anymore the resistances which evolved from the negative effects of the Technical system would be overcome. However, considering the information provided by Williamson that informal institutions in general take a period of 100-1000 years to change, the probability that this happens in practice is small (Williamson, 1998). Hence, the Informal institutions can hardly be considered as a factor that contains the power to overcome resistances. However, in theory it would be possible.

The Formal institutions can both overcome resistances from the Informal institutions and the Technical system. If for instance, the (effects of the) Technical system to extract and use the resource violate the norms and values of a society and resistances are created in the Informal institutions, the Formal institutions should be changed to such extent that the effects of the Technical system or the effects of the resource which is produced and used with the Technical system, which violate the norms and values, will be mitigated. The adjustments in the Formal institutions will often function in the form of an incentive for the Technical system, which then has to change to mitigate the negative effects. If these adjustments in the Formal institutions are not accomplished, the Informal institutions and the Formal institutions may become incongruent. When that happens, citizens may feel unprotected by the government and may fear that the development and functionality of that resource violates their norms and values. In this case the institutions might become unstable which could lead to agitation in the country. Furthermore, the public acceptance is expected to be low in this situation, since the resistances are still present. The Formal institutions can also provide incentives for the Technical system to overcome resistances, even when no problems are perceived in the Informal institutions (yet). This may for example happen when the government poses more stringent rules for a Technical system, in order to have the system improved, even though no norms and values are violated (yet). However, often Formal institutions only change when the Technical system does create problems in the Informal institutions.

Finally, the technical system can overcome resistances posed by Nature, the Informal institutions and Formal institutions. First, the resistances posed by Nature can be overcome by the development or adjustment of the Technical system. Second, when the Technical system is developed in way that does not violate the norms and values of society, no resistances will be posed by the Informal institutions. In addition, resistances from the Informal institutions can be overcome by the technical system, if the system is adjusted to such extent that it does not violate the Informal institutions anymore. However, often in order to overcome resistances evolving from the Informal institutions, incentives from the formal institutions are necessary, that require the Technical system to adjust to such extent that the resistances from the Informal institutions can be overcome. When that happens, the Technical system has to overcome the resistances which are posed by the Formal institutions to protect the Informal institutions.

Round in the framework

The development of a possible resource starts with a Want from Man. In order to satisfy this Want, Man starts to look for a substance in Nature which could satisfy this Want. Often Nature poses resistances which have to be overcome to attain and use the substance. If this happens, Man has to use his capacities to overcome these resistances. He first addresses the informal institutions which will pose the unwritten limitations and opportunities for the development of a Technical system, such as norms and values. This process does not have to happen consciously; often this happens without full awareness of all the elements of the Informal institutions. After the consultation of the Informal institutions, the Formal institutions are consulted. These institutions pose the written limits and opportunities for the Technical system. After the consultation of the institutions, Man will develop a Technical system to overcome the resistances posed by Nature. If the development of the Technical system is achieved, the substance can be attained. If the substance is able to satisfy at least one Want, it will be able to function as a Resource.

The usage of the substance as resource will pose effects on its environment in almost all cases. These effects will be evaluated according to the standards, norms and values etc. present in the Informal institutions. Here, it will be evaluated if these effects can be accepted or not. Again, this process may not always happen in a conscious way. When residents react negative to certain developments, they often cannot explain which, for instance, norms and values are trespassed by the development. Though they do know that they do not accept this effect. When this happens, the Informal institutions pose resistances. These resistances may be overcome, if the Formal institutions are adjusted to such extent that these are able to mitigate the negative effects. The institutions than become congruent again. The Formal institutions will than, for instance, provide new or adjusted rules and regulations, which protect the Informal institutions. These rules and regulations, laws or other formal aspects can be seen as the resistances posed by the Formal institutions. These resistances create new limits or incentives for the Technical system. In order to have the Technical system become congruent with the requirements from the Formal institutions again, the Technical system also has to be adjusted. These adjustments will then be of influence on the usage and effect of the resource. So, due to the changes, in the Formal institutions and Technical system the effect of the resource is expected to change. The changed effect will then again be evaluated by the Informal institutions, which will form the start of a new round.

If all the resistances are overcome, or the resistances are overcome to such extent that the situation is acceptable for most stakeholders, the substance may function as a resource for most stakeholders. When this is the case, the substance will be accepted by the major share of the stakeholder and public acceptance can be expected. However, it seems not very realistic that all resistances will be overcome. Often, there still are resistances present since not all stakeholders hold the exact same norms and values. When this happens the substance will be not be accepted by all stakeholders and may therefore be subject to resistance and a lack of public acceptance. Though, the substance may be accepted as a resource, if the situation is acceptable to the major share of stakeholders. Therefore, the resources which may be used in our current society, can still pose negative effects, however these negative effects do not create resistances for all people in the society and the substance is therefore accepted by most stakeholders.

Finally, the resource which is consulted in the framework will be judged according to the six judgment factors of Societal appraisal. If the resource is judged positive on all elements, the resource is expected to face only minor to no resistances from the public. However, when the resource satisfies not all criteria, it may still be accepted by the major share of the stakeholders. For example, there are resources, such as wind, for which the profitability is debatable. However, the usage of this resource fits in the strategy of the EU governments and is considered environmental friendly by many stakeholders and therefore the resource is accepted by the major share of stakeholders. However, if a resource is ranked negative on all criteria, it is unlikely that it will attain any acceptance and will be used, even though it may satisfy Wants. So, the outcome of the Societal appraisal provides, next to the presence of resistances which are not overcome, an indication of the level of public acceptance which can be expected. Also it provides an indication in which areas improvements for the resource have to be achieved to increase the level of public acceptance.

What can be learned from these rounds is that the development and functionality of a resource is a dynamic process. A resistance posed in one field, requires an adjustment in another field, which again may lead to another resistance and another adjustment. These rounds may continue as long as the resource Wanted and the substance available. The framework can be used as a guidance to assess the exact resistances in the different fields and create an understanding how these resistances evolve and interact. This may lead to insights how these resistances evolve, how they are interrelated and how these resistances could be overcome. This can increase the understanding on why a resource is accepted by the public or not and how this acceptability could be improved. Furthermore, it may create understanding in which fields solutions can be found if continuation of the usage of the substance is desired.

5.4 Discussion framework

Due to the necessity of the framework to maintain simple, the level of detail is low. For this reason it could be beneficial to develop sub-framework for the factors in the framework, to provide guidance on the content to be analyzed. Another point of discussion considers the terms Man and Society. Man represents mankind in this framework, the race of human beings, while Society represents a group of Man who live together. An example of a society is formed by the U.S., the country for which the development and functionality of shale gas will be analyzed in the next chapter. Thus, there are multiple and different societies, while the term Man is a general term for all human beings. This should be kept in mind when the framework is used.

The insights which can be derived by usage of this framework will become clear in the next chapter; the case study on the development and functionality of shale gas as a resource in the U.S.

6. Operationalization framework for shale gas U.S.

In this chapter a case study is performed with the 'Modernized Zimmerman framework' on the development and functionality of shale gas in the U.S. The goal of this case study is to validate the framework and to explore if, with the usage of the framework, new insights on the development and functionality of resources can be generated. In the end of this chapter two conclusions are provided. The first conclusion is a methodological conclusion in which usability of the model is evaluated. The second conclusion concerns the conclusion on the content of the case study. In this conclusion the insights on the shale gas development in the U.S., which are attained in this case study, are presented.

The structure of this chapter is based on the framework. The different paragraphs of this chapter are formed by the different factors present in the diagram. In these paragraphs the content of these factors, for the shale gas case of the U.S., is explored. Furthermore, the relations of the described factor with the other factors in the framework, is presented. These interrelations will illustrate the dynamic character of the development and functionality of a resource and the ability of the framework to describe these dynamics.

This chapter will start with an analysis of the Wants of the stakeholders in the U.S., for the substance shale gas. Second, the resistances which are posed by Nature to attain and use the wanted substance are considered in the paragraph on the factor Nature. With the Wants and the resistances posed by Nature identified, the native physical abilities and brain power of Man will be addressed. Since this factor is an additional factor, inserted in framework to increase to understanding and usability of the framework, the content of this specific factor is not explored in this chapter. However, the effect of this factor, in the form of the developed Informal and Formal institutions and the Technical system is analyzed in the paragraphs 6.3, 6.4 and 6.5.

In order to understand the dynamics between the Informal institutions, Formal institutions and Technical system and to understand how, why and when the resistances from these three systems evolved, three timelines are developed which present the most important events concerning shale gas in these three systems. By means of these timelines it is explained what happened in these systems at which moment and why.

From these three systems, the Informal institutions are consulted first. In this paragraph the aspects of the Informal institutions that were of influence on how the shale gas revolution could take off are presented. Furthermore, the current resistances posed by the Informal resistances are presented and explained. Here after the Formal institutions are addressed. In paragraph 6.4 the Formal institutions that were already present when the shale gas evolution took off and the Formal institutions that evolved from the resistances posed by the Informal institutions are presented. Finally, the Technical system is described in paragraph 6.5. In this paragraph, the Technical system developed to overcome the resistances posed by Nature and the system used today, after alterations to overcome Formal resistances, is presented.

Hereafter, the economic aspects of the shale gas are explored paragraph 6.7. These economic aspects are necessary for the Societal appraisal of the substance shale gas, presented in paragraph 6.9, and for the identification of to what extent (economic) Wants are satisfied.

With the factors Wants, Nature, Informal institutions, Formal institutions and Technical system explored, it will be possible to assess the role of Man in the development and functionality of shale gas. What is assessed in this paragraph is the way Man has handled the development and usage of shale gas. Next to the fact that Man poses Wants and provides his native physical and brain power, he is also the decision maker in how the handle things. The decisions Man has made in this case and the attitude of the Man will be addressed in paragraph 6.8.

Finally, with the resistances and effects of the Informal and Formal institutions and the Technical system, and the economic aspects evaluated, it is possible to provide a Societal appraisal on the functionality and development of shale gas. This Societal appraisal provides the judgment if the substance shale gas meets the criteria to become a resource accepted by (most of) the stakeholders. Therefore, the Societal appraisal may be considered as the conclusion on the substance analyzed by means of the 'Modernized Zimmerman framework'.

The factors resource and resistances are not presented in a separate paragraph in this chapter. If the substance is able to satisfy a Want, this implies that the substance will function as a Resource. Therefore the factor resources will be present through the multiple paragraphs. The resistances related to the development and functionality of shale gas are also presented in the paragraphs in which these resistances evolve.

Every section will be finalized with a conclusion on that section. Furthermore an overview of the resistances which are overcome by the specific factors, the resistances which are posed by the factors and the negative effects of the system which could create new resistances are presented in the form of tables in appendix V.

Finally, due to the time limitations it was not possible to address all state laws, next to the federal laws. Therefore, not all the Formal resistances derived from these state laws concerning shale gas are identified. During the case study, only a few examples these laws and the associated resistances are provided. Therefore, it can be that the resistances posed by the Formal institutions are in reality more stringent than presented in this case study. Further research would be necessary to identify the resistances posed by the Formal institutions on state level, in order to provide a complete view on the situation.

6.1 Wants

As stated in chapter 5, the Wants of Man form the starting point for the possible development of a substance as a resource. These Wants provide the objective which the substance has to fulfill. If, at least one of these Wants is satisfied, the substance functions as a resource.

With the Wants, and therefore the objectives for the substance to achieve, are present, Nature can be addressed in order to find a substance which could satisfy these Wants. However, for this case, the substance that is looked for is already known and the search for this substance is therefore not presented in this research. Therefore, in this paragraph the Wants which have led to the search for shale gas are presented. These Wants present the objectives the substance shale gas has to fulfill in order to function as a resource.

One problem, with the analysis of this factor, is that no stakeholders could be interviewed on their Wants, due to the time limitations and focus of this research and since all stakeholders are located in the U.S. Therefore the Wants presented here, are mostly the objectives of the U.S. government that can be retrieved from articles, papers and reports. During further research on this topic, it would be valuable to analyze the exact Wants of the stakeholder by means of, for instance, interviews.

6.1.1. Analysis Wants

The U.S. has been looking for a substance which could provide a cheap energy source for consumers as well as energy independence, energy security and strong economic growth for the country (Economides, Oligney, & Lewis, 2012). Furthermore, this substance should, when explored and used, pose minimal risks for human health and the environment (Economides et al., 2012).

When considering the energy sources used today, it appears, that these resources cannot satisfy these Wants. Most of the easy accessible and economic feasible conventional wells have been exploited and the amount of easy accessible wells has declined (Tiemann & Vann, 2013). This has led both to a price increase of conventional fuels as to energy insecurity for the U.S. There is still a significant amount of conventional energy sources present, which could be developed, however the U.S. contains a smaller share of these resource than they would like. According to an estimation of the EIA on the first of January 2011, The United states seem to have a conventional natural gas reserve of 2.327 tcf (U.S. Energy Information Administration, 2013). When the consumption rate of 2010 is considered for gas, it appears that this amount is enough for 20 years of gas supply (Shale gas information Platform, n.d.). More information of the share of conventional energy resources of the U.S. (compared to other regions in the world) can be found in appendix IV.

Since U.S. does not want to depend on other countries for their energy security, their energy independence is very important. Therefore, the U.S. started to research the possibilities in unconventional energy resources, such as shale gas. According to Economides et al. it appears from the reaction of the U.S. government that they consider shale gas to be the substance which can bring them the Wanted energy security, energy independence and economic growth, while having a minimal impact on the environment and human health (Economides et al., 2012). The shale gas revolution is considered as “One of the most promising trends in the U.S.”, due to its increase of domestic energy sources and the creation of new jobs and other economic benefits (Sakmar, 2012).

Also, according to both the scientific alliance and EPA, shale gas could have a positive impact on the energy security (The Scientific Alliance, 2010)(Environmental Protection Agency, 2013a). This energy security seems to be the most important reason for the exploration of shale gas (The Scientific Alliance, 2010) Especially, since the human beings in the Western part of the world are accustomed to living standards for which a high energy level is required. In 2011 the U.S. EIA launched in report in which the shale gas reserves of the U.S. are estimated on 862 tcf (U.S. Energy Information Administration, 2011).

When again taking the gas demand of 2010 (2.327 tcf/20yr) , the shale gas reserves could satisfy the natural gas demand for more than 7000 years (Shale gas information Platform, n.d.; U.S. Energy Information Administration, 2013).

When considering the Want for a clean fuel, according to the EPA “Natural gas plays a key role in our nation’s clean energy future” and would provide significant environmental benefits (Environmental Protection Agency, 2013a). Since, shale gas can form an alternative for coal in for example power production, a significant reduction in carbon dioxide emissions could be accomplished (The Scientific Alliance, 2010). The usage of shale gas is considered a more reliable and cost effective alternative by the scientific alliance to reduce emissions, than the usage of wind and solar energy for which subsidization of solar panels and wind farms is needed (The Scientific Alliance, 2010). Also, it is seen as the “Transition resource”, the substance which could form the bridge between the current energy economy in which fossil fuels play the leading role and the future economy in which renewable energy sources become the most prominent energy producers (Sakmar, 2012).

Next, the production and consumption of shale gas could lead to economic strength. This economic strength would be expressed in an increased income for the government in the form of tax royalties and an significant increase in the amount of jobs (Shale gas information Platform, n.d.). Also, the profit generated in the shale gas sector forms an incentive for operators and gas and oil companies to get involved in this sector and to start producing shale gas. These new developments could both bring profits as continuity to these companies.

Finally, the citizens of the U.S. Want to live in a clean and safe environment. Furthermore, they want to live their live according to the living standards they are accustomed to.

6.1.2. Conclusion Wants

So, from the previous stated information the following table is developed which presents the Wants for the substance shale gas and the actors who own these Wants.

Table 1 Wants

Want	By who
Energy security	U.S. government, citizens
Energy independence	U.S. government
Clean energy resource	U.S. government
Cost effective energy resource	U.S. government, citizens
Economic strength	U.S. government, citizens
Profit	U.S. government, operators
Company continuity	Oil and gas companies
Safe living environment	Citizens
Clean living environment	Citizens
Live a life according to the current living standards	Citizens

6.2. Nature

In this paragraph the substance shale gas and its relating natural properties are explored. These properties are needed to identify the resistances posed by Nature, which need to be overcome in order to attain and use this substance. By overcoming the Natural resistances, the substance can be retrieved and used to satisfy Wants and could therefore become a resource. Also, the reserves of these substances and the locations of these reserves are explored. These reserves and locations provide information on the areas where shale gas can be found and for which time period considering the current conditions. The different locations, will pose different resistances because the differences in the area from which the shale gas is extracted. A mounted area will require a different approach than a flat, though maybe populated, area. The reserves are important to consider, since these will provide the time frame in which the substance shale gas can to satisfy the Wants derived in the previous section. Though, as stated earlier, these reserves are dynamic and can change due to changing Wants and conditions.

The usage and attainment of a resource will most likely have effects. These effects will be evaluated in the Informal institutions.

This chapter will be finalized with an overview of the resistances posed by Nature which are overcome by the Technical system. This overview is also provided in a table in appendix V.

6.2.1. Analysis Nature

Search for the substance shale gas

The process of searching Nature in order to find a substance which could satisfy specific Wants, started in the end of the 1970's (Haas & Goulding, 1992). However, the Wants to be satisfied were not the same as identified in the previous section. The congress was looking for a substance which could replace the declining conventional gas resources (Haas & Goulding, 1992). Thus, the congress was looking for a substance which could satisfy the same Wants as conventional gas. According, to the framework this approach would actually be wrong, since the Wants of stakeholders should be identified separately from the substances, and not be identified by means of assessing the Wants which are satisfied by a declining resources. What is meant by this, that if the Wants of stakeholders would be identified in a separate and objective way, maybe another substance found in Nature would appear to be more beneficial to satisfy these Wants, than for example unconventional gas which can satisfy the same Wants as the declining conventional resources. Though, it may be easier for policy makers to look for substances which have approximately the same properties and can satisfy the same Wants as the substances already present, since they do not have to consider the possibilities of substances which are not used (yet). Hence, probably for this reason, the congress started looking for unconventional gas resources (Haas & Goulding, 1992).

Unconventional gas resources were presented by a study of the Department of Energy and the National Petroleum council, as the resources which could satisfy the future demand for gas (Haas & Goulding, 1992). Again, this study therefore was not started with the Wants of the stakeholders in mind, but from an approach that another substance could satisfy the same Wants as natural gas. Even though, the approach used to identify shale gas as the required substance was possibly not optimal, the substance shale gas is the substance which is chosen to attempt to satisfy the presented Wants and is therefore analyzed in this paragraph.

Natural-cultural resource

Thus, the congress amended shale gas as the substance which could satisfy the present Wants and become a new resource. However, even though shale gas was present in Nature, Man could not attain it. Man was not able to pick it up from the ground and use it. Improvements had to be done in order to attain the substance, therefore shale gas is considered a natural-cultural resource (Zimmerman, 1951).

Often when a 'new' substance becomes a resource, capital has to be developed in order to be able to use the substance. However, since the substance shale gas will complement conventional gas and satisfy the same Wants as conventional gas, most of this capital to use it was already present. So, when shale gas was transformed from neutral stuff into a resource, the capital equipment, transportation system and knowledge to use it was already developed.

Thus, the only improvements necessary were the technical advancements to obtain the substance from the ground. With technical advancements the resistances posed by Nature related to the properties of shale gas could be overcome. These properties are described in more detail in appendix IV.

Depth of shale gas

Shale gas can be located at wide range of depths. The Fayetteville play in the U.S is an example of a shale formation which is located at a depth of 1200 meter (Prohaska & Thonhauser, 2012). Though, in the Haynesville shale gas is produced from a depth of 4500 meter (Prohaska & Thonhauser, 2012). Since, groundwater may be located in wide range of depths as well, the distance between the ground water level and the formation in which will be drilled can vary between a few hundreds of meters to multiple kilometers (Prohaska & Thonhauser, 2012). The presence of ground water in the formation in which drilling takes place, may lead to contamination of ground water. If this is the case, drilling for shale gas poses effects for the human populations and the environment. If these effects are considered negative by the stakeholders and are not accepted these effects can be transformed into resistances. In order to prevent risks of groundwater contamination, and therefore the negative effects and possible resistances, several technical measures have to be taken. These measures will be explained in the paragraph on the technical system.

Location recoverable resources

The total recoverable resources of natural gas of the U.S. are estimated on a total of 862 tcf (U.S. Energy Information Administration, 2011). The technical recoverable amount of shale gas is expected to increase over time as the recovery methods improve (Tranfield, Denyer, & Smart, 2003). The locations of these resources are shown in the map provided in figure 23. All of these locations will have their own natural environment and therefore resistances specific for that location. Though, the analysis of the different properties of these specific locations and therefore the identification of the specific resistances falls outside of the scope of this research.

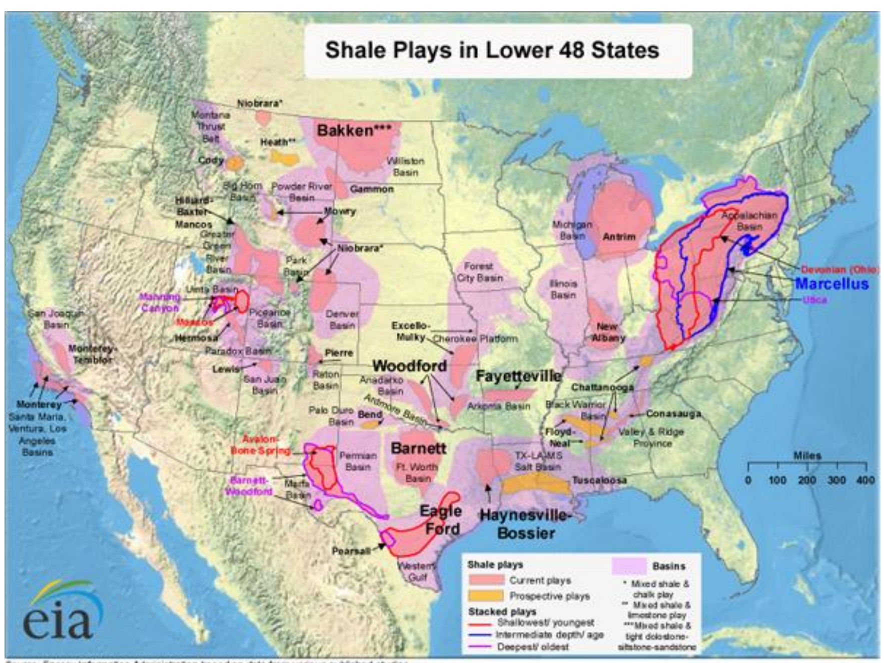


Figure 23 Shale plays U.S. U.S. Energy Information Administration, 2012b

6.2.2. Resistances Nature

A conventional gas resource evolves when natural gas, due to its low density, moves from its organic rich source rock up to the earth surface, until it reaches a layer which is impermeable (Geology.com, 2010). The natural gas cannot move further upwards and maintains in the permeable reservoir rock underneath the seal of impermeable formations (Geology.com, 2010). Shale gas is produced in an organic rich source rock, however due to the low permeability of the shale formation, the natural gas cannot migrate upwards and is therefore locked inside the impermeable shale formation (Geology.com, 2010). Thus, where conventional gas migrates upwards and leaves its organic source rock until it reaches an impermeable layer, shale gas maintains in its impermeable source rock. Therefore the conventional and unconventional gas reserves have different properties which made it necessary to develop a new drilling technology for unconventional resources. This difference in reserves is presented in figure 24.

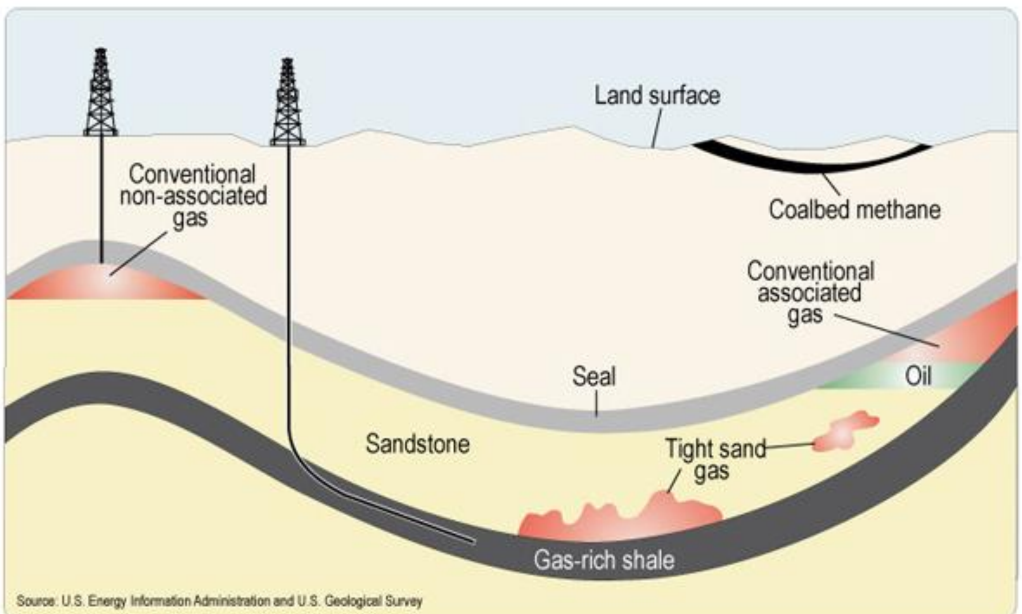


Figure 24: Conventional and Unconventional gas (U.S. Energy Information Administration, 2012)

The resistances posed by Nature are related to the properties of the shale formation. *The low permeability of shale gas* was the reason that shale gas cannot be exploited with the techniques to obtain conventional gas (U.S. department of the Interior & U.S. geological Survey, 2013).Therefore improvements in the Technical system had to be done to be able to attain this substance. These improvements were the development and combination of horizontal drilling and hydraulic fracturing.

These improvements in the technical system will have effects on the environment in which shale gas is drilled. If these effects are perceived as negative and are not tolerated by the stakeholders, new resistances can evolve in the Informal institutions. These resistances will evolve in the Informal institutions, since this is the system in which the effects of a resource are processed and evaluated according to the living standards, norms and values. These resistances from the Informal institutions can then be translated into resistances from Formal institutions, designed to overcome the informal resistances. Also, new resistances provided by Formal institutions, as a direct reaction on (effects of) the resource, can be developed in order to eliminate the negative effects. However, as stated before, often an incentive from the Informal institutions is necessary for the Formal institutions to pose resistances. The effects and resistances associated with the Technical system and the resource shale gas, are considered in the sections in which these resistances are explored, so either in the Informal institutions, Formal institutions or in the Technical system itself.

As stated before, Nature itself is not capable of overcoming resistances. This is because Nature is the first factor which poses resistances. It seems that Nature could overcome resistances if it could deliver a substance which could be used to attain something which cannot be obtained by the substances already present. However, this is not the case, since it would then be a different Want which can be satisfied and not be a resistance which is overcome by Nature.

6.3 Informal institutions

In this paragraph the elements of the Informal institutions related to the development and functionality of shale gas as a resource are discussed. First, a short analysis of the American culture is provided, in order to present the context in which the substance shale gas is developed and functions as a resource. Hereafter, an analysis on the development of shale gas as a resource and an analysis of the current situation concerning shale gas in the U.S. are provided. For these two analyses three timelines are created which present the important events related to the shale gas development in the Informal and Formal institutions and the Technical system. These timelines will provide insights on how these three different systems 'inside' the framework' interrelate.

These timelines will also be used during the analysis of the Formal institutions and the Technical system, presented in the next two paragraphs.

In the end of the paragraph, the resistances, both overcome and posed by the Informal institutions are presented. These resistances are also provided in a table in appendix V.

6.3.1. The enriched American culture

When one tries to define the ''American Culture", he poses himself to a major challenge. This because there is not one unified American culture. The American culture has evolved out of the adaption to the natural environment of the U.S. This could have led, according to Zimmerman, to one culture. At least in the areas for which the resistances posed by Nature were the same, though in the case of the U.S. this has not happened. When excluding the initial residents of the U.S. out of this brief analysis, since their successors only form a very small part of the current American population, almost all residents today are successors of immigrants who went to abroad find their luck. The people, who went to the U.S., already had their own culture, which they brought along with them. Therefore, the American culture could be expressed as an "enriched" culture, a culture with assets from multiple cultures (Zimmerman, 1951). Thus, the new residents of the U.S. all brought bits and pieces of their own culture and also made adaptions to their new location which resulted in new cultural aspects. Furthermore, due to the wideness of the U.S. which required many different adaptions many different cultural aspects evolved. Thus, only due to these 'new' residents and the wideness of the country, the American culture was already a broad concept. Though, the culture even became more diversified, due to movement of more people from all over the world to this country, either voluntary or involuntary. Even today, people from many nations immigrate to the U.S. Subsequently with all these different people who all brought their own culture and adapted to the different environments present in the U.S., it is impossible to specify this American culture, without delivering a whole new research project. Therefore, due to the limited time, only a few aspects of the American culture that are typical and very important for shale gas evolution are presented.

6.3.2. Development shale gas

The timelines below present the chronological order of important events in the Informal institutions, Formal institutions and Technical system concerning the development of shale gas. The areas which are marked green are the periods in which the system was supportive towards the development of shale gas. The red areas present the periods in which the conditions in the system were not supportive and possible posed (new) resistances for the substance shale gas. The gray area in the Technical system presents a time frame in which there was low to no activity in the technical field of shale gas. This part is not made green, since it is not a period in which the technical situation was supporting the development and functionality of shale gas; the situation was neither supporting nor presenting resistances towards the resource shale gas. No activity does not necessarily lead to a neutral situation; in the period from 1929-2010 Informal institutions provided a supporting situation for shale gas; however no important events took place.

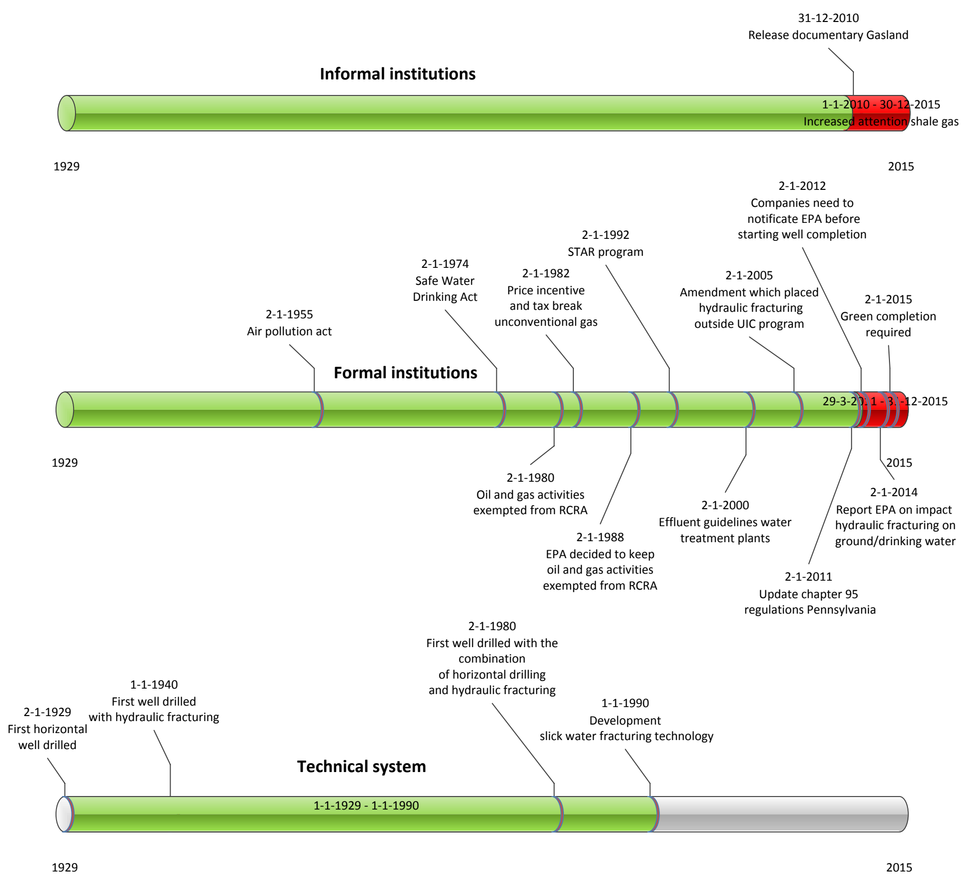


Figure 25 Timeline

What can be seen is that until 2010, there were no significant events concerning the development or functionality of shale gas in the Informal institutions. The Informal institutions were mainly supporting and stimulating the development of shale gas. During this period the effects of the resource shale gas did not create resistances in the field of Informal institutions. This supportive and stimulating period ended in 2010, when the movie/documentary *Gasland* was released. From this moment the attention towards the exploration of shale gas increased, and the first resistances from the Informal institutions developed. The activities and their effects in the Informal institutions, from the period from when the first horizontal well was drilled (1929) until 2010 and the period after 2010, are described in more detail below.

Period from 1929 to 2010

In the period between 1929 and 1990, the Technical system to produce shale gas was developed. During this period, the Informal institutions were mainly supportive towards the development of shale gas. Most of the first wells were drilled by wild cat drillers and other independents (Newman, 2012)(Kefferpütz, 2010). According to Newman, all these independent drillers were 'seeking a slice of the action' (Newman, 2012). These drillers had the initiative to start the drilling process, which can be perceived as the outcome of an entrepreneurial mind. This entrepreneurial mind is something which can considered as a part of the Informal institutions of the U.S. Being an entrepreneur is viewed as something good and is respected in the U.S. Initiatives to take care of your own income and start your own business are regarded as important and valuable. This has probable evolved from the moment the immigrants entered the U.S. At that moment, there was no back-up system for people who were not able to take care of themselves. The attitude to develop your own business and create your own 'luck' or 'American dream' is deeply founded in many people in the U.S. This attitude created a supporting climate for entrepreneurs and therewith for the development of shale gas, since the revolution started with many wildcat drillers and independents who wanted to create a new business and were willing to take a risk. Bigger companies were less involved in this stage. This could be explained by the fear of reputation loss if things would go wrong, which is not unlikely during new (technical) processes. The independent drillers were less subject to these fears, possibly since their activities are often not known by the public.

Furthermore this initial period was marked by easy credit, companies could finance their operations without problems (Newman, 2012). The fact that credit was/is easily provided and accepted can also be considered an element of the Informal institutions that supported the development of shale gas in the U.S. In the U.S. people are more accustomed to loans. Even groceries are paid with a credit card, which can be considered a short term loan from the bank. Furthermore, while in many other countries a solid business plan often has to be presented before a loan can be attained, this was not (always) the case in the U.S. when the shale gas evolution took off. In the beginning of the gas development, it was challenging for drillers to present the exploration activities of shale gas as a solid business case, since it was in many situations challenging to prove that shale gas could be produced (in a profitable) way. Though, these drillers still attained loans, which points to the fact that loans (at that moment) were more easily provided in the U.S. Thus the facts that loans were easily provided and accepted provided another supporting issue for the Technical system to evolve.

The last element in the Informal institutions, which may have been one of the reasons why the shale gas development could take place in the U.S. and not in Europe, is the attitude of the U.S. government and citizens towards the environment. As stated by Kefferputz, the development of shale gas in the U.S. did not cause many environmental concerns (Kefferpütz, 2010). Due to the abundance of land and resources, which has always served the American nation, the awareness of the importance of this land and its resources came in later stage than in nations in which these assets are scarce (Zimmerman, 1951). Land and its resources used to be the long, or in other words, the abundant factor in the U.S. (Zimmerman, 1951). In Europe, land and resources were short factors, while labor was a long factor (Zimmerman, 1951). Due these characteristics, Europeans have learned to preserve and use their land in a way that the next generations can still use it. This possibly has made the citizens of Europe, indirectly more aware of their impact on the environment. In the U.S. this awareness has not always been present. This has also led to the ignorance of environmental aspects in the past. The lack of ratification of the Kyoto Protocol could be seen as an example of this ignorance (United Nations, 2013). So, where the development of a new resource in other countries often leads to an assessment of the environmental effects, before a resource is developed, this was not the case in the U.S. Therefore, the development of shale gas could proceed in a higher speed, than would have been the case in a country where this environmental assessment is necessary. Hence, the lower priority for the environment provided an advantage for the development of shale gas. So, this lack of or reduced environmental concern in the U.S. was another element of the Informal institutions which allowed the shale gas development to take place as it did.

Finally, due to the mineral rights system in the U.S., which is part of the Formal institutions, often the people on whom land the exploration activities took place are also the owners of the minerals. Due to this ownership they receive a royalty share of the produced gas. Therefore, the people suffering from the nuisance of the production often are also the people earning money from the production. Therefore there were almost no resistances from the people in whom land was drilled in the early stages of production. Especially, since people often did not knew the possible negative effects of the exploration of shale gas.

Thus, the entrepreneurial mind, the fact that land was and is abundant the U.S., the easy credit available and used, the fact that the environment is a lower priority in the U.S. and the system of mineral rights which reduced the premier Informal resistances created a climate in the U.S. in which the Technical system to explore and produce shale gas could be developed. The effects of the resource shale gas did not create any new resistances from the Informal institutions until 2010. This also implied that there was no incentive for the Formal institutions to develop new rules and regulations for the exploration and production of shale gas. This can also be found in the timeline. It was not until 2011 that the first rules and regulations were developed in order to protect the citizens and the environment from the negative effects of the Technical system and the resource shale gas. These rules and regulations are most probably the result of the resistances posed by the Informal institutions since 2010.

Period from 2010

In 2010 the documentary/movie *Gas land* was released. In this documentary, the effects of the production process of shale gas for the local environment, according to the documentary maker, were presented. These effects amongst others considered the presence of methane in drinking water, water pollution due to the chemicals used in the fracturing process, air pollution due to the drilling activities and other negative aspects. The people interviewed in this documentary were people living close to the wells and people harmed by the exploration and production of the wells. Independent from the fact if all these effects were true, the documentary maker probably reached his goal. From a nation in which everything was possible concerning shale gas, citizens now became aware of the production of shale gas and the attitude that everything is possible and allowed now belongs to the past. The major share of the lawsuits against companies and drillers which exploit and produce shale gas, also started after the documentary G*asland* was released and belong to the period after 2010 (Beirne, Maynard, Parsons, & L.L.P, n.d.). These lawsuits can be considered as resistances posed by the Informal institutions.

Thus, the current attitude towards shale gas has changed. People are more aware of what is happening and fear that these developments may have negative impacts on their environment and their health. What people will believe is hard to predict, though the fact that people are not easy-going about the development of shale gas anymore and that resistances will be posed, is certain. People Want to have a safe and clean living environment, which includes safe drinking water, and they fear that shale gas could pose a risk to this. However, the environmental aspects, which are not a threat for the safety of residents, are still not really an issue. This is probably still due to the abundance of land.

6.3.3. Relations Informal resistances

Where the Informal institutions did not pose any resistances, but actually supported the development of the shale gas business until 2010, the Informal institutions of today do pose resistances. People fear that the negative effects of the Technical system and the resource shale gas, pose a threat for their health and their safe environment. When these fears are turned into negative propaganda, lawsuits, up rises and problems for the governments, these fears are translated into resistances from the Informal institutions. This is currently the case in the U.S.

When people would be and would also feel protected by the Formal institutions, these fears are expected to decrease and therewith the resistances coming from the Informal institutions. Thus, the resistances from the Informal institutions should form an incentive to create new or adapted Formal institutions which are able to reduce the resistances from the informal resistances. These more stringent Formal institutions would pose an incentive to improve the Technical system and mitigate the negative effects of the resource. Though, the Technical system, may also able to mitigate the negative effects of the resource shale gas directly without any incentive from the Formal institutions and overcome the resistances coming from the Informal institutions directly. However, in most cases, unless the improvements in the Technical system are profitable or a company wants to create a better reputation, these improvements are only done as a reaction on the Formal institutions.

6.3.4. Resistances Informal institutions

Thus, until 2010 the Informal institutions posed a climate in which there were no resistances concerning the development of shale gas. It offered a climate in which the Technical system could be developed and improved and the resistances posed by Nature could be overcome. However, after the movie *Gasland* people fear the negative effects of the resource shale gas. The usage of chemicals, the safety of the living environment and drink water are the main subjects of these fears. These fears are in most cases already translated into resistances, in the sense that lawsuits and agitation of the public are present. The fact that these resistances appear, indicates that the Informal institutions are not congruent with the Formal institutions. The people want something different than what the government is providing them with. One of the main values of people, to feel safe, is not protected by the Formal institutions.

These fears and resistances pose incentives for the Formal institutions to create new and improved rules in order to protect the citizens and take away these fears and associated resistances. When this happens, the institutions become congruent again, which leads to reduced resistances. Therefore, in many cases resistances can be overcome by the Formal institutions. If not, they could mostly be overcome by the Technical system, which in most cases requires an incentive from the Formal institutions to improve. However, in some cases it may be challenging to overcome the resistances from the Informal institutions by the development of resistances from the Formal institutions, since the Informal resistances are often not evolved consciously and are often based on feelings. Also, sometimes people will not be aware of the fact that new rules have been developed which better protect their norms and values. Therefore, in some cases it can be challenging to overcome the Informal resistances and more than changes in Formal institutions and the Technical system are required. In this situation it could be necessary to use, for instance, the media to convince people that they are protected (again).

6.4 Formal institutions

With the Wants defined and the resistances posed by both Nature and the Informal institutions identified, the Formal institutions will now be addressed. In this paragraph the Formal institutions which regulate the activities concerning shale gas are presented.

In order to explain the dynamics between the Formal institutions, in relation to the events in the Informal institutions and the Technical system, the timeline of the three systems is considered again. This timeline also forms the chronology in which the elements of the Formal institutions are considered. This chronology provides insights on the reaction of the Formal institutions on the resistances posed in the Informal institutions as well as on the effect of the Formal institutions on the Technical system.

First, a short introduction of the American law system will be provided in order to understand the types of law and the authorities present in the U.S. Hereafter, the rules concerning the ownership of minerals and the tax breaks which were of influence on the kick-start of the evolution of shale gas are presented. This is followed by the federal laws and their related programs and requirements which are applicable to shale gas. Here after the other actions of the EPA (Environmental Protection agency to improve the shale gas industry and the FRAC act are provided.

In this paragraph the rules and regulations of individual states, such as Pennsylvania, are used to present which laws may present on state level. However, this is not done for all states, due to the time limit of this research. Though as stated before, the inclusion of all the Formal institutions, also on state level would be required to provide a complete view on the Formal institutions. This implies that this research on the Formal institutions may not be complete, since only the federal laws and some state laws are assessed.

Finally in the end of this paragraph the conclusions on the Formal institutions will be presented. In appendix V an overview of the resistances which are overcome and posed by the Formal institutions and the risks which should be transformed into Formal resistances can be found. These risks consider, for example, the risk of negative effects of the shale gas exploration on the environment and human health, due to lack of regulation.

6.4.1. The timeline

As identified in the previous section, the resistances from the Informal institutions did not evolve until 2010, the year of the release of *Gasland*. Therefore, almost no incentives were provided to adjust the Formal institutions until this point. For this reason almost no alterations, related to shale gas, in the Formal institutions were done until 2010. Moreover, just as the Informal institutions, the Formal institution provided a supporting environment for the development of shale gas. The rules and regulations provided opportunities and almost no limitations. In fact the Formal institutions proved beneficial in overcoming resistances, both from the Informal institutions and Technical system. An example of this can be found in the tax breaks and mineral rights. This period until 2010, in which the development of shale gas was mainly supported by the Formal institutions, is marked green in the timeline.

From 2010, when the first significant resistances arrived from the Informal institutions, the first adjustments were starting to be considered in the Formal institutions. This time period is marked red in the time line, since it presents a period in which the Formal institutions are subject to changes which could pose limitations for the development and functionality of shale gas. An example of such a limiting measure, are the New Source Performance Standards which require green completion after the first of January 2015.

However, the Formal institutions are not quite there yet. When it comes to overcoming the resistances posed by the Informal institutions and making the two institutions congruent again the Formal institutions are still lacking adequate measures. This becomes clear when the rules and regulations are analyzed in this paragraph and the effects of the Technical system on society are explored in the next paragraph.

Because of the turning point in 2010, the Formal institutions will be explored in two parts; the Formal institutions present before 2010 and the Formal institutions present after 2010. From this analysis it will become clear that the Formal institutions lack the necessary adjustments to overcome the Informal resistances, which have evolved since the release of Gasland. Changes are required in the Formal institutions in order to keep citizens safe, the environment protected and make the two types of institutions congruent again.

As stated, this analysis will start with a short introduction on the legal system of the U.S.

6.4.2. Introduction Formal institutions U.S.

In the U.S. there are two systems of governance, namely the federal system and the state system (“Overview of the Legal System,” n.d.). The constitution of the U.S. forms the foundation of the legal system and provides specific authority to the Federal government (Federal Judicial Center, n.d.). It is

“The supreme law of the land” (“Overview of the Legal System,” n.d.). This law cannot be changed by statutes, cases or regulations (“Overview of the Legal System,” n.d.) . Furthermore all laws should be congruent with the constitution (“Overview of the Legal System,” n.d.). The congress is authorized by the constitution to enact federal laws, also called statutes, however the constitution also provides the individual states with specific authorization forces which are purposefully not preserved to congress (“Overview of the Legal System,” n.d.). Furthermore, the 50 states also have their own *state constitution, governmental structure, legal codes and judiciary* (Federal Judicial Center, n.d.).

All the authority which is not given to the federal government is in hands of the states (Federal Judicial Center, n.d.). This implies that States can set more stringent rules and regulations, as long as these are congruent with the federal laws. The last form of government, is the local government (“Overview of the Legal System,” n.d.). The laws developed by local governments are minor laws which apply to specific local situations (“Overview of the Legal System,” n.d.). More details on these Formal institutions can be found in appendix IV.

Thus, the shale gas industry is subject to three types of rules and regulations, the federal laws, the state laws and the local government. Since, the state laws may be more stringent than the federal laws, the rules and regulations may differ per state. This implies that the possibilities to exploit shale gas will be also different per state. This may also have implications on the possibilities and obligations in the Technical system. Furthermore, the strictness of the rules may have an effect on the amount of trust the citizens have in the government. If citizens trust the government to full extent, that it will serve at the citizens’ best interest, it is unexpected that citizens will pose resistances against the developments in their area. They have faith in that what the government is doing is best for them, and that it will not cause any harm to them or to their environment. However, if citizens perceive that the government cannot be fully trusted and that it may makes decisions which could be of harm to them or to their environment, they are expected to raise resistances. They may not agree to certain developments until they understand the possible risks themselves. Therefore, this trust in the government is important in the shale gas case. If the citizens do not have trust in the acts of their local, state and federal government they are unlikely to accept the shale gas development.

6.4.3. Formal institutions associated with shale gas until 2010

6.4.3.1. Mineral rights

In the U.S., the ownership of the minerals which lie beneath the surface was initially provided to owners of the surface (Geology.com, n.d.-a). These owners had the complete private ownership of both the “surface rights” as the “mineral rights”(Geology.com, n.d.-a). The owners had the right to sell, lease of give these right to another legal person (Geology.com, n.d.-a).

Today, the transfer of mineral rights is subject to state laws (Geology.com, n.d.-a). These laws may differ per state (Geology.com, n.d.-a). The mineral rights may be separately sold from the surface rights to, for example, a drilling operator (Geology.com, n.d.-a). The owners will then remain owner of the surface rights (Geology.com, n.d.-a).

The owner can sell all the minerals beneath the surface, or limit it one material, for instance shale gas (Geology.com, n.d.-b). The buyer of these mineral rights than has the rights to exploit the sold minerals (Geology.com, n.d.-a). Another option is to lease the mineral rights (Geology.com, n.d.-a). During the lease period the legal person who leases the subsurface, has the right to access the property, perform tests and identify of the required minerals are present (Geology.com, n.d.-a). When an owner leases his subsurface to a drilling company he normal receives a signing bonus (Geology.com, n.d.-a). Furthermore, when the mineral is exploited the owner receives a royalty share, which often is either a price per ton of the mineral or a percentage (Geology.com, n.d.-a). A common percentage is 12.5 percent; however there are cases in which the owner receives 25 percent (Geology.com, n.d.-a).

The financial benefits associated with the mineral rights provide a significant incentive for people to cooperate and lease their land. Due to the royalties granted for the mineral rights, the resistance from residents was only minor in the beginning of the evolution of shale gas (Kefferpütz, 2010). However, the leasing structure may also provide some negative aspects. If the operator does not start the exploration activities before the end of the leasing periods, the mineral rights will be transferred to the owner again (Geology.com, n.d.-a). Therefore the leasing structure requires the operator to produce the oil or gas in certain time period, even though the selling prices for gas may be low in that period (Newman, 2012). Together with high costs for the equipment this may lead to negative profitability for the operator (Newman, 2012). Furthermore, this is can have negative influence on the oil and gas market because of the possibility to create oversupply. This oversupply may again lead to lower prices, which decreases the profitability even further. Next, the system of mineral rights in the U.S. poses purchase or lease costs to the operators. This implies that the Technical system should be cost effective to such extent, that with these costs included, the system is still profitable. When the leasing structure leads to lower gas prices, the Technical system may has to be improved in order to lower the costs and maintain the cost-effectiveness of the system. More information on mineral rights can be found in appendix IV.

6.4.3.2. Taxes

As stated before, due to the declining conventional gas resources in the end of the 1970s, the congress started looking for other, more unconventional gas resources (Haas & Goulding, 1992). However, these sources could only be developed under favorable economic and technical conditions (Haas & Goulding, 1992).

Therefore, the federal government implemented around 1982 both price incentives and section 29, a production tax credit (Haas & Goulding, 1992). These were used as a tool to speed up the evolution of unconventional gas resources (Haas & Goulding, 1992). The tax credit and price incentives were developed to decrease the risks and increase the economic feasibility of the projects to attain these expensive gasses (Haas & Goulding, 1992). Section 29 has expired in 1993, but the state of Texas has maintained the tax relief for tight reservoirs (Martineau, 2007). Since the Barnett shale is subject to this tax relief, the tax credit still maintains important (Martineau, 2007). More details on this tax credit can be found in appendix IV.

According to Kefferpütz, the tax breaks that provided support for the oil and gas industry formed one of the reasons why shale gas could evolve as it did (Kefferpütz, 2010). The tax breaks and price incentives appeared beneficial for the start-up of the production and the improvement of the cost effectiveness of the technology. Therefore their effect on the Technical system was positive and supporting. The effects of these incentives on the Informal institutions cannot be identified that easy. People may either be happy with these kinds of incentives, since it provides a boost for a new industry. However, as stated before, residents may also fear the negative impacts of these developments, and may therefore not be content with the fact that government resources are spent on the support for these developments. The direction of the relation between the Informal institutions and the tax credits is therefore not clear.

6.4.3.3. Federal laws applicable to shale gas activities

The regulation of activities related to the exploration of oil and gas fall under the jurisdiction of state governments (Sakmar, 2012). However, there are also federal laws applicable to certain aspects of oil and gas exploration. The reason for these federal regulations concerns the fact that the issues regulated in these acts, concern aspects that are of influence on all citizens of the United States and should therefore be regulated on federal level.

The federal laws which control certain aspects of the activities of the exploration of oil and gas are:

- The Safe Drinking Water Act
- Clean Water act
- Clean air act
- Resource Conservation and recovery act (Sakmar, 2012)

These federal laws and their relation to shale gas are further explained below. What should be kept in mind is that these laws are not static. Often they have been altered by amendments or other aspects which can lead to alterations, into the laws they are today. Therefore, the laws described below, can differ in some aspects from the original laws. Due to the time limit and the scope of this research it is not possible to present the original laws and all the changes they have been subject to. Therefore, the dates of these laws should be considered as the starting point from which these laws were applicable, even though the content of the laws may have been slightly different at that date and may have changed over the years.

6.4.3.3.1. Safe water drinking act

The safe water drinking act (SWDA) is a federal law which was originally established in 1974 with the goal to protect public health by regulating the nation's public drinking water supply (Environmental Protection Agency, n.d.-a). The law obligates action to protect drink water and water bodies that serve as a source for drink water (Environmental Protection Agency, n.d.-a)
The SDWA authorizes the Environmental Protection Agency (EPA) to set standards for drink water as well as to protect drink water against contamination of both man made and naturally contaminants (Environmental Protection Agency, n.d.-a). The state, the water systems and the EPA work together to deliver drink water that meets the required standards (Environmental Protection Agency, n.d.-a).

This safe water drinking act provides the EPA with the responsibility of two programs, the Public Water Supply Supervision (explained in appendix IV) and the Underground Injection Control program.

6.4.3.3.1.1. Underground Injection Control Program

The underground injection control (UIC) program has the function to regulate the construction, permitting, and closure of injection wells (Environmental Protection Agency, n.d.-a). In these wells fluids are stored or disposed underground (Environmental Protection Agency, n.d.-a). The UIC program is developed in order to ensure that underground drink water resources cannot be injected with liquid waste (Hammer & Levine, 2012). Therefore requirements for the waste fluid and the injection processes are determined and some fluids are even prohibited to be injected (Hammer & Levine, 2012). Furthermore it is illegal to inject waste fluid underground that is not allowed to be injected by this program (Hammer & Levine, 2012). The aim of the UIC programs is to improve the coherence between the results that follow from injection activities and the requirements set for drink water by the SDWA (Environmental Protection Agency, n.d.-b).

The UIC program diversifies the injection wells into five classes which all have their own requirements and standards (Hammer & Levine, 2012). In class I wells, hazardous chemicals are placed (Hammer & Levine, 2012). However, the wastewater from the hydraulic fracturing processes is allowed to be placed in the class II wells, since it concerns waste fluid from oil and gas activities (Hammer & Levine, 2012). According to the Resource Conservation and Recovery Act (RCRA), waste water coming from these activities is not classified as hazardous waste and therefore does not has be placed in class I wells (Hammer & Levine, 2012). Thus, shale gas waste water can be placed in class II wells for which less stringent rules are set than for class I wells (Hammer & Levine, 2012). These class II wells are distanced from underground drinking resources by means of a ‘fault-and fracture-free zone’ (Hammer & Levine, 2012). Though, extensive studies on the effect of the injection of waste on potential harm for human health and environments on other classes than the class I wells, are not finished yet (Hammer & Levine, 2012). Therefore, the complete assessment of the effect of injection of oil and gas waste in class II wells is not finished yet and the effects of this injection may not be completely understood at this moment.

There are three types of class II wells. The first type is used to dispose brines and other fluids associated with production of oil and natural gas (Environmental Protection Agency, n.d.-c). The second type is the enhanced recovery well, used to produce residual oil or natural gas by means of the injection of fluids (Environmental Protection Agency, n.d.-c). The third type is the hydrocarbon storage well which is used to inject liquid hydrocarbons in subsurface formations (Environmental Protection Agency, n.d.-c). In 2005, the EPA has lost its authorization to regulate the class II wells used for production under the UIC program, unless diesel is used, due to the Halliburton loophole (Environmental Protection Agency, n.d.-c).

Lack of research and the Halliburton loophole

In 2004 the EPA executed a study on the effects of hydraulic fracturing in coal bed methane (Eden, 1996). This research was based on the available literature on shale gas and interviews (Sakmar, 2012) From this research they concluded that hydraulic fracturing only poses a small threat to underground water resources (Sakmar, 2012). Though, the EPA also observed that there was a lack of research on the environmental impact of hydraulic fracturing (Sakmar, 2012) They also noted that the concentration of diesel and the other components present in the injection fluid, were only analyzed until injection into the formation (Sakmar, 2012). What these concentrations in the formation were after injection fell outside the research scope (Sakmar, 2012). The report was subject to critics from both members of the congress and professionals from EPA itself (Sakmar, 2012). According to these critics, the conclusions of this report were not based on scientific results (Sakmar, 2012).

In addition to this criticized research, the U.S. congress amended the SDWA in the Energy Policy Act of 2005, to such extent that 'Underground Injection' does not include the injection of propping agents (other than diesel) used for hydraulic fracturing activities (Sakmar, 2012). The definition of 'Underground Injection' in the statute states that Underground injection *excludes* "*the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas or geothermal production activities*" (Legal Information Institute, n.d.). This means that the activities of hydraulic fracturing, unless diesel is used, do not fall under the UIC program and therefore not under the SDWA. This implies that the EPA has lost its authorization to regulate the underground injection of fluids used for hydraulic fracturing activities, unless diesel is used (Sakmar, 2012). In the case that operators or owners do use diesel for the hydraulic fracturing process, they are obligated by means of the SDWA to attain a permit for the process of hydraulic fracturing (Environmental protection agency, 2012). The reason for the necessary permits when diesel is used, are the perceived risks for drink water related to diesel fuels (Sakmar, 2012). These risks can be found in appendix IV.

Thus, the amendment of the congress resulted into the fact that the EPA lost its authority to regulate the underground injection of fluids used for hydraulic fracturing with the SDWA (Sakmar, 2012). This development is also known as the "Halliburton loophole" (Sakmar, 2012). So, even though the SDWA requires EPA to control the underground injection of fluids, the law on the other hand, limits the EPA in its actions (Sakmar, 2012) The following statement about the EPA regulations for state UIC programs underlines this: the EPA "*May not prescribe requirements which interfere with or impede any underground injection for the secondary of tertiary recovery of oil or natural gas, unless such requirements are essential to assure that underground sources of drinking water will not be endangered by such injection*" (Sakmar, 2012). Consequently, the EPA is only allowed to subscribe requirements for the oil and gas industry if drink water sources are in real danger.

Moreover, since the injection of fluids for hydraulic fracturing processes is not subject to regulations under the SDWA, the injection fluid or waste water treated with the purpose of reuse in hydraulic fracturing processes, will also not be subject to the SDWA (Hammer & Levine, 2012). So, recycled water can also be injected in class II production wells, without any regulation. However, states may set their own regulations for the recycled waste water coming from shale gas explorations (Hammer & Levine, 2012).

There have been many requests to regulate hydraulic fracturing by means of the SDWA (again) (Sakmar, 2012). However until today, the congress has not provided the EPA with (new) authority to regulate hydraulic fracturing under this act (Sakmar, 2012)

Thus, the UIC program leads to a gap in the regulations. First, since the RCRA does not classify the waste from oil and gas activities as hazardous, this waste can be placed in the less stringent regulated class II wells. Second, because the EPA has lost its authorization to regulate the activities of hydraulic fracturing (unless diesel is used) under the SDWA. These two issues can pose negative effects for the human health and the environment, especially since the effects of the injection of oil and gas waste in class II wells may not be thoroughly understood. Due to this gap in the rules and regulations, residents may feel unprotected. This can lead to distrust in the government and resistances from the Informal institutions. In order to prevent the evolvement of these resistances from the Informal institutions, research should be done towards the exact risks of the usage of class II wells. Furthermore, if risks are identified, more stringent rules may have to be applied in order to protect the citizens. This can have implications for the Technical system.

6.4.3.3.2. Clean Water Act

The Clean Water Act (CWA) is the common name for the federal Water Pollution Control act and limits the release of pollutants that could be harmful for the human health or the environment into water bodies (Hammer & Levine, 2012). The EPA and state regulatory agencies have developed water quality criteria for various contaminants in the water bodies (Hammer & Levine, 2012). If waste water is to be discharged, this should not increase the levels of contaminants in the receiving water to such extent that these exceed the water quality criteria (Hammer & Levine, 2012). Therefore, the CWA contains the regulations for the treatment of waste water and disposal of waste water into surface water (Hammer & Levine, 2012). The CWA requires that anyone, such as water treatments plants or factories, who plans on either disposing waste water or a by-product from natural gas exploration into surface water, must attain a National Pollutant Discharge Elimination System (NPDES) permit (Hammer & Levine, 2012). These NPDES permits are provided by the EPA or, if authorized by the EPA, by the states, and contain the limitations for the contaminants in the effluent, also referred to as the Effluent Limitation Guidelines (ELG), for that facility (Environmental Protection Agency, n.d.-d; Hammer & Levine, 2012). These ELG are based on the technologies which are available and economically achievable as well as on the required water quality of the surface water (Environmental Protection Agency, n.d.-e) The CWA authorizes the EPA to develop the Effluent Limitation Guidelines present in the NPDES permits (Environmental Protection Agency, n.d.-f; Hammer & Levine, 2012). How the standards on these permits are exactly developed can be found in appendix IV.

Outdated water criteria

As stated, the EPA has developed water quality criteria, which it recommends to use in order to maintain the water quality of the surface water (Hammer & Levine, 2012). These water criteria provide the basis for the development of the effluent limitation guidelines (Environmental Protection Agency, 2013a). However, these water criteria have become outdated since today's treatment plants also process waste water derived from shale gas activities, and will therefore discharge other contaminants in the surface water than before (Environmental Protection Agency, 2013a). This means that water criteria now have to be developed for 'new' contaminants, contaminants which can become present in the surface water due to shale gas exploration activities. Despite this, the draft document containing the water criteria for these 'new' pollutants will not be delivered until late 2013 (Environmental Protection Agency, 2013a). Though, EPA is updating the water criteria for chloride, which is the main component of TDS (Total Dissolved Solids), in order to protect the aquatic life (Environmental Protection Agency, 2013a). TDS is the sum of the inorganic and organic substances present in a liquid and may therefore present different types of contaminants. However, also the water criteria for the other contaminants present in shale gas waste water such as sulfates should be developed. Especially, since it is known that the concentrations of these contaminants in the surface water are known not to comprehend with the desired water quality standards for surface water (Hammer & Levine, 2012). Thus, due to the lack of updates of water criteria, the quality of the surface water may be at risk, which may provide negative effects for human health and the environment.

Water treatment plants

Since the direct disposal of waste water into surface water is not allowed according to federal law, many operators bring their waste water to POTWs (Publicly Owned Treatment Works) or CWT's (Centralized Waste Treatment). The plants provide treatment to the waste water where after they dispose the treated water, also referred to as the effluent. These plants require a NPDES permit to be allowed dispose the treated waste water (Hammer & Levine, 2012). The POTW's are generally in possession of the state or local authorities and are developed to treat the sewage water (Hammer & Levine, 2012). After treatment, these POTW's discharge the treated water into the surface water (Hammer & Levine, 2012). The CWT's usually have private owners and are developed to process waste coming from industries (Hammer & Levine, 2012). The CWT's have three options; dispose the waste water to POTW's (indirect discharge), discharge waste water directly into the surface water or recycle the waste water and deliver it for reuse purposes (Hammer & Levine, 2012). The effects of the treatment of shale gas waste water for the treatment plants and the effect of the delivery of shale gas waste water to these plants, to the environment are presented in the following two paragraphs.

Requirements disposal waste water to POTW

Next to limitations concerning the level of contaminants in the effluent, NPDES permits require the POTW's also to address the EPA and if necessary the state, if they want to start processing more or a different type of waste water (Hammer & Levine, 2012). Thus POTW's can become allowed to process other types of waste water than sewage water after consultation of the EPA or state. So, if POTW's aim at to start accepting shale gas waste water, while they have not processed this type of waste water before, they have to inform the EPA. The reason for this required notification can be found in the fact that different types of waste water, can cause problems inside the POTW's or can lead to the presence of contaminants in the effluent, as is the case for shale gas waste water. Therefore the POTW's have to provide an evaluation of the potential impact of a new type of waste water on the effluent, in advance (Hammer & Levine, 2012).

In order to prevent problems associated with the delivery of shale gas waste water to POTW's, the EPA has developed requirements for the disposal of industrial water to POTW's (Hammer & Levine, 2012). First, industrial plants are not allowed to deliver any pollutant to the POTW's that could disrupt the process, or could leave the POWT in such concentrations that the POTW cannot comply with its NPDES permit (Hammer & Levine, 2012). The TDS present in shale gas waste water could create both problems. First, some aspects of the TDS may be able to disrupt the plant (Hammer & Levine, 2012). Second, even though the NPDES permits may set maximum allowances for TDS, POTW's are not developed to remove these solids and therefore do not have processes capable of doing this. Therefore the TDS can be present in the effluent of the POTW's (Hammer & Levine, 2012).

The second requirement set by EPA includes the pretreatment standards for specific types of waste water, which pose maximum allowances for certain contaminants present in the waste water delivered to the POTW's (Hammer & Levine, 2012). However, there are no pretreatment standards set for waste water coming from shale gas activities (Hammer & Levine, 2012). However, the EPA has declared to develop these standards (Hammer & Levine, 2012). Anyhow, this means that currently the POTW's face problems if shale gas waste water is delivered to these plants, since this waste water is not subject to pretreatment requirements and could lead to violation of the NPDES permits as well as to destruction of the plant.

However, the EPA has also developed a third part of the pretreatment requirements which requires POTW's to develop their own pretreatment programs (Hammer & Levine, 2012). These pretreatment programs are developed to reflect the 'local limits' of the plant (Hammer & Levine, 2012). These limits pose the maximum allowances of pollutants which can cause disruption or which can leave the plant in harmful concentrations (Hammer & Levine, 2012). The EPA provides help for the municipalities in determining their own local limits (Hammer & Levine, 2012). However, these local limits have seldom been established by POTW's for shale gas waste water, which implies that the plants still face the risk of destruction and violation of the permits (Hammer & Levine, 2012). For this reason, federal regulations on this issue could be valuable to protect the processes inside these POTW's as well as the water quality.

Outdated Effluent Guidelines CWT's

As stated before, the Effluent Limitations Guidelines present in an NPDES permit are different for different facilities. Therefore, the ELG and NPDES standards for CWT's are different than those for POTW's, amongst others because CWT's process different types of waste water streams. The Effluent Limitation guidelines for the effluent of CWT's were developed in 2000 and last amended in 2003 (Hammer & Levine, 2012). This was before the shale gas evolution took its flight. Contaminants such as oil and grease, Total Suspended Solids (TSS) and the biochemical oxygen demanding pollutants are taken into account in these guidelines (Hammer & Levine, 2012). However, the 'new' pollutants, typical for shale gas, such as TDS, bromide and the radioactive materials are not integrated in these guidelines (Hammer & Levine, 2012). Also, the chemical components added in the hydraulic fracturing process, are not taken into account in the NPDES permits (Hammer & Levine, 2012) This may lead to an effluent which could still contain these 'new' pollutants and chemical additives. These contaminants are not even monitored because they are not present on the permit. Thus, the discharged water can contain contaminants which can affect the quality of the water bodies in which the water is discharged. For this reason, the effluent guidelines and there with the NPDES standards for these contaminants need to be updated in order to preserve the desired water quality.

CWA requires adjustments

Concluding, it seems the CWA requires adjustments in order to fulfill its purpose; to control the release of harmful pollutants into water bodies. The shale gas industry delivers new pollutants which require adjusted water criteria, ELG and NPDES permits. These changes in the Formal institutions will require adjustments in the Technical system, such as the development of processes to monitor and treat these new contaminants. In addition, the (pretreatment) requirements concerning the delivery of shale gas to the treatments facilities have to be improved to ensure that the plants do not get destructed and that the effluent of these plants will not contain harmful pollutants. Also these rules and regulations can have effect on the Technical system, since shale gas production companies may have to change their processes in order to comply with these standards. Another option would be to deliver the waste water to a company which treats the waste water until it meets the pretreatment standards. In that case the costs of the shale gas production would increase, which could make it necessary to adjust the Technical system to lower the costs. Though, at this moment, with the current rules, no incentives for improvements of the Technical system are present, since there are no rules which make these improvements necessary.

At this moment people may feel unprotected by the government, since their surface water may contain harmful pollutants. Contamination of this surface water will have effect on their living environment. For instance their cattle may not have safe drinking water and water may not be safe for recreation. These assumptions, may lead to resistances from the Informal institutions against the shale gas industry. Thus, in order to prevent these resistances, the CWA has to be updated.

6.4.3.3.3. Clean Air act

The clean air act is developed to protect and improve the quality of air and the ozone layer (Environmental Protection Agency, n.d.-e). These two aspects are the responsibility of EPA (Environmental Protection Agency, n.d.-e).

The EPA applies the Clean Air act Regulations to regulate oil and natural gas exploration activities (Environmental Protection Agency, 2013a). Therefore this act is also applicable to the exploration of shale gas. Together with the Department of the Interior and other federal agencies, the EPA aims to better describe and decrease emissions and their impact, which evolve from the exploration of natural gas (Environmental Protection Agency, 2013a). These regulations include the requirement to provide a report on the greenhouse gas emissions related to the production of natural gas (Environmental Protection Agency, 2013a).

Negative effect exploration natural gas

The exploration of natural gas may pose negative effects on the air quality (see appendix IV). The EPA has determined that uncontrolled well completions with hydraulic (re)fracturing always results in Volatile Organic Compound (VOC) emissions that were not present previous of these fracturing activities (Environmental Protection Agency, 2012a).

In addition, during the production of natural gas, air toxics are released that are related to cancer as well as to other negative health effects (Environmental Protection Agency, 2012b). States had already developed requirements which aim at minimizing the risk that these toxics are released (Environmental Protection Agency, 2012c). However, these requirements did not pose such significant consequences for the Technical system that the system had to be adjusted. Therefore the effects of the Technical system on the air quality have not changed either.

The increased VOC emissions due to hydraulic fracturing may lead to the resistances from local residents and environmental protection groups. In order to overcome these resistances, the Formal institutions have to become more stringent towards the release of emissions and air toxics. This will provide an incentive for the Technical system to improve and overcome these resistances.

6.4.3.3.4. Resource conservation and recovery act

The Resource Conservation and Recovery Act (RCRA) regulates the treatment and discharge of waste (Hammer & Levine, 2012). This entails that it regulates the transportation, treatment, storage and disposal of waste (Hammer & Levine, 2012). Though, due to an amendment to this act in 1980, waste from the oil and gas sector is exempted from the regulations under this act (see appendix IV) (Hammer & Levine, 2012).This implies that waste generated with oil and gas activities is not considered hazardous waste. Thus, when waste water coming from shale explorations, for instance, is transported, it is not transported as hazardous waste (Hammer & Levine, 2012). This leads to the consequence that precautions set by the RCRA for transport, do not have to be met (Hammer & Levine, 2012). The same accounts for the storage , handling and disposal of waste derived with shale gas activities (Hammer & Levine, 2012). In addition, due to this act, the usage of shale gas waste water for land application is not regulated at a federal level (Hammer & Levine, 2012).

So, due to a lack of federal rules, there is room for the states to regulate the management, transport, storage and land application of this wastewater on a state level (Hammer & Levine, 2012). For this reason, the storage of shale gas waste water in tanks and impoundments is regulated on state level (Hammer & Levine, 2012). Because of the lack of federal rules, the regulations how to handle, transport, store and dispose the shale gas waste may differ per state. Furthermore, due to the lack of state regulations, the states are provided with the option to apply regulations; they are not required to do this. This provides the freedom to the states to not apply more stringent rules and regulations on these activities, which leaves room for negative effects to the environment and human health. This issue is also acknowledged by the current research of the EPA, which evaluates if there is need for state guidance on the development and operation of pits under the RCRA in order to decrease the associated environmental problems (Environmental Protection Agency, 2013a). However, due to the content of the RCRA the effect is expected to be limited, since the waste water will still be exempted from precautions applicable for hazardous waste.

Furthermore, as stated, the usage of waste water for land aims such as deicing is due to the RCRA also regulated on state level (Hammer & Levine, 2012). In some states permits are provided to use waste water for road application while the state of new York does not provides these permits, since it perceives that there is insufficient information on Naturally Occurring Radioactive materials (NORM) to state that land application does not provide a potential danger (Hammer & Levine, 2012). Thus, the states do not agree on the effect of this land application. This may provide a signal to residents that land application does have negative effects, and that residents of the states in which land application is allowed, are subject to health and environmental risks. Together, with the knowledge that states are not required to apply more stringent rules, residents may feel threatened by the development in the shale gas industry. This can lead to resistances in the Informal institutions.

Since the RCRA leads to a lot of options and almost no resistances on federal level for the Technical system, the RCRA can be considered as a supportive element for the Technical system. Therefore, no incentives were posed by the Formal institution to improve the Technical system in terms of handling, transport, storage and disposal of shale gas waste (water). For this reason, only minor changes in the form of best practices have been achieved in this field, though these are not obligated by federal law.

6.4.3.4. Other EPA actions

Next to the rules and regulations, EPA has also developed programs in order to minimize emissions associated with the oil and gas industry. In 1992, the EPA developed the STAR program. The goal of this program is to explore technologies which may reduce methane emissions in the oil and gas sector in a cost effective way (Environmental Protection Agency, 2013a). The STAR program is a voluntary partnership between oil and natural gas companies, developed to exchange best practices in order to improve technologies and minimize methane emissions and other negative environmental impacts concerned with the production of oil and natural gas (Environmental Protection Agency, 2013b). Due to this program best practices in the field of shale gas can be exchanged, which may lead to adjustments and improvements in the Technical system. Furthermore, the development and combination of best practices provide possibilities for innovations in the shale gas industry. This program can (partly) replace the necessary incentives in the form of rules and regulations, and may support the improvement of the Technical system in another way. Moreover, these improvements can lead to a more cost-effective system, which can be a reason for companies to implement these advancements. Furthermore the best practices developed in this program, might be able to decrease the negative effects of shale gas exploration on the environment and human health and may therewith decrease the resistances from the Informal institutions.

The second example of a program developed by EPA, is the clean construction program that encourages the usage of more efficient technologies and cleaner fuels for the hydraulic fracturing equipment and transport vehicles (Environmental Protection Agency, 2013a). This program also aims at the minimization of emissions (U.S. Department of energy, 2013). However, the program only includes the equipment and vehicles that use diesel (see appendix IV for more information) (U.S. Department of energy, 2013). This program may also lead to an improved Technical system and a reduction in resistances derived from the Informal institutions.

6.4.3.5. The Frac act

Due to the public concern about the environmental impact of hydraulic fracturing, the 'Fracturing Responsibility and Awareness of Chemicals' (FRAC) act was introduced in 2009 (Sakmar, 2012). This act would amend the definition of "Underground Injection" in the SDWA (Sakmar, 2012). In the changed definition of *Underground injection* the underground injection of fluids or propping agents, used during hydraulic fracturing processes would also be included in the definition of underground injection, instead of being excluded (Sakmar, 2012). This would mean that hydraulic fracturing would again be regulated under the UIC program and therewith would fall under the SDWA again. This would provide the EPA with the authorization to regulate the fluids and propping agents used during hydraulic fracturing. The FRAC act would acquire companies to reveal the chemicals used during hydraulic fracturing (Sakmar, 2012) However, the act is still awaiting its confirmation (Sakmar, 2012). Though, some states require the publication of the chemicals used per well, on the website Fracfocus (Sakmar, 2012). Since, it is often not known which chemicals are used; it is difficult to understand their effect in the environment. The publication of these chemicals could increase the understanding which chemicals create negative effects. Furthermore, the obligation to make chemicals public could lead to the usage of different chemicals, since some chemicals may be perceived as negative by the public and may lead to reputation loss for companies.

The adjustments in the usage of chemicals can be considered as changes in the Technical system. Additionally, the obligation to make the chemicals public increases the information available for the public, which may increase the level of trust and reduce resistances from the Informal institutions. However, the publication of the chemicals may also have the reversed effect and increase the fear amongst residents, since many people will not understand the function and effect of these chemicals. Therefore, the publication of these chemicals should be accompanied with a thorough explanation of the function and possible effects of the chemicals. Otherwise, the opposite and unwanted effect, an increase of informal resistances, could happen.

6.4.4. Consideration Formal institutions until 2010

As stated before when considering the time line, until 2010 the Formal institutions were mainly supporting the development of shale gas. Instead of adding more stringent regulations, when the activities in the shale gas industry increased, the Halliburton loophole was introduced, which even decreased the amount of regulations for the exploration of shale gas. Furthermore, shale gas waste is due to its exemption under the RCRA, not considered as hazardous waste and is therefore subject to less stringent rules. Also, the regulations concerning the mineral rights and the tax breaks were instruments which both supported the development of shale gas and did not pose any limitations for the development of shale gas.

Furthermore, because of the lack of updated water criteria and updated ELG, the NPDES permits are not adjusted to the delivery of shale gas to water treatment plants yet. In addition there were no pretreatment standards for waste water generated with shale gas exploration activities. Therefore there were also no limiting requirements in this field of the Technical system and operators could deliver their shale gas waste water to water treatment facilities without any pretreatment.

Thus, almost no resistances were offered by the Formal institutions until 2010. This was expected, since no resistances were provided by the Informal institutions either. So, until this point the institutions were congruent. In the next paragraph the desired alterations for the Formal institutions, and the alterations in the Formal institutions after 2010, after the first resistances were posed by the Informal institutions, are presented.

6.4.5 Formal institutions after 2010

6.4.5.1. Desires for regulation on federal level

Although, oil and gas exploration activities have always been regulated by state governments, increased calls for federal regulation and investigation are coming from landowners, environmental and citizen groups (Sakmar, 2012). They feel that federal laws are necessary to mitigate the negative effects related to the oil and gas activities. Even though the process of hydraulic fracturing of shale formation itself is not considered the source for groundwater contamination, there are other significant problems concerning water because of the production of shale gas, which have triggered the discussion if the state laws on well construction and water management are adequate enough and enforced in the right way, to protect the human health and environment (Tiemann & Vann, 2013). Though, during the last years, several states have revised their laws and regulations to make them more suitable for the processes of hydraulic fracturing (Tiemann & Vann, 2013). Also, some states have attained more inspectors to manage the growth in the amount of exploration and production activities (Tiemann & Vann, 2013). However, until today the oil and gas industry has claimed that the states are the best capable to regulate the issues associated with the oil and gas industry (Sakmar, 2012). This is also underlined by the Ground Water Protection Control (GWPC) (Sakmar, 2012). Though, as stated before, due to the lack of federal regulation, state regulations do not have to be applied which leaves room for the negative effects associated with the exploration of shale gas. More stringent federal laws could mitigate these problems. These more stringent federal laws would require adjustments in the Technical system to comply with these rules, which then would be the same thorough the whole U.S. These federal laws may increase the feeling of citizens that they are protected by the government, which may reduce the resistances. So, if the Technical system is able to comply with these more stringent (federal) rules and regulations, this may be beneficial for all parties.

6.4.5.2. The new regulations of the clean air act

The Clean Air Act has been updated (see appendix IV for more information). On April 17th 2012, the EPA has issued new regulations in order to reduce harmful air pollutions related to natural gas and oil exploration activities (Environmental Protection Agency, n.d.-g). These regulations pose the premier federal air standards for natural gas production for which hydraulic fracturing is used (Environmental Protection Agency, n.d.-g). These regulations were developed based on feedback of several stakeholders such as the public, public health groups, the states and the industry (Environmental Protection Agency, n.d.-g)(Environmental Protection Agency, 2012c).

New Source Performance Standards

The New Source Performance Standards (NSPS) for the natural gas and crude oil industry are part of these new regulations and are established to regulate VOC emissions produced from gas wells as well as from other VOC emitting aspects (Environmental Protection Agency, 2012c). These standards imply that in the period until the first of January 2015, operators have to decrease their emissions either by flaring using a completion combustion device or by capturing the gas by making use of green completion (see appendix IV) (Environmental Protection Agency, 2012c)(Environmental Protection Agency, n.d.-h). A completion combustion device is used to burn the gas which would otherwise escape into the environment (Environmental Protection Agency, n.d.-h). This process is also known as flaring. During the green completion process, the gas and liquid hydrocarbons are removed from the rest of the flow back, where after these can be sold when treated (Environmental Protection Agency, 2012b). The usage of completion combustion devices to reduce VOC emissions is allowed until the first of January 2015, however the usage of green completion is encouraged (Environmental Protection Agency, n.d.-h) After January the first, 2015, operators both have to capture the gas by means of green completion and they have to use a completion combustion device (Environmental Protection Agency, 2012a). However, when the utilization of green completion is not feasible, operators are not required to use it (Environmental Protection Agency, 2012a).These final rules do not necessitate federal permits, but make use of standards and reports delivered by operators to increase insight in the activities of the operator (Environmental Protection Agency, 2012c).

These rules will require adjustments in the Technical system. However, these technologies are already used in 50 percent of the fractured wells and are congruent with the path the industry is taken in capturing natural gas which can then be sold (Environmental Protection Agency, 2012c). These NSPS may lead to a reduction of VOC emissions of 95 percent and a decrease in air toxics and therewith to a decreased negative effect of shale gas on the air quality (Environmental Protection Agency, 2012b)(Environmental Protection Agency, 2012c). These benefits may decrease the feeling of citizens that shale gas poses a threat for the environment and health. This is expected to have a positive effect on the attitude of the residents and may lead to reduced informal resistances.

6.4.5.3. Stricter regulations on state level

In 2011, the state of Pennsylvania has updated the chapter 95 regulations for 'new and expanding' waste water streams. The content of these updates and its effects can be found in appendix IV. These updated regulations present that the state regulations may indeed be stricter than the federal laws. Though, it also presents that even though these regulations may be more stringent, they are not always consistent and capable of mitigating all the risks considered with the discharge of treated shale gas waste water. Therefore, these state laws may also need to be improved to protect the citizens. These more stringent regulations would require adjustments in the Technical system, especially in the system of water treatment.

6.4.5.4. Impact study hydraulic fracturing on drink water

At this moment EPA, is performing a study in order to gain a better understanding of the impact of hydraulic fracturing on drink water sources and ground water (Environmental Protection Agency, n.d.-i). The first progress report was delivered in December 2012 and the final draft report, which will be open for public comments, will be finished in 2014 (Environmental Protection Agency, n.d.-i).

6.5.5. Lack of response Formal institutions

With the resistances evolved from the Informal institutions since 2010, it would be expected that the Formal institutions would be adjusted in order to overcome these resistances and make the institutions congruent again. However, with the previous described alterations and new rules and regulations considered, it is obvious that the resistances posed by the Informal institutions will not be overcome by these adjustments. These adjustments consider only several aspects in the shale gas case, and will not be sufficient to protect the citizens and the environment. Therefore the fear of citizens that they are unsafe will not be reduced. Thus, the resistances posed by the in Formal institutions are expected to maintain until more adequate rules and regulations will come into place. Until the moment that more stringent rules and regulations will be applied, possible at state level, improvements in the Technical system, unless voluntary, are unexpected.

6.5.6 Resistances and effects Formal institutions

From this analysis it can be concluded that the development of shale gas is almost not limited by the resistances posed by the Formal institutions. The only limitations consider the facts that operators need to obtain a permit when they want to use diesel, that operators have to use both green completion and a completion combustion device from 2015 and that operators are not allowed to discharge waste water directly into the surface water. Furthermore, the Formal institutions were actually supporting the shale gas developments in terms of royalty shares and the tax breaks.

Though, due to the inadequacy of the Formal institutions to pose incentives for the Technical system to mitigate the negative effects, there are significant risks for the human health and the environment associated with the resource shale gas. These negative effects could, if these are not tolerated by the stakeholders, turn into resistances posed by the Informal institutions. It is expected that this will be the case, since many of these effects pose risks for the human health and the environment. Therefore, in order to prevent that resistances evolve from the Informal institutions, these risks should be mitigated by means of adjustments in the Formal institutions. Thus, these risks should be transformed into Formal resistances which pose incentives for the Technical system to mitigate the negative effects which pose these risks.

Formal resistances preferred above Informal resistances

The reason why Formal resistances are preferable above informal resistances is that Formal resistances are, normally, set after a well-considered process in which the facts are evaluated. It is a process which can be steered by the government and stakeholders. Informal resistances are often not that well formulated and understood and therefore more challenging to overcome. Furthermore, these resistances cannot be steered; they evolve as a reaction on the environment. In addition, these resistances do not set clear requirements which should be met. For example, the feeling that people are safe has to be fulfilled. This is very hard to achieve, since it is not possible to quantify this requirement and there no minima and maxima for this requirement. Also, the Informal resistances will take, when set, a significant amount of time to overcome, if this is possible at all, since all the people who are posing resistances have to be convinced that their norms and values are safeguarded again. For these reasons, the Formal resistances are easier to manage and achieve and are therefore preferred above Informal resistances. For this reason, it would be advisable to develop Formal resistances before the Informal resistances are developed. Because of this, the risks which appear due to a lack of adequate Formal institutions and which could lead to resistances are listed below. Suggestions are done how these risks can be mitigated by the creation of Formal resistances. By means of these Formal resistances, incentives for the Technical system are created to mitigate these risks.

Mitigation of risks by formal institutions

First of all, the fact that due to Halliburton loophole the underground injection of hydraulic fracturing fluids is not regulated, poses a risk for the environment. This amendment should be changed again, in order to provide the EPA with the authorization to regulate these activities again.

Second, there are risks for the human health and the environment since waste water may be injected in class II wells, while these wells have not been extensively tested yet and may not be suitable for the waste water coming from shale gas activities. This issue could be solved by lifting the exemption of oil and gas activities under the RCRA. The waste water should then be injected in class I wells, which are considered safe. By lifting the exemption of the oil and gas activities from the RCRA the risk of contamination of the environment due to transport, storage or reuse of waste and residuals of shale gas activities could also be decreased.

Third, there is the risk that POTW's disrupt because of the shale gas waste water introduced in the plants which could result in the contamination of water bodies because of a lack of treatment. Pretreatment standards for shale gas waste water should be developed in order to overcome this problem. The water may also become contaminated, since many of the contaminants in shale gas waste water are not targeted in the treatment processes because they are not present on the NPDES permits of POTW's. This could also lead to contamination of the water bodies. In order to overcome this problem, the NPDES permits have to be updated for the introduction of shale gas waste water into these plants. This would, amongst other, require an update of the water criteria for the 'new' contaminants present in shale gas waste water.

Fourth, there is the risk that water bodies will become contaminated due to lack of adequate treatment in the CWT's. This problem should be solved by adjusting the NPDES permit with updated ELG for the CWT's, in order to have the 'new' shale gas pollutants targeted to be removed.

Fifth, there is no thorough understanding of the effects of hydraulic fracturing on drinking and ground water sources. The EPA is working on a study which should provide more insights in these matters. However, this study should be speeded up, since the report will not be ready until 2014, while drink and ground water resources may be at risk.

Seventh, there is the risk for the environment and human health since the chemicals used during the hydraulic fracturing process do not have to be made public. Because of this, it is impossible for scientists to determine if the process of hydraulic fracturing could pose threats to the environment. By enacting the Frac act, this problem could be solved.

Finally, there is the risk of oversupply which could lead to low prices (discussed in Informal institutions). This risk will lead to resistances created in the Technical system, since the activities can become unprofitable. The Formal institutions could decrease these risks by developing a structure and a plan for the leasing of contracts in order to prevent an oversupply on the market.

These resistances overcome and posed by the Formal institutions as well as the risks which should be turned into Formal institutions are presented in the tables in appendix V.

6.5 Technical system

This paragraph explores the Technical system of the shale gas case. The Technical system described, comprises the most important technical assets which make the production and usage of shale gas as a resource possible.

Again, the occurrence of important events in the Technical system will be analyzed in relation to the events which occurred in the Informal and Formal institutions to increase the understanding on the relations and interactions between these three systems. This analysis will be done by using the timeline that is also used in the previous two paragraphs. The technical developments will be provided in a chronological way as far as possible.

The elements of the Technical system that will be discussed are the drilling technologies, the construction of the wellbore and the water management system. Furthermore, a few aspects involved with the Technical system, which have raised concerns such as earthquakes are shortly discussed. For the part on water management, most data is derived from the State of Pennsylvania. This because the Marcellus shale, present in Pennsylvania, is one the biggest shale gas plays for which a lot of data is present. It is understood, that conditions may be different in other states. Therefore the data from Pennsylvania is only used to illustrate what can happen around large shale gas plays and which technologies could be used. In order to understand the effects of exploration of shale gas in all states, an assessment of all the states in the U.S. where shale gas is explored would be necessary. However, this is, due to the time limit, not possible.

The technical aspects are described in two sections; the Technical system used to overcome the resistances of Nature and the Technical system used to overcome the resistances posed by the Formal and Informal institutions. First the technical improvements which made it possible to overcome Nature's resistances are discussed. Also, the aspects of the Technical system which could lead to resistances, due to its effects on society, will be presented. Hereafter the aspects of the Technical system, used to overcome the Formal and Informal resistances, are presented. Hereafter a subject is explored which is one of the major issues that provides Informal resistances; ground water contamination. This paragraph ends with the conclusions on the Technical system. This conclusion presents the resistances overcome by the Technical system and the negative effects related to the Technical system which could lead to resistances. In addition, an overview of the resistances which are overcome by the Technical system and the ones which have evolved from the Technical system can be found in appendix V.

6.5.1 Time line

When considering the time line, presented in figure 25, it can be concluded that during the period in which the Technical system was developed, the Informal institutions and Formal institutions were mainly supportive and did not pose any resistances. Therefore, the development of the Technical system did not have to meet many requirements and could evolve in the best technical way, without consideration of aspects related to the institutions. The first resistances concerning shale gas, evolved almost 20 years after the last important technical improvement. During these 20 years the production was continued and further developed, and apparently there were no issues in the institutions which provided resistances. It was not until 2010 that the documentary G*asland* has attracted the attention to this industry.

Considering both the time period of 20 years, between the technical developments and the first Informal resistances, and the fact that a documentary was one of the reasons why there was finally a reaction from the Informal institutions, it appears that the whole system in the U.S. is actually rather slow in reacting to the developments in other areas. The Formal institutions are also not adequate in reacting to the resistances posed in the in Formal institutions, as can be seen in the amount of risks and resistances that are still present, though which could be overcome by the Formal institutions (see appendix V). Also, the fact that the study on the impact of hydraulic fracturing is not released until 2014 provides an example of this slow reaction. This study is finished 24 years after the final technical improvements, which made it possible to extract shale gas, were done.

As stated, when Formal institutions do not change and pose Formal resistances, the Technical system is not offered an incentive to improve either. This is also the reason why there have not been major changes in the Technical system after 1990, there were no Formal institutions which required these improvements. Therefore the activity in the Technical system was low after 1990. This period is marked gray in the timeline. This does not imply that there were no improvements at all; however no significant improvements were done to overcome resistances, either posed by Nature, Informal institutions or Formal institutions. The improvements presented in the timeline of the Technical system all aimed at overcoming the resistances posed by Nature. The next improvements of the Technical system, to limit the negative effects of the resource shale gas and limit the resistances evolved, should be aimed at overcoming the resistances posed by the Formal institutions and therewith the resistances of the Informal institutions. Though, how these improvements will look like, will depend on the Formal institutions which first have to be developed.

6.5.2 Technical Improvements to overcome Nature's resistances

In the end of the 1820's, in New York, shale gas was for the first time commercially extracted from the ground (Kefferpütz, 2010). However, the radical change in the 1980s, which gave the shale gas evolution it's kick-start, came from the company Mitchell Energy (Kefferpütz, 2010). This company experimented with new and innovating drilling techniques (Kefferpütz, 2010). These techniques were hydraulic fracturing and horizontal drilling (Kefferpütz, 2010). When these technologies were developed there were no Formal or Informal institutions which posed resistances for this development. Therefore, the development was only focused on the technology and not on how these inventions could be done in a way which was congruent with these institutions. There was a lot of room to experiment with technologies and there were little limits posed by the government. However, there are some effects of these technologies which could lead to resistances in the Informal institutions. This is further explained in the paragraph *potential resistances drilling system (6.5.3).*

Horizontal drilling

The first horizontal well was drilled in 1929 in Texas (U.S. department of the Interior & U.S. geological Survey, 2013). Though it took until 1980 that the technology was improved to such extent that it could become a widely used operation in the drilling industry (U.S. department of the Interior & U.S. geological Survey, 2013). Due to this technology operators could now drill until 21000 ft. deep, several hundred feet above the target reservoir, where after the drill bit was directed through a curved unit to drill for another 6000 ft. horizontal (U.S. department of the Interior & U.S. geological Survey, 2013)(Kefferpütz, 2010). The usage of horizontal drilling brings the following benefits:

- The part of the reservoir which can be drilled horizontally is increased from only a few feet to more than 5000 ft. (U.S. department of the Interior & U.S. geological Survey, 2013)
- It provides an increased number of vertical and sub vertical fractures that are crossed and interconnected (U.S. department of the Interior & U.S. geological Survey, 2013)
- It may be used to exploit hydrocarbon resources underneath area's where a rig cannot be placed such as wetlands or populated areas such as cities (U.S. department of the Interior & U.S. geological Survey, 2013).

Hydraulic fracturing

Hydraulic fracturing was initially developed to stimulate oil wells with a declining production activity (Tiemann & Vann, 2013). Currently, due to advancements in technology, it is can be used to initiate oil and gas production from formations with a low permeability (Tiemann & Vann, 2013).

The process of hydraulic fracturing can take place after the horizontal well has been drilled. During the process of hydraulic fracturing water, sand and chemicals are pumped into the well under a very high pressure in order to fracture the rock (Stevens, 2012). The fractures in the rock serve as canals through which the gas can migrate into the well (Geology.com, 2013). Figure 26 presents the process of hydraulic fracturing.

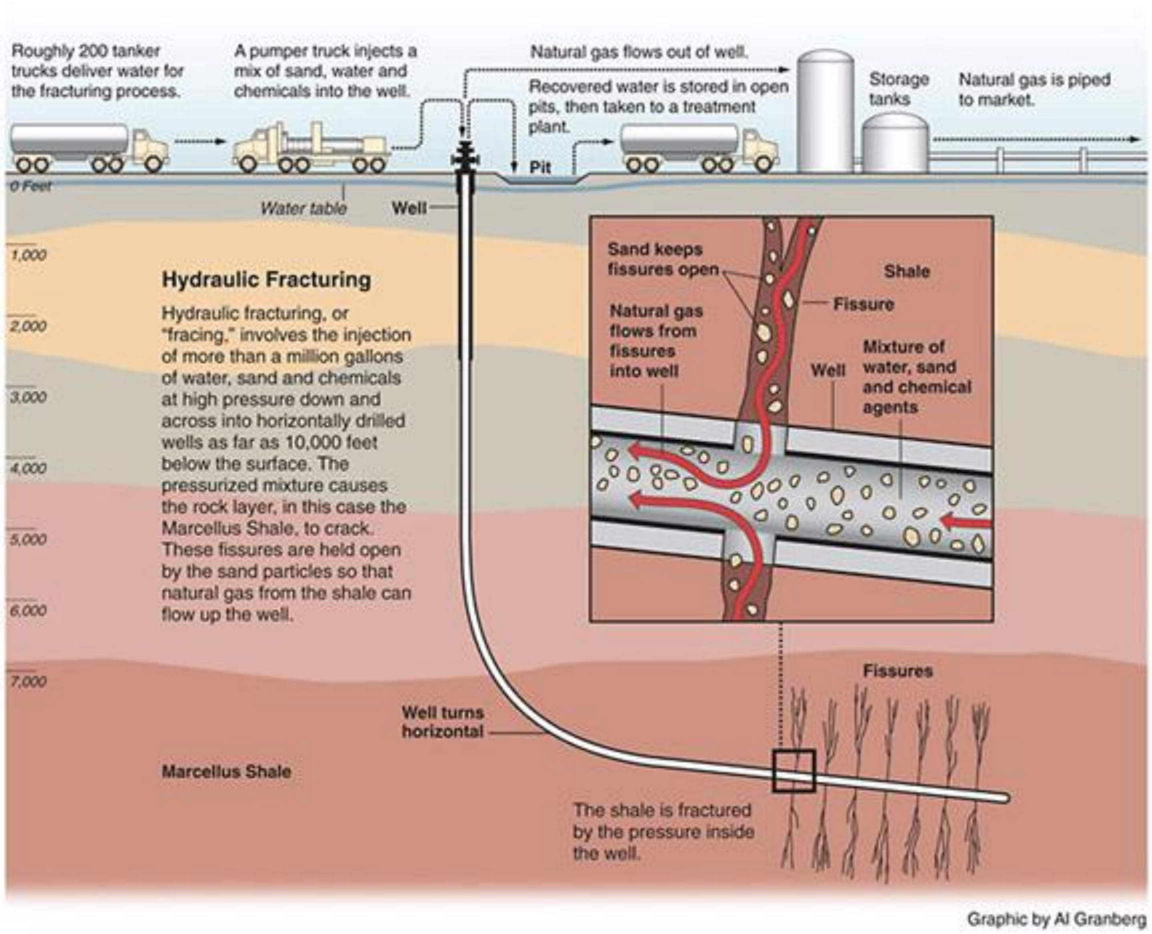


Figure 26 Hydraulic fracturing (ProPublica, n.d.)

Since 1940 over a million wells have been drilled with the usage of hydraulic fracturing (Sakmar, 2012). At this moment in 90 percent of the oil and gas explorations, hydraulic fracturing is used to induce production (Chevron, 2012).

The advancements in the hydraulic fracturing fluid may be considered as the final important improvement in the Technical system. This improvement considered the development of the technology of "slick-water-fracturing". This technology was developed in 1990 during the development of the Barnet shale (U.S. department of the Interior & U.S. geological Survey, 2013). During this process, the hydraulic fracturing fluid consisting of sand and water is injected with friction reducers such as a gel (Go Frac, n.d.) (U.S. department of the Interior & U.S. geological Survey, 2013). This technology enables the maximization of the length of the horizontal well and the minimization of the vertical height of the fracture (U.S. department of the Interior & U.S. geological Survey, 2013). These improvements led to an increased mobility of the gas (U.S. department of the Interior & U.S. geological Survey, 2013). Furthermore, the production of gas in high volumes could happen in a more efficient way (U.S. department of the Interior & U.S. geological Survey, 2013). Today, more technologies are developed in order to stimulate the production of the wells (Go Frac, n.d.).

The mixture of the fracturing fluid today consist for 99 percent out of sand and water (Chevron, 2012). The sand is used maintain the cracks from closing, in order to keep the gas flowing, also referred to as a propping agent (Chevron, 2012). The remaining one percent is left to several chemical additives with multiple functions (Chevron, 2012).

Role independent drillers

Even though, it now became possible to extract natural gas from shale formations by means of horizontal drilling and hydraulic fracturing, companies were not convinced that this could bring them significant amounts of money (Kefferpütz, 2010). The big companies kept their focus on finding new gas fields, and left the opportunities to drill in unproved fields to the smaller drilling operators (Kefferpütz, 2010). These independent driller have succeeded in opening up many shale 'plays' (Kefferpütz, 2010).

6.5.3 Potential resistances drilling system

The aspects of the exploration of shale gas, which may be considered as negative by the stakeholders, are evaluated in this paragraph. If the perceived negative effects are not tolerated by the stakeholders, resistances may be created in the Informal institutions.

Water usage

The water demand of a well, which may have to be fractured several times, may vary between 0.5 million up to more than 6 million of gallons per well (Tiemann & Vann, 2013). In North Texas, the water demand for the production of the Barnett shale in combination with population growth and drought, has led to fears about the water stock (Sakmar, 2012). According to a study of the Texas Water Development Board (TWDB) more than 3.5 million gallons of water may be necessary for the fracturing of a horizontal well (Sakmar, 2012). Though, the well may have to be re-fractured several times, since the production flow of gas can decrease after multiple years of production (Sakmar, 2012). The TWDB estimated that the water usage of the Barnett shale complied to three percent of the groundwater used in 2005 (Sakmar, 2012). They expect this percentage to increase with seven to thirteen percent in 2025 (Sakmar, 2012).

Also, the local water management agencies in the Marcellus play area are worried how these volumes of water are to be attained (Sakmar, 2012). Also, they are concerned about the effect of these required volumes on the local water supply (Sakmar, 2012). According to Chesapeake Energy corp., one of the operators in the Marcellus shale, the fracturing of horizontal deep shale gas well requires on average 5.5 million gallons of water (Sakmar, 2012). However, the biggest share of this water, 60-80 percent, will come back to the surface (Sakmar, 2012). Though, this water will require severe treatment, since according to the USGS three million gallons water would bring 15.000 gallons of chemicals back up (Sakmar, 2012).

These fears could be converted in resistances from the local governments to allow shale gas exploration in their regions. Also, worried residents may pose resistances against the exploration of shale gas in their surrounding, because of the fear for water scarcity. If rules and regulations could be developed to prevent the possibility of water scarcity, these resistances could be mitigated. Also, improvements in the Technical system, aimed to decrease the water requirement, could overcome the possible resistances. The technologies that aim at the minimization of water usage and waste water production are still under development (Hammer & Levine, 2012). However the benefits of these technologies remain uncertain (Hammer & Levine, 2012). One of the benefits of system which would require less water could be formed by a cost reduction for the operator, because less water is required. Though, it may be possible that a cost incentive is not enough for operators and that more stringent Formal institutions are necessary to provide the necessary incentive to improve the technological system in terms of water usage.

Chemical additives fracturing fluid

Some of the chemicals which are used in the hydraulic fracturing fluid are toxic, even in small concentrations (Hammer & Levine, 2012). The chemical additives used in the fracturing fluid have been subject of attention, since 29 of these chemical additives used, have been considered as potential danger for human health (Hammer & Levine, 2012). Furthermore thirteen of these chemicals have been evaluated as likely or diagnosed *human carcinogens* (Hammer & Levine, 2012). The most important are 2-butyxythenaol also known as 2BE, naphthalene, benzene and polyacrylamide (Hammer & Levine, 2012). The added chemicals are causing fear among citizens, especially since the chemicals used do not have to be made public according to federal law. Only in some states this is required (see Formal institutions). Since, people fear for their health and their environment they are posing resistances against the usage of these chemicals. Even though, these chemicals may not pose any threat to their health and environment, people may still be scared. In order to provide safety for the citizens as well as to provide this feeling of safety to citizens who might judge the effect of the chemicals used incorrect, the Formal institutions should be adjusted to both protect the citizens and increase the understanding amongst citizens on which chemicals are allowed and for what reason. This could be done by enacting the Frac act (see Formal institutions). The Formal institutions may also pose incentives for the Technical system to use only environmental friendly chemicals or chemicals for which the effects are understood, by the development of a list of chemicals that are allowed for usage.

However, some of the chemicals which are added to the hydraulic fracturing fluid can also be present in the formation and may therefore come to the surface along with the water which is produced from the well in a later stage and possibly in a larger amount (Hammer & Levine, 2012). The most significant problems with these chemicals are formed by the biologically active chemicals and the chemicals that are assumed to have negative effects on human health (Hammer & Levine, 2012). This knowledge leads to the understanding that improvements in technologies and requirements of the Formal institutions will not eliminate all problems concerned with hydraulic fracturing and the usage of chemicals, since many chemicals are present in the formation and can therefore be brought to the surface when the formation is fractured, even when no chemical additives are used (Hammer & Levine, 2012). Because of the presence of the chemicals in this water, the treatment and handling of produced water should be managed with care. However, this would also require more stringent rules and regulations, because (due to the RCRA) this waste water is not considered as hazardous waste and therefore does not have to be handled as such. This could provide risks for the environment and human health.

Induced seismicity

There has been a discussion on the induced seismicity due to processes of hydraulic fracturing. However according to the study *Induced Seismicity Potential in Energy Technologies*, the processes of hydraulic fracturing does not pose a high risk of inducing seismic events that can be noticed (Committee on Induced Seismicity Potential in Energy Technologies et al., 2012). Only at one place in the world the hydraulic fracturing of a well has been identified as the reason for a minor *seismic event* (Committee on Induced Seismicity Potential in Energy Technologies et al., 2012). The introduction of waste water, does create some risks of induced seismicity, however only a small number of these cases is present (Committee on Induced Seismicity Potential in Energy Technologies et al., 2012). Especially, when this number is compared with the amount of wells used for the disposal of waste water (Committee on Induced Seismicity Potential in Energy Technologies et al., 2012). The reason for this low number of events, is because these disposal wells are capable of storing a large volume of waste water and the injection takes place at a very low pressure (Committee on Induced Seismicity Potential in Energy Technologies et al., 2012). Therefore, induced seismicity is not considered to create significant negative effects, based on this study. However, additional research may be required to provide a more founded answer on the risk of induced seismicity.

People may fear induced seismicity and may therefore pose resistances. These resistances could be overcome by the distribution of correct information on this subject to citizens, assuming that hydraulic fracturing indeed does not lead to induced seismicity, by an objective and trustworthy institution. Since, the role of the EPA is not perceived as trustworthy by some stakeholders, this party is not suitable. Universities may provide a more feasible candidate for this role.

More wells

Due to the low permeability of the shale formations, more wells have to be drilled than required for the exploration of a conventional reservoir (Tiemann & Vann, 2013). Though, from each well path six to eight horizontal wells can be drilled that enter the same reservoir (Tiemann & Vann, 2013). This increased number of wells to be drilled does not seem to pose an effect which is evaluated as negative in the U.S. This is probably because of the abundance of space. Therefore, this subject is not expected to create resistances in any system in the U.S. and will therefore not be considered in more detail.

6.5.3.1 Wellbore construction

The next facet in the Technical system of shale gas is the construction of the wellbore. This technology cannot be considered as one of the improvements which led to the overcoming of resistances specific for shale gas. Namely, this technology was already used for drilling towards conventional oil and gas reserves and has already been used for a long period. Even though, this system is not specifically developed to overcome the resistances associated with shale gas, it will still be considered in this research in order to evaluate the possible negative effects. The reason for this is that the construction of the wellbore forms an important aspect of the Technical system of the resource shale gas.

Poor wellbore construction can be the cause of leakage of drilling fluids into the environment and the migration of gas into the groundwater. These effects are in most cases perceived as negative and can create fear amongst citizens that their ground water can become contaminated. This can lead to Informal resistances. The Technical system of and the several options for wellbore construction are thoroughly described in appendix IV.

Threats improper wellbore construction

The proper construction of the wellbore is an important aspect towards safe exploration of shale gas. If technologies and instruments are used in proper way and best practices are used, the biggest threat is formed by the behavior of the operator. If the operator would act with a state of mind to protect both the environment and the shale gas industry and if the processes are executed in the correct way, the problems seem limited. Several studies have indicated that the contamination of groundwater due to hydraulic fracturing is very unexpected, if operators comply with the standards and use best practices available for the construction of the wellbore and the drilling process (Prohaska & Thonhauser, 2012).

Though, the implementation of these best practices concerning the wellbore construction may require investments from the industry (Prohaska & Thonhauser, 2012). The unwillingness to pay for the costs associated with this implementation may be the cause of poor wellbore construction, even though this could lead to ground water contamination (Prohaska & Thonhauser, 2012). However, according to Informal sources, even when the operators do comply and act responsible, the risk of contamination can still be present, due to the complexity of the process. However, in order to eliminate the possibility that operators do not use the best available options present, which could at least minimize these risks, federal laws or state laws should be developed which obligate operators to act responsible and use responsible technologies. This responsible behavior is often already voluntarily presented by companies who may suffer reputation loss if they are involved with a case of ground water contamination. However, the smaller operators, who are not known by the public and do not face problems such as reputation loss, may form a danger for the environment and human health, since they have no incentive to implement best practices and show responsible behavior.

The negative effects related to improper wellbore construction can lead and have already led to resistances from Informal institutions. These resistances can be solved or reduced by improvements in the Technical system (of the construction of the wellbore) which reduce the risk of the leakage of fluids or gas in the environment. However, as for every improvement necessary in the Technical system, it is expected that an incentive from the Formal institutions is required to make sure all operators use the best practices available and pose an incentive for innovations in the Technical system. Currently there are no (adequate) rules and regulations that mitigate the risks associated with the construction of the wellbore.

6.5.4. Water management in order to overcome Formal and Informal resistances

According to federal law, waste water is not allowed to be discharged into surface water without any treatment. So, this rule is one of the few resistances posed by the Formal institutions towards the Technical system. In order to overcome this resistance several water treatments options were developed to treat waste water. Because the exploration of shale gas generates waste water, the water treatment facilities are part of the Technical system of shale gas.

In the next paragraph, these different treatment options are analyzed. Furthermore the effect of these different water treatment options is discussed. With the analysis of the different treatment options and an example provided on the effect of treatment plants in Pennsylvania (stated in appendix IV) it will become clear that the current water treatment systems are not sufficient to mitigate the negative effects associated with the exploration of shale gas. These negative effects could turn into resistances if these are not tolerated by the stakeholders. These resistances will then evolve from the Informal institutions. In order to reduce or eliminate these negative effects and therewith the chance that resistances can evolve, it is necessary that both the Technical system and Formal institutions will be adjusted. However, it should be kept in mind, that this report does not provide data on all state laws; therefore it is possible that there are states who do manage this problem, though that this is not presented in this research.

6.5.4.1. Water treatment

The process of hydraulic fracturing generates two types of waste water, "Flow back water" and "Produced water" (Hammer & Levine, 2012). Flow back water refers to the fracturing fluid which is injected during the fracturing processes and which comes back to the surface when the pressure is released (Hammer & Levine, 2012). The water that returns to the surface in this early phase of the process will contain primarily the chemicals additives of the fracturing fluid (Hammer & Levine, 2012). The second type of waste water is "Produced water" which relates to all the waste water which emerges from the well from the moment production is started (Hammer & Levine, 2012). Produced water is more a reflection of the chemicals present in the formation. than the chemicals used in the fracturing fluid (Hammer & Levine, 2012). More information on the properties of these two types of waste water is presented in appendix IV.

The main difference between produced water coming from shale formations and from other formations is the high salt content of the produced water (Hammer & Levine, 2012). This produced water may contain three to ten times more salt than water coming from the ocean (Hammer & Levine, 2012). Thus before the waste water can be used again, the salt concentration should be lowered. This can either be done through treatment or by diluting the produced water in fresh water of 100 to 500 times the volume of this produced water (Hammer & Levine, 2012). This implies that the presence of a significant water body is required for this option (Hammer & Levine, 2012).

Next to this high salt content, which also includes metals, both types of waste waters may carry other possible pollutants that may be dangerous for the eco-system and human health (Hammer & Levine, 2012). These other contaminants are *organic hydrocarbons* also referred to as *"Oil and grease", inorganic and organic additives and NORM* (Hammer & Levine, 2012). These pollutants may be toxic, radioactive of corrosive and can damage the ecosystem by their depletion of oxygen and the increase of algal blooms (Hammer & Levine, 2012). Furthermore, when these pollutants interact with the disinfectants of water plants they may create cancer-causing chemicals (Hammer & Levine, 2012). The inorganic additives often relate back to the chemical additives that were added in the fracturing fluid (Hammer & Levine, 2012). The radioactive elements relate back to the formations. Most organic rich shale formations such as the Marcellus shale are perceived radio-active, as is the Marcellus shale, and therefore provide radioactive elements (Hammer & Levine, 2012).

6.5.4.1.1. Treatment options

Due to the presence of potential dangerous contaminants in waste water derived from hydraulic fracturing, this waste water should be managed in a proper way to mitigate possible negative effects. As stated before, it is obligatory by federal law to pose some form of treatment before the water is allowed to be discharged into surface water. This leads to the following options to handle waste water:

- Recycling for further hydraulic fracturing usage
- Release to surface waters after treatment
- Underground injection
- Storage in reservoir tanks or other bodies of water
- Usage for land aims, such as road spreading (Hammer & Levine, 2012)

Figure 27 provides an image of the different waste water management options.

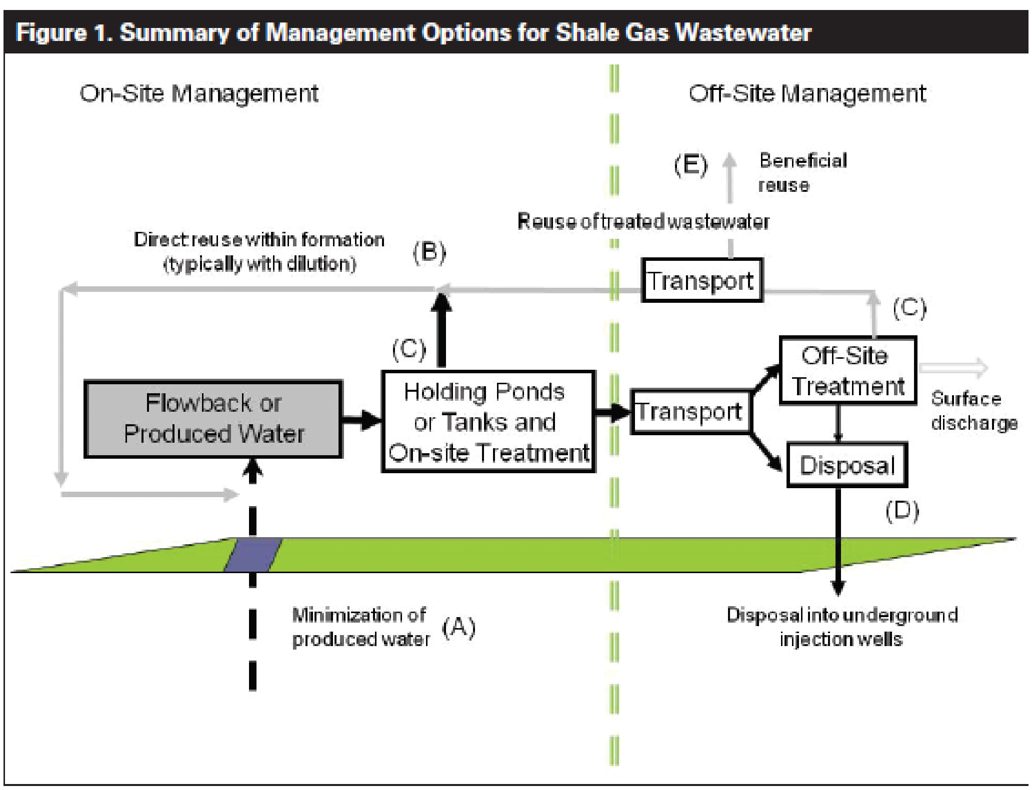


Figure 27 Management options shale gas waste water (Hammer & Levine, 2012)

Figure 27 indicates that when waste water is produced it will first be stored in tanks and may be subject to on-site treatment. After this treatment the water can directly be reused for other hydraulic fracturing processes or it can be transported. When transported, the pretreated waste water will either be disposed by means of underground injection or it will be delivered to water treatment facilities. When the waste water is treated in a water facility it can hereafter either be discharged in the surface water or it can be transported for reuse on-site or for beneficial reuse such as land application. These five management options and their advantages and disadvantages will be explained in the next paragraphs.

6.5.4.1.1.1. Recycling for further hydraulic fracturing usage

The recycling and reuse of waste water during drilling operations has become more widely used, because of the possibility to apply this technique on-site (Hammer & Levine, 2012). During operations, the off-site water management options may be too far away (Hammer & Levine, 2012). However, before waste water can be used again, it must be treated to such an extent that the contaminants of one well do not cause problems in the next (Hammer & Levine, 2012).

On-site recycling leads to significant environmental benefits and a reduction in costs due to a decrease in waste water production and fresh water demand (Hammer & Levine, 2012). The decrease in waste water output and fresh water demand reduces the impact of the shale gas industry on society and may therefore have a positive influence on the resistances evolved in the Informal institutions. However, the residual of the recycling process may be very concentrated and may therefore require careful handling (Hammer & Levine, 2012). Though, since this type of waste water is exempted from the RCRA, the residual is also not subject to rules and regulations for hazardous waste. Another downside of this handling option is that it may require a significant amount of energy (Hammer & Levine, 2012). There are no Formal institutions which currently pose limitations for this handling option. However, in order to reduce the risks associated with the spillage or leakage of the residual, the exemption of the oil and gas activities under the RCRA should be lifted and possible more stringent rules and regulations should be applied.

6.5.4.1.1.2. Treatment and release to surface water

As stated before, all waste water requires some form of treatment, depending on the management option chosen to handle the waste water (Hammer & Levine, 2012). This treatment may either be applied to make the wastewater ready for reuse, prepare the water for the discharge in injection wells, provide clean or *partially treated* water for discharge or to deliver residuals which may be used again (Hammer & Levine, 2012). The nature of the contaminants and the concentration of these contaminants defines which type of treatment should be used (Hammer & Levine, 2012). Furthermore, the treatment targets of the allowed the contamination levels and the desired water quality will be of influence the required treatment methods (Hammer & Levine, 2012). The two types of treatment plants and the effects of the provided treatments are discussed in next part.

Publicly Owned Treatment Works (POTW)

Publicly owned treatment works (POTW’s) are developed in order to extract and dispose *suspended solids* and *dissolved organic compounds,* which provide an increased demand in oxygen in the water bodies in which they are discharged, and in some cases to remove *nutrients* such as *ammonia and nitrate*

(Hammer & Levine, 2012). The treated water will not leave the facility as pure water, since it will still contain the level of contaminants as allowed in the permit (Hammer & Levine, 2012).

Many contaminants delivered by waste water coming from shale gas sites, will still be present in effluent since these contaminants are not targeted on the NPDES permit or because these contaminants are capable of obstructing the plant (Hammer & Levine, 2012). First of all, salt which is most frequent particle in waste water, mostly leaves the POTW's again and is discharged in the surface water (Hammer & Levine, 2012). This because the POTW's are not designed to remove dissolved particles from the waste water. since their common waste water streams do not contain high levels of dissolved solids such as salt (Hammer & Levine, 2012). Therefore, these dissolved solids are also not stated on the permit to be removed (Hammer & Levine, 2012). Furthermore, due to operation of processes with certain chemicals inside the POTW's, the level of TDS may increase even further, which leads to an effluent which even contains a higher amount of TDS (Hammer & Levine, 2012). Therefore, in order to have an acceptable output of 500< mg/l TDS in the effluent, the input water has to have a lower concentration of TDS than the required concentration for the disposed water (Hammer & Levine, 2012). Since, shale gas waste does not have a lower concentration of TDS than the required concentration of the output, it is likely that the effluent, when shale gas waste water is treated in the plant, will have a TDS concentration which is too high and will provide negative effects for the environment. Second, organic compounds which are not affected by microbial degradation will not be removed in the POTW's (Hammer & Levine, 2012). Last, the delivery of high concentration of salt, organic materials and heavy metals may provide problems for the POTW's, since these may cause the breakdown of certain processes inside the POTW's (Hammer & Levine, 2012). This may lead to the obstruction of the POTW, what could lead to presence of these contaminants in the effluent.

For these reasons, in Pennsylvania operators are not allowed to provide their waste water without pretreatment to POTW's (Hammer & Levine, 2012). (See appendix IV)

So, many of these plants are not capable to treat shale gas waste water (Sakmar, 2012). Thus, when waste water is sent to POTW's for treatment, it may lead to serious environmental problems, since certain contaminants will not be removed in the POTW's (Hammer & Levine, 2012).

Centralized Waste Treatment (CWT's) facilities

Next to the option to treat wastewater in POTW's, waste water can be treated in CWT's (Hammer & Levine, 2012). These facilities provide many of the same treatments as the POTWs, however may also offer processes such as coagulation and precipitation used to extract dissolved solids (Hammer & Levine, 2012). Although these CWT's are developed to remove these dissolved particles, the effluent may still contain high levels of pollutants such as bromide (Hammer & Levine, 2012). This because the ELG and NPDES permits have not been updated for TDS, bromide and radioactive chemicals and these contaminants are not targeted to be removed (Hammer & Levine, 2012). Nevertheless, after the treatment in CWT's it is allowed to release the treated water into the surface water (Hammer & Levine, 2012). This discharge lead to the release of harmful pollutants into the environment (Sakmar, 2012) Next to the option to discharge the treated water in surface water, it can also be delivered to the sewerage which leads to the POTW's (Hammer & Levine, 2012).

According to Hammer and Levine, the discharge of treated shale gas waste water in surface water, is not a suitable option for water produced from the Marcellus shale (Hammer & Levine, 2012). The consequences and the possible impacts of this discharge are challenging to estimate (Hammer & Levine, 2012). Therefore, according to them the discharges of the treated waste water from the Marcellus shale into surface water, should not happen until the impact of this option is more clear (Hammer & Levine, 2012).

Effects treatment plants

So, many of these plants are not capable to treat shale gas waste water (Sakmar, 2012). Due to the lack of updates in the permits, the 'new' contaminants present in shale gas waste water are not targeted to be removed in the treatment plants. Therefore, these contaminants will also be present in the effluent. The discharge of this effluent into surface may lead to the contamination of this surface water (Hammer & Levine, 2012). This may also affect drink water resources (Hammer & Levine, 2012). If the amount or concentration of particles in the effluent is either too high and the concentration cannot be lowered by the receiving water body, these contaminants may provide a real danger for the eco-system and human health (Hammer & Levine, 2012). These contaminants may either be directly toxic or create problems in combination with particles found in the environment (Hammer & Levine, 2012). These negative effects are unlikely to be accepted by stakeholders are therefore feasible aspects which could turn into resistances. In order to prevent these resistances from evolving or to overcome these resistances when evolved, both the Technical system and the Formal institutions should be adjusted. The permits have to be updated to make sure that the contaminants are targeted to be removed and will not be discharged into surface water. This may lead to improvements in the Technical system to develop processes which can remove these contaminants (more cost-effectively). Also, improvements have to done to prevent the POTW's from disruption. The improvements in the technical (water) system may be very valuable, since these may also be applied in other places in the world where water treatment is required. Anyhow, currently due to the lack of rules and regulations, outdated permits and technical processes which cannot process the shale gas waste water, the shale gas waste water forms a threat for the quality of the surface water, the environment and the human health and is expected to lead to resistances.

6.5.4.1.1.3. Underground injection

Since, direct release of waste water into the surface water is not allowed according to federal law many operators make use of the possibility to dispose the waste water underground (Hammer & Levine, 2012). This possibility requires the least amount of treatment compared to the other options (Hammer & Levine, 2012). Nevertheless, partial treatment may be necessary to decrease the chance of *well clogging* due to *suspended solids,* the development of precipitate from the waste water components and the development of bacteria (Hammer & Levine, 2012). When the process of Underground injection is executed with correct precautionary measures it provides the smallest risk for the contaminants to be discharged in the environment (Hammer & Levine, 2012). This is underlined by the information present on treatment plants. Though, underground injection may create earthquakes, and transport of the waste water may be necessary if the well is located elsewhere, which can also provide risks for the environment as stated before (Hammer & Levine, 2012).

There are 14.000 class II wells in which the disposal of waste water, generated with oil and gas activities, is allowed (Environmental Protection Agency, n.d.-c). However, as stated before, hazardous waste should be located in class I wells (Hammer & Levine, 2012). Though, due to the RCRA, shale gas waste water is not considered hazardous waste and is therefore located in class II wells, for which the studies on the potential to have negative effects on the human health and environment are not finished yet (Hammer & Levine, 2012). Since, these studies have not been finished yet; it is possible that this disposal option could have negative effects which can turn into resistances. Therefore, the study towards the safety of these class II wells for the disposal shale gas waste water should be finished. If underground storage of shale gas waste water provides significant negative effects, new or adjusted rules and regulations should be developed to mitigate these negative effects and therewith resistances from appearing.

6.5.4.1.1.4. Storage in reservoir tanks or other bodies of water

When liquids are stored, the risk of accidental spills that may contaminate the environment can be present (Hammer & Levine, 2012). This can for example be the case when liquids are stored in a pit, an open impoundment (Hammer & Levine, 2012). Even though these pits are subject to rules and regulations, these regulations are not always satisfactory (Hammer & Levine, 2012). Furthermore, these regulations may vary over different places, due to the fact that these issues are not regulated on federal level, because of the RCRA exemption. Next to the storage in a pit, there is the option to store waste water in closed tanks (Hammer & Levine, 2012). A secondary containment is a best practice in which the tank is placed in a “tray-like structure” with elevated sides (Hammer & Levine, 2012). This should prevent the leakage of material into the environment when the tank is fractured (Hammer & Levine, 2012). This secondary containment is obligated for the storage of hazardous waste (Hammer & Levine, 2012). However, since waste coming from oil and gas activities is not classified as hazardous waste, this secondary containment is not required for the storage of shale gas waste water (Hammer & Levine, 2012). Of all the trespasses in 2010 at well sites which concerned the environment, 25 percent was related to pit and storage issues such as leaks and poor construction (Hammer & Levine, 2012). These violations may pose ground for the development of resistances in the Informal institutions. Therefore, in order to mitigate the risks of spillage and therewith the negative effects of storage on the environment and possibly human health, the exemption of oil and gas waste under the RCRA should be lifted, so that the storage of shale gas waste water in a secondary containment becomes obligated and the precautions for the handling of hazardous waste have to be applied.

6.5.4.1.1.5. Reuse and Usage for land aims

The produced water of oil and gas activities is reused in many ways (Hammer & Levine, 2012). The reuse of waste water off-site can be possible for several industrial functions, such as the cooling of hydro-electric plants (Hammer & Levine, 2012). Furthermore, waste water volumes which are not heavily contaminated can be for instance be used for irrigation, livestock watering and dust control on roads (Hammer & Levine, 2012) However, shale gas waste water often contains a TDS value which is too high to be used for purposes such as irrigation and livestock watering (Hammer & Levine, 2012).

In many states the waste water of oil and gas activities is used for the reduction of dust on unpaved roads or for the deicing of roads (Hammer & Levine, 2012). The produced waste waters are not as good as the commercial products developed for this goal, however they are cost-effective (Hammer & Levine, 2012). The waste water saturated with salt, produced from the Marcellus shale, is used in Pennsylvania for road application (Hammer & Levine, 2012). This water has to meet some quality standards and plans on the rate of usage and the frequency in which it will be applied have to developed in advance (Hammer & Levine, 2012). Furthermore, limitations can be set for the application close to water bodies as well as during periods of rain and snow (Hammer & Levine, 2012). This because, the application of waste water provides the risk of contamination of ground water and nearby water types when the contaminants are rinsed from the road (Hammer & Levine, 2012). Furthermore, dust control and deicing of roads with waste water may lead to an increase in the amount of chlorides used (Hammer & Levine, 2012). This could lead to an increased concentration of chloride present in the surface and ground water, compared to the usage of commercial products (Hammer & Levine, 2012). This may lead to increased risks for the *aquatic life* (Hammer & Levine, 2012). Concentrations of chloride in the water bodies then could on the long term exceed drink water standards and these waters could become toxic for the aquatic life (Hammer & Levine, 2012). Finally, when the waste water is applied to the roads by means of spraying it is possible that volatile compounds are released into the air (Hammer & Levine, 2012).

Because of negative effects for ground and drink water, the aquatic life and the environment, road application is forbidden some states. However due to the lack of federal rules and the exemption under the RCRA, road application of shale gas waste water is allowed in some other states. In order to mitigate the negative effects associated with road application and prevent resistances from evolving in the Informal institutions, it appears that federal regulation is required.

6.5.4.1.2. The residuals

All treatment options provide waste products, also referred to as the residuals (Hammer & Levine, 2012) These waste products often occur in the form of sludge, solids or in a liquid substance (Hammer & Levine, 2012). The same treatment and discharge options are available for these residuals as there are for the initial waste water (Hammer & Levine, 2012). Though, there is less substance to be treated.

The residuals with an acceptable salt content, may be handled by the common processes such as land application, land fill and composting (Hammer & Levine, 2012). The land fill option is available for salt solids which do not contain water anymore (Hammer & Levine, 2012). These landfills should have sufficient protection to avoid the creation of new brines, due to the migration of water into these landfills (Hammer & Levine, 2012). Furthermore, in Pennsylvania operators of landfills are obligated to observe the radioactivity of the waste posed in the landfills (Hammer & Levine, 2012). The main disposal option for liquid residual waste water streams with high a concentration of salt (due to the treatment process) is underground injection (Hammer & Levine, 2012). Also, the liquid residuals may be used for land aims as described above (Hammer & Levine, 2012).

Even though the PADEP (Pennsylvanian Department of Environmental Protection) request drillers not to bring the Marcellus waste water to facilities that are obligated to follow the chapter 95 regulations, it does not provide any statement on the residuals (Hammer & Levine, 2012). This implies that these residuals may still be disposed to these facilities. If the residuals are disposed to treatment facilities, which do not have standards for the effluent considering the dissolved particles, the previous treatment of the waste water and transport of the residuals to these facilities is useless (Hammer & Levine, 2012).

This because the effluent of these facilities will than still contain the contaminants of the waste water, and the attempts done to treat the water and create these residuals were worthless (Hammer & Levine, 2012). Also, the delivery of these residuals to these facilities will pose negative effects for the environmental and human health, and may therefore create resistances from the Informal institutions. Therefore, the right management option for the liquid residuals is underground injection (Hammer & Levine, 2012). Formal institutions to guarantee the right management option for the residuals, also in other states than Pennsylvania, should be developed to prevent a waste of effort and energy as well as negative effects to the environment and human health.

6.5.4.1.3. Treatments used in practice

In order to understand the situation concerning the treatment and discharge of shale gas waste water, a brief example on how waste water is treated in the Marcellus shale and what the effect of this treatment is, is presented in appendix IV.

From this brief example, it can be concluded that the water treatment plants do not remove all the contaminants introduced by the shale gas waste water. Significant amounts of harmful contaminants are still present in the effluent and are discharged in the surface water. If these plants would have been subject to the chapter 95 regulations (see appendix IV), they would have to update and improve their processes in order to meet the discharge criteria as stated in the chapter 95 regulations. In that case all the steps of table 231 (see appendix IV) would have to be executed. This would make the effluent suitable for al purposes, such as the discharge in surface water

The improvements of these plants may lead to increased costs. Therefore, the chance that these plants will be improved without a strong incentive in the form of regulations is slim. This implies that until these rules and regulations, for all treatment plants in all states, are present, the quality of the water bodies may be at risk and therewith the environment and the human health. As stated before, this can lead to resistances.

6.5.5. The Informal resistance: Ground water contamination

In this paragraph the main source for Informal resistances is presented; Ground water contamination. The reason that groundwater contamination is analyzed in separate paragraph is to be able to provide and analyze all data specific on this aspect and create an understanding where the informal resistances are founded on.

There has been a lot of concern about the contamination of groundwater due to shale gas exploration processes. This discussion was even more fired up due to the lack of scientific reports on the complaints about hydraulic fracturing and the processes that were executed (Tiemann & Vann, 2013). For this reason congress has demanded a study from the EPA on the impact of hydraulic fracturing on drink water (Tiemann & Vann, 2013). Until today, regulators have not identified a relation between hydraulic fracturing and groundwater contamination (Tiemann & Vann, 2013). Though, as indicated before, there have been concerns on the adequacy of the wellbore construction to protect the ground water (Tiemann & Vann, 2013).

There are concerns that when hydraulically created fractures enter the overlying rock, channels will be created for pollutants to flow into the overlying rock (Prohaska & Thonhauser, 2012). These created fractures could link with natural fractures or other linked *pore spaces* and provide opportunities for the fluid to flow (Prohaska & Thonhauser, 2012). Though, the risk of fluids that will flow from one place to another due to hydraulic fracturing is expected to be low, however the risk of gas doing the same seems more feasible (Prohaska & Thonhauser, 2012). Some studies indeed suggest that natural gas coming from hydraulic fractured wells, was able to migrate into ground water sources (Prohaska & Thonhauser, 2012).

However, if ground water contamination appears, it may be challenging to define the cause. Tiemann and Vann state that the complexity of the processes provide one of the causes of this challenge (Tiemann & Vann, 2013). In addition, there appears to be a lack of analysis of the groundwater and other wells in the area before the hydraulic fracturing and drilling processes are started (Tiemann & Vann, 2013). This makes it hard to identify if the contamination of ground water is indeed the result of hydraulic fracturing, or if it was already present. In addition, the fact that the chemical additives ,used for the fracturing process, are often not made public makes is difficult to determine if the chemicals present in a water source or formation were introduced by the process of hydraulic fracturing process or were already present in these locations (Tiemann & Vann, 2013)(Sakmar, 2012). In the cases that have been investigated, the hydraulic fracturing process was not the cause of the groundwater contamination, other aspects were. The causes were found in inadequate wellbore-casing and cementing, and problematic situations during well operations and surface activities (Tiemann & Vann, 2013). The issues relating to surface activities may vary between leaking pits, accidental or in-accidental spillage of the hydraulic fracturing fluids or the wrong handling of the drilling fluids on the well site (Tiemann & Vann, 2013).

Also, according to Prohaska and Thonhauser, the hydraulic fracturing process itself does not pose a significant risk for the contamination of ground water (Prohaska & Thonhauser, 2012). They agree with Tiemann and Vann, that the procedures around the hydraulic fracturing process are often the cause of the contamination. They identify sources such as the management and disposal of waste, and the transport and the storage of chemicals (Prohaska & Thonhauser, 2012). In addition, as stated before, the reuse of waste water for, for instance, land application may also lead to groundwater contamination (Hammer & Levine, 2012).

An example of ground water contamination, due to other causes than the hydraulic fracturing processes, is showed by the cases in Pennsylvania in which methane was able to move into the nearby water wells (Tiemann & Vann, 2013). In these cases the gas movement was enabled by poor casing setting and cementing and in a few cases due to pressures that were too high during production (Tiemann & Vann, 2013). So, the gas migration was not caused by process of hydraulic fracturing, but by the improper construction of the wellbore and usage of the well. However, the risk of groundwater contamination due to these problems associated with the sealing and isolation of the groundwater from the well, are problems that are normal for all oil and gas wells and are not specific for hydraulic fracturing or shale gas exploration (Tiemann & Vann, 2013).

Even though the problems with the wellbore construction are not specific for the shale gas industry, the concerns for groundwater contamination due to the exploration of shale gas seem to be grounded. Causes appear to be the wellbore construction and poor management of waste water and chemicals. The concerns of the citizens have already been translated into resistances, in the form of, for instance, pending lawsuits. In order to overcome these resistances, measures have to be taken which can mitigate these risks of groundwater contamination. These measures will initially have to be found in the formal institutions which should pose resistances to provide an incentive for the technical system to improve. Again, by lifting the exemption of oil and gas activities under the RCRA, the problems with the handling, storage and transport of aspects which could create ground water contamination could be reduced since precautions for hazardous waste would then be applicable. In addition, the usage of best practices for the wellbore construction should be encouraged or obligated by federal law, to at least, minimize the possibility of groundwater contamination due to the wellbore construction. However, it may take a while before the concerns and associated resistances of the citizens are decreased, since they will have to attain trust in that the improvements done, indeed remove the risks of ground water contamination.

6.5.6. Resistances Technical system

The most important improvements done in the Technical system were to overcome the resistances posed by Nature. Other improvements considered; the improvements of the Technical system in order to increase its productivity and to overcome the resistance posed by the Formal institutions that waste water is not allowed to be discharged into the surface water directly. This last resistance was overcome by the development of several treatment and storage options.

However, as has become clear after the analysis of this section there are still many negative effects related to the Technical system which could lead to new resistances.

First, there are the problems associated directly with the hydraulic fracturing process; the extensive water usage and the usage of chemicals. In order to take away the fear for and possibility of water scarcity, rules and regulations should be developed to pose limits to this water usage. Furthermore, attempts should be done to improve the technical system in order to reduce the required amount of water. The Formal institutions can provide the incentive for these improvements. The fear of residents concerning the chemicals used could be lifted if it would become required to publish the chemicals used and provide an explanation on the function and effects of these chemicals.

Second, there is the construction of the wellbore. If this is not done correctly, leakage of drilling fluids and natural gas into the direct environment could take place. Furthermore, in a worst case scenario the fluids and/or the natural gas could migrate into the ground water. These problems could be reduced by stringent rules and regulations on what is allowed and which best practices are required to be used.

Third, due to incapability of POTW's to remove dissolved solids present in the shale gas waste water, these solids may be present in the effluent of these treatment plants. This issue may be overcome by obligating operators to send the shale gas waste water to CWT's, plants which are capable of removing these dissolved solids. Also, other contaminants, not targeted in the permit can still be present in the effluent. In order to overcome this problems NPDES permits have to updated and technical processes have to be improved to able to meet the standards on these permits.

Fourth, the POTW's may break down due to input of high concentration of salt and metals. Also, this problem may be solved by the Formal institutions in the form of prohibition of the delivery of shale gas waste water to POTW's.

Fifth, bromide and other contaminants may be present in the effluent of CWT's, since these contaminants are not targeted to be removed and the plants are not designed to remove these 'new' contaminants. In order to overcome this problem, the ELG and NPDES permits for CWT's should be updated for the 'new' input of shale gas waste water in order to have the 'new' contaminants targeted to be removed. Furthermore, the plants may have to be adjusted to make them capable of removing these contaminants.

Sixth, if the treatment plants have to be improved to be better able to treat shale gas waste water, increased costs are involved for the water treatment plants. This could form a problem for the owners of these plants (local government or states). This problem could be reduced if the improvements would be (partly) financed by the income derived from the shale gas industry.

Seventh, is the possibility of leakage due to the fact that shale gas waste water and chemicals do not have to be handled with precautions, since these are not considered as hazardous waste. This problem could be solved by lifting the exemption of the RCRA for oil and gas activities.

Eight, there are the intentional spills of man which could lead to contamination of the environment. By creating an increased understanding of the effects of these spillages and by posing sanctions, these intentional spills may be decreased.

Ninth, the application of residuals and waste water for land usage may have negative effects on the environment and the groundwater. This negative effect could be mitigated by lifting the exemption of oil and gas activities under the RCRA, with the result that the waste water will have to be treated as hazardous waste and is not allowed to be used for land application anymore.

Finally, there is the negative effect which is already considered as a resistance; the contamination of groundwater. This resistance could be decreased if measures are taken against the possibility of groundwater contamination. These measures could involve the improvement in technology of the wellbore construction and by lifting the exemption of oil and gas under the RCRA to be able to apply more stringent rules and regulations concerning the handling, storage and transport of chemicals and waste water.

The resistances overcome by the Technical system and the negative effects of the Technical system that could lead to new resistances are also summarized in tables that are presented in appendix V.

6.6 Economics

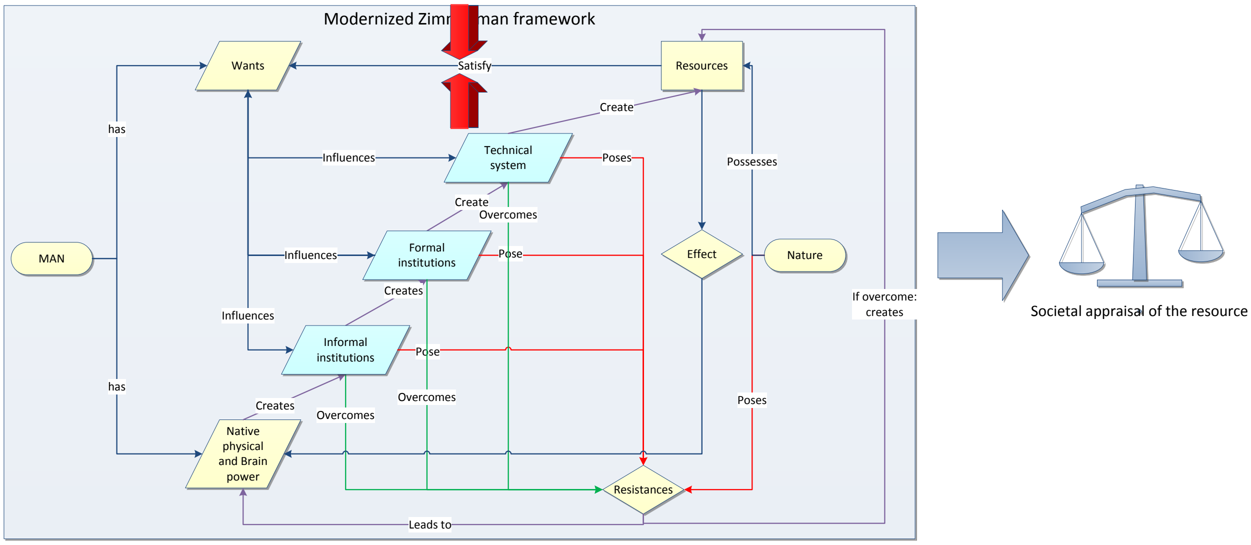


Figure 28 Economy

In this paragraph the result of the relation between Wants and Resources, the economic aspect of shale gas, is explored. The profitability, the economic benefits of shale gas, the effects of shale gas on the natural gas price and the effects of the low natural gas price are explored. As mentioned earlier, the factor Economy is not present in the framework anymore, but is represented by the relation between Wants and Resources.

The economic factor has to be explored, since the analysis of the economic aspect of shale gas is necessary for the Societal appraisal of shale gas. The Want satisfying capacity and profitability of a resource are two of the judgment factors of this Societal appraisal and are economic aspects.

This paragraph ends with the analysis on to what extent the substance shale gas is able to satisfy the stated Wants and is able to provide the economic relation as stated in figure 28. The judgment on the profitability of shale gas will be presented in the paragraph dedicated to the Societal appraisal. However, this judgment will be based on the information provided in this paragraph.

6.6.1 The evolution of shale gas

Due to the extreme high henry hub price in 2005 of $491 per thousand cubic meters (Mcm), the evolution of shale gas could take a flight (Newman, 2012). This high gas price made it possible to recover the costs of exploration, even though the cost-effectiveness of the production was not optimal (Newman, 2012). Another economic reason, for the fast take-off of the shale gas production was the, already mentioned, 'easy credit' available (Newman, 2012). This easy credit made it easy for companies to obtain loans and to invest in the production of shale gas (Newman, 2012). An estimation of EIA stated that the costs of construction, drilling and completion of a well started from 7 million dollar in many of the already developed fields (Newman, 2012).

In 2009, the first economic problems appeared for the shale gas sector. Due to the financial crisis, the global economy declined, which resulted in lower gas prices and reduction of easy credit available

(Newman, 2012). This had a negative effect on the investments done in the shale gas industry and caused a decline in the exploration and development of production and a created a reduced demand for hydraulic fracturing (Newman, 2012). Nevertheless, the shale gas supply still increased (Newman, 2012). The supply increased to such extent, that shale gas represented 25 percent of the total gas output of the U.S. in 2011 (Newman, 2012). Though, due to a decline in the energy demand, the gas prices dropped even further, leading to a gas price of $162 per Mcm in 2011 (Newman, 2012). The decline continued, and in September the average gas price was $100 per Mcm while the moving average over ten years was $214 per Mcm (Newman, 2012). Figure 29 provides the annual average Henry Hub price, determined by the U.S. Energy information administration. This picture is retrieved from the annual energy outlook 2013.

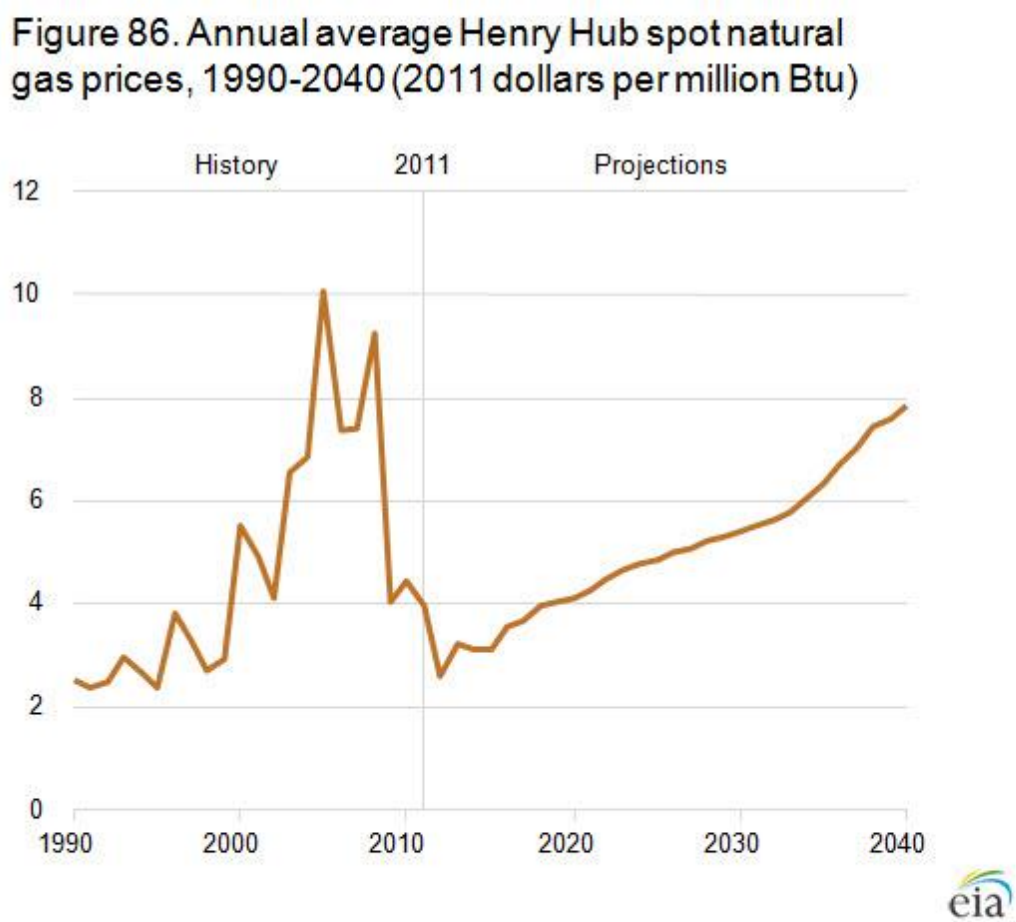


Figure 29 Annual average henry hub spot price (U.S. Energy Information Administration, 2013)

According to the EIA, the low gas prices of the previous years are the result of domestic oversupply and the efficient ways of production (U.S. Energy Information Administration, 2013). Though, from now they expect a rise of 2.4 percent per year until 2040 (U.S. Energy Information Administration, 2013). The reason for this can be found in an increase in consumption due to a rise in the expected export (U.S. Energy Information Administration, 2013).

6.6.1.1. Profitability shale gas

Even before the decline in the gas price, drillers were spending two to five times the money used for operation activities in order to pay for the leasing, the drilling and completion of the well according to the financial times of May 2012 (Newman, 2012). According to Newman, in order to break even, the gas price should be around, $350 per Mcm. In order to provide a simple assessment of the profitability of shale gas for operators, the break-even price according to Newman and the figure provided by the EIA with the expected gas prices are used.

In the figure of the EIA the unit, dollars per million Btu, is used. Since, one million Btu accounts for 0.0283 Mcm, this implies the break-even price is approximately $9.9 per million Btu according to Newman (Delek Energy, n.d.). The prices for natural gas are expected to rise from 2015 (U.S. Energy Information Administration, 2013). Though, even with this price increase, the shale gas production with this break-even price is not expected become profitable anymore before 2040. Furthermore, according to the EIA the production costs are expected to increase over time, since the most productive, easy and inexpensive sources have been already produced (U.S. Energy Information Administration, 2013). This will result in the exploration of more inaccessible and difficult sources, which may increase the production prices and therefore the break-even price (U.S. Energy Information Administration, 2013). Though, the break-even price will differ per play. According to Informal sources, the gas price for several plays varies around the three to four dollar per million Btu. However, even then, due to the expected low gas price, the profitability of shale gas does not seem promising in the coming years. Nevertheless, according to the EIA drilling will remain ‘robust’, especially when drilling activities are exploited in areas with Natural Gas Liquids (NGL) or oil (U.S. Energy Information Administration, 2013).

6.6.1.2. Effects on gas price

The price of natural gas depends both on the economic growth and the speed in which resources are exploited. The price is the highest in the case when natural gas and oil are exploited at a slow rate (U.S. Energy Information Administration, 2013). In appendix IV, more information can be found on the effect of the natural gas price on the economic growth as well as on the speed in which resources are developed.

6.6.1.3. Production natural gas

The production of shale gas rose from 36.3 billion cubic meters (1.28 tcf) in 2007 to almost a fourfold of 179 billion cubic meters (6.3 tcf) in 2012 (Newman, 2012). More information on this increase in production and the role of natural gas can be found in appendix IV.

6.6.2. Economic benefits

The economic benefits associated with shale gas, come in the form of tax, royalty revenues and employment possibilities. In 2010, $18.6 billion was generated with the exploration of shale gas by means of federal, state and local government tax and federal royalties (Shale gas information Platform, n.d.). Furthermore, shale gas has contributed $76 billion to the GDP in 2010 and 600.000 jobs were fulfilled in the shale gas industry (Shale gas information Platform, n.d.). In 2015 it seems possible that more than 204.000 jobs will be established due to the Utica shale reserve in Ohio (Shale gas information

Platform, n.d.) Also, costs for natural gas of consumers and electricity has decreased which is considered stimulating for economic growth (Shale gas information Platform, n.d.).

Another important economic benefit is the positive influence of the presence of shale gas on the petrochemical industry in the U.S. The petrochemical industry is dependent on the presence of natural gas to power the processes but also since natural gas is a raw material for many of these processes (Economics & Statistics American Chemistry council, 2011). The low gas price in the U.S. therefore provides an important advantage for the petrochemical companies located there (Economics & Statistics American Chemistry council, 2011). According to a report of the American Chemistry Council, $16.2 billion dollar will be invested in the chemical industry to increase the petrochemical capacity (Economics & Statistics American Chemistry council, 2011). This will lead to 17.000 high educated jobs, a $32.8 billion increase in the production of chemicals, an additional $4.4 billion in taxes and a $83.4 billion economic output due of increased chemical production (Economics & Statistics American Chemistry council, 2011).

Furthermore, the worth of the market for waste water treatment and disposal, could exceed $3 billion a year just in the Marcellus shale play (Thakre & Shenkar, 2013). Furthermore, the technologies used to treat wastewater from hydraulic fracturing may be applied in other fields of water treatment (Thakre & Shenkar, 2013). This could have both economic benefits as environmental benefits. Finally, operators and drilling companies who have worked in the shale gas industry in the U.S. can use their expertise for the development and production of shale gas activities in other countries. The showcase and usage of this expertise can create additional income for the U.S.

6.6.3. Export

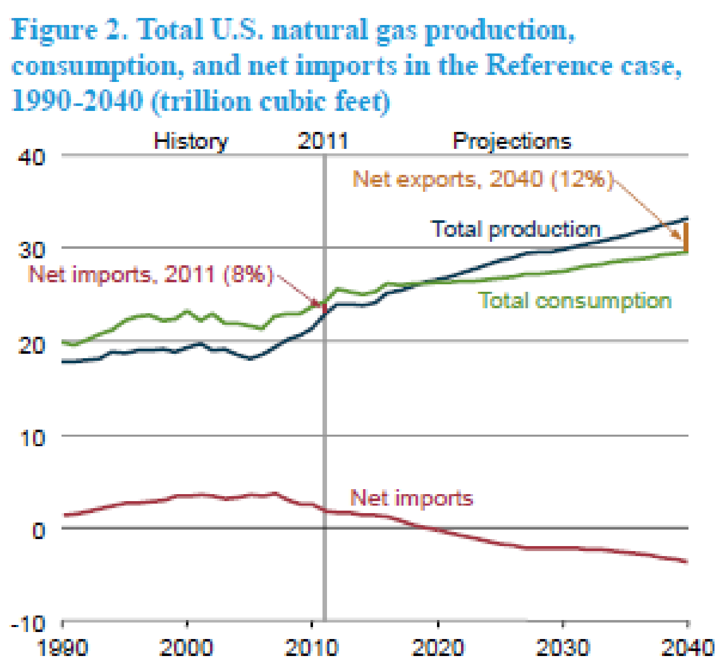


Figure 30 U.S. natural gas production, consumption and net imports (U.S. Energy Information Administration, 2013)

Even though the gas price may be low in the United States, the gas could still be profitable if exported to regions with a high gas price. According to the EIA, the total production of natural gas in the U.S. will exceed the total consumption of natural gas in 2019 (U.S. Energy Information Administration, 2013). This will lead to exports of natural gas (U.S. Energy Information Administration, 2013). Furthermore, in 2016 the U.S. will become a net exporter of LNG (U.S. Energy Information Administration, 2013). These exports will start in 2016 and are expected to account for 1.6 tcf per year in 2027 (U.S. Energy Information Administration, 2013). However, amounts of these exports are rather insecure and depend on several factors such as the rate of speed in which world gas prices will become more congruent, the production volume of shale gas reserves, the competition position of natural gas compared to other liquids and the development of the arctic (U.S. Energy Information Administration, 2013).

6.6.4. Effects low gas prices

Due to the increased shale gas production, the prices of natural gas maintain to be low (U.S. Energy Information Administration, 2013). This will lead to an increase of the usage of natural gas in the industrial and power sector, mainly in the next ten years (U.S. Energy Information Administration, 2013). The usage of natural gas in the industrial sector is expected to increase with sixteen percent in the period from 2011 to 2025 (U.S. Energy Information Administration, 2013). This natural gas consumption will rise from 6.8 tcf in 2011 to 7.8 in 2025 (U.S. Energy Information Administration, 2013). In the electric power sector the usage of natural gas will also increase (U.S. Energy Information Administration, 2013). In 2000, sixteen percent of the production of electricity was achieved by natural gas (U.S. Energy Information Administration, 2013). This was increased to 24 percent in 2011 and is expected to rise to a share of 27 percent in 2025 and 30 percent in 2040 (U.S. Energy Information Administration, 2013). This is shown in figure 31.

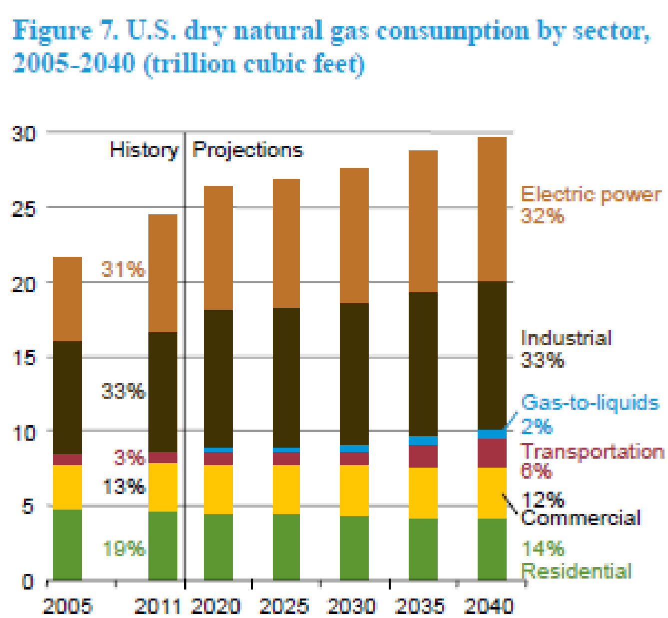


Figure 31 Dry natural gas consumption per sector (U.S. Energy Information Administration, 2013)

The increased usage of gas in the industrial and electricity sector can lead to environmental benefits, since it will replace other fossil fuels, such as coal, which emit more CO_2 emissions when used. Due to the increased usage of natural gas in the electricity production and industrial sector, the consumption of natural gas is expected to grow with 0.6% per year in the period from 2011-2040 (U.S. Energy Information Administration, 2013).

6.6.5. Want satisfaction by means of shale gas

Since the relation between the factors Wants and Resources is also considered as the economic relation between demand and supply, it is analyzed to what extent the demand is satisfied by the supply. In other words, to what extent is the Resource shale gas able to satisfy the Wants of the stakeholders?

To start, the Want for energy security can be satisfied by the substance shale gas. The amount of shale gas present in the U.S. is around 862 tcf, which should be enough for almost 7000 years of consumption, considering the current consumption rate (U.S. Energy Information Administration, 2011)(Shale gas information Platform, n.d.).

Second, the U.S. has enough gas to become a net exporter from 2019, so also the Want for energy independence can be satisfied by the substance shale gas (U.S. Energy Information Administration, 2013).

Third is the Want for a clean energy resource. If the substance shale gas is suitable to satisfy this Want depends on the angle from which this is considered. Natural gas is a fossil fuel, which emits less CO_2 when used to generate electricity than other fossil fuels (Foster & Perks, 2012). Since the usage of gas in the industrial sector is expected to increase with sixteen percent between 2011 and 2025 and the usage of natural gas in the electricity sector is expected to increase from 16 to 30 percent between 2000 and 2040, environmental benefits may be achieved (U.S. Energy Information Administration, 2013). However, the usage of natural gas still has a more negative impact on the environment than generation of energy by means of renewable energy sources. In addition, as could be determined in the previous section, the production process of shale gas does provide negative effects for the environment. So, shale gas may be considered a ‘cleaner’ fuel than other fossil fuels when used, however the production of shale gas process requires some significant improvements in order to become a ‘clean’ fuel.

Fourth is the Want for a costs effective resource. The costs of the development of a shale gas well are significant. Because of the low gas prices, it would be beneficial if these production costs would be lowered in order to increase the cost-effectiveness of the resource. Therefore, the cost effectiveness of the shale gas as a resource could be improved.

Fifth, the substance shale gas does bring economic strength and does satisfy this Want. Jobs are created, the GDP is increased, income for the state is generated in terms of taxes and royalties and the presence of shale gas provides a reason for petrochemical companies to invest and increase their capital and workforce in the U.S.

Sixth is the Want for profitability. This profitability will depend on the price for which the gas can be sold. Currently, the profitability for the operators is low; however this may increase when shale gas is exported for higher prices. The profitability for the government seems to be well, since the government receives taxes and royalties associated with the development and exploration of shale gas.

Seventh is the Want for continuity of companies. This continuity can be achieved if companies have sufficient work and generate a turnover which exceeds their costs. The continuity of the companies will depend on the type of company, on the costs of their production processes and the price for which the product can be sold. At this moment the industry is still attained with a significant amount of work. However, with the current gas prices, the production costs of the companies may at a certain point exceed the turnover, especially if more difficult plays are explored. So, unless gas prices will rise again or companies are allowed to export their products, it may happen that companies at a certain point will not continue their activities in the shale gas industry. Therefore the continuity of companies in the shale gas industry is not guaranteed for the future and the satisfaction of this Want may change over time.

Eight, are the Wants of the citizens of the U.S. for a safe and clean living environment. As is concluded in the previous sections, the exploration of shale gas as it is, does pose some risks for the safety of this environment. Also, the development and exploration of shale gas can pose a negative influence on the cleanness of the environment, in the sense that water may become contaminated and emissions are released during the production process. Even though NSPS reduce the VOC emissions with 95 percent, more regulations are required to guarantee a safe and clean living environment. Therefore the Wants for a safe and clean living environment are not satisfied.

To finalize, there is the Want of citizens to live according to their current living standards. Due to the substance shale gas, the period in which our society is able to use fossil fuels is extended. Therefore, the period in which human beings can live as they do now, in terms of electricity and mobility, is increased. However, the exploration and production of shale gas also provides the possibility of environmental changes. So, the living standards according the living environment may change. Thus the substance shale gas is able to satisfy the Want to maintain the current living standards in terms of our 'modern' live in which we are dependent on electricity. However, the usage of the substance may change the conditions around us, and may therefore not be able to satisfy this Want. Therefore the answer if the Want of citizens to live according to their current standards is satisfied by the substance shale, again, does depend on the angle from which you look at it.

The ten Wants and their rate of satisfaction are also presented in a table the paragraph on Societal appraisal.

6.7 Man

In this section the role of Man is explored. Man poses Wants and provides Native physical and brain power. The ways in which Man has transformed is physical and brain capabilities into usable assets is represented by the aspects explored in the paragraphs "Technical system s", "Formal institutions" and "Informal institutions". Examples of these aspects can be found in the developed rules and regulations or the developed technologies. However, all these aspects have already been discussed in previous sections; therefore this section will just explore the role of Man in the evolution of shale gas, concerning his attitudes and actions.

6.7.1. The role of Man

Man, the decision maker, who decides which substances will be used as resources and which functions these substances will serve, again has made some remarkable decisions when it comes to the substance shale gas.

To start, one would expect human beings to act wiser when it comes to their environment, especially since the knowledge about the effects of their behavior on the environment has increased. However, this increase in knowledge cannot be found in the attitude of Man. An example can be found in the situation concerning hydraulic fracturing in the U.S. The EPA has set up a plan to study the potential impact of hydraulic fracturing on drink water resources, though what it is remarkable is that this final report will not be finished until 2014 (Environmental Protection Agency, n.d.-i). It appears an act of a wise Man to consider the potential harm of a process before this process is one of the core economic activities of his country. Furthermore, since shale gas has such a high priority in the U.S., why is it that the EPA cannot increase the speed of this research? Even when the outcome of the research would be that the impact of the exploration of shale gas is acceptable, the moment of release and the speed of this research appear unprofessional and foolish concerning the situation. When using the theory of Zimmerman on the appraisal of resources, the human appraisal of a resource is amongst other based on knowledge of facts. However, it is questionable if this was the case when the exploration of shale gas started, since apparently not all information is gathered and understood yet.

Next to the fact, that Man apparently still starts the gathering and usage of substances without understanding the full impact of his actions, he also still acts folly and with cussedness. Examples of this are the intentional spills and disposal of waste water, and the irresponsible operation of shale gas wells, whether or not due to the involved costs of best practices. However, it is not only the individual Man which handles Resources with ignorance and folly; also governments may act in way which does not preserve resources. The objectivity of the role of the EPA, the organization which is aimed to protect the environment, is questioned by several scientists. The lack of speed in which the impact of shale gas is investigated by the EPA, seems to underline this suspicion. This raises the question if the EPA has as its highest priority of protect the environment or serve the government in executing its plans in a way which seems environmental friendly. These attitudes, both of the EPA and the government, could lead to reduced resources available for future generations.

Thus, Man seems to still handle without full consent of his situation, even though his handling could lead to significant (negative) impacts on the environment, human health and possible resources of the future.

6.7.2 Conclusion Man

- Even though Man was expected to learn from his fully and cussedness in the past, the evolution of shale gas in the U.S. was marked by a lack of knowledge and understanding of the impact of this development on the environment
- In order to reduce the impact on the environment and human health, Man should provide priority to research which helps him to understand the full impact of the development and usage of shale gas. This will enable him to make the right the decisions and make adjustments in the Formal institutions and Technical system

- Furthermore Man should act responsible during processes concerning shale gas. He should not handle with ignorance since this may have disastrous consequences for the environment, his own health and the resources of the future
- It seems that the conservation of the environment and its resources is not a priority of the U.S. government, since the organization addressed by them to protect the environment and its resources seems to fail in bringing important knowledge to the table in times this is required

6.8 Societal appraisal

In this final section the Societal judgment on the functionality of the substance shale gas as a resource is explored. A substance can function as a resource, if it at least satisfies one want. However, this functionality does not imply that the substance is judged positive by society in its function as a resource. The reason for this can be that the substance as a resource, for instance, is not profitable or environmental friendly.

The Societal appraisal can be seen as the modern form of human appraisal, since human beings cannot individually decide if they Want to use a resource anymore. They have become stakeholders in the process of resource appraisal. So, today not the individual but the society judges if a substance is suitable and Wanted as a resource. The societal judgment can be seen as the conclusion on the information stated previously, which states if a substance is accepted to function as a resource in a specific society.

The substance shale gas will be assessed on the factors State of Wants, Knowledge of facts, Environmental feasibility, Profitability, Technical feasibility and its suitability to fit into the strategy along socio-economic lines of the U.S.

6.8.1 State of Wants

In the paragraph on Wants the Wants that the resource shale gas has to satisfy are identified. In the previous paragraph it was analyzed to what extent the substance shale gas indeed is capable of satisfying these Wants. Table 2 presents and overview of these Wants and to what extent these are satisfied.

Table 2 Satisfaction of Wants

Want	Satisfied	Satisfaction rate could be improved by
Energy security	Yes, according to the shale gas information platform for another 7000 years	-
Energy independence	Yes, U.S. may become a net exporter	-
Clean energy resource	Debatable, gas is cleaner than other fossil, though production brings negative environmental effects	Formal institutions Technical system
Cost effectiveness energy resource	Could be improved	Technical system
Economic strength	Yes, jobs, income through taxes and royalties are created	-
profitability	Depends on the break-even price Profitable for government	Technical system
Company continuity	Depends on the involvement, strategy and Technical system of the company	Technical system
Save living Environment	No	Formal institutions Technical system
Clean living environment	No	Formal institutions Technical system
Live a life according to the current living standards	According to the usage of fossil fuels: yes According to the possibility that the environment may change: No	Formal institutions Technical system

What can be concluded from this table and the paragraph on Want satisfaction, in the section on Economy, is that the Wants of the Citizens for a save and clean living environment are not satisfied by the substance shale gas. Furthermore, the satisfaction of the Want for a clean energy resource and the Want to live according to the current living standards is debatable. In addition, the satisfaction of the Wants for cost-effectiveness and profitability depends on the price of shale gas, which is currently very low in the U.S. What can be concluded is that the resource shale gas scores reasonably on the satisfaction of Wants, four Wants are satisfied, two Wants are not satisfied and the satisfaction of the four remaining Wants is debatable.

6.8.2 Knowledge of facts

As concluded in the paragraph on Man, the knowledge of Man to use the substance shale gas as a resource and the understanding of the consequences of this usage are still limited. This knowledge should be increased in order to prevent that the usage of this substance can have negative effects of the resources available for future generations, the environment and human health. So, in order to attain a positive judgment on this criterion, the knowledge on the effects of the development and exploration of shale gas should be increased.

6.8.3. Environmental feasibility

At the time when the shale gas evolution took its flight, environmental issues did not cause problems (Kefferpütz, 2010). Therefore, the substance shale gas could function as a resource. The environmental issues were not known yet, and if these were known the economic advantages in the form of royalty shares and profit were considered more important.

However, with the increased knowledge on shale gas, the environmental problems have increased in attention. It appears that shale gas as a resource poses significant risks for the environment. These risks on the environment may also become risks for the human health when (drink) water sources become contaminated and the environment is damaged to such extent that it poses negative effects for the human health. Since the negative effects and associated risks of the shale gas system are not mitigated (yet), the judgment on the environmental feasibility of shale gas is negative.

There are several aspects of the exploration and production of shale gas which lead to this negative judgment. These are briefly summarized as:

- The water usage for the fracturing of the well
- The usage of chemicals during the hydraulic fracturing process
- The emissions caused during the drilling process
- The flow back and treatment of waste water
- The discharge of ’treated’ waste water into the surface water
- The possible contamination of groundwater
- The (inadequate) handling, transport and storage of both chemicals and waste water

If all of the negative effects could be mitigated the judgment on the environmental feasibility would become positive. These negative effects are also acknowledged by EPA. In a study which is still proceeding the EPA also recognizes four potential impacts which the activities around shale gas may have on the environment (Sakmar, 2012). These potential impacts include all of the previous listed negative effects (Sakmar, 2012). These are:

1. The contamination of groundwater due to spills, poor well construction or other causes
2. Tension on surface water and ground water supplies, due to high water demand of the shale gas production processes

3. Negative impacts due to discharges of (treated) water in surface water and due to the disposal in underground wells
4. Air pollution resulting from VOC emissions, air pollutants and greenhouse gasses (Sakmar, 2012)

Therefore, it seems that also the EPA is aware of the possible negative effects that the development and exploration of shale gas have on the environments; however, the actions to reduce these problems are in many cases still lacking. Until these problems are solved, it appears that the societal judgment on environmental feasibility of shale gas will remain negative.

6.8.4. Profitability

With a break-even price of $9.9 per million Btu, according Newman, and a Henry Hub gas price of under the $8 dollar per million Btu until 2040, the shale gas industry does not seem profitable (Newman, 2012; U.S. Energy Information Administration, 2013). This profitability is improved if the production price ranges from three to four dollars per play, as considered for several plays by informal sources. However, in that case shale gas still remains unprofitable to sell in the U.S. until approximately 2020. Furthermore, this unprofitability only seems to increase in the coming years due to the expected rise in production costs since the 'easy' fields are exploited in the first stage of a technical development. Though, profit may be achieved if the gas is sold and exported to countries where the gas price is higher. Additionally economic benefits may be achieved if the drilling activities are exploited in areas with high amounts of NGL and oil.

However, even though there seems to be a lack of profit, shale gas brings significant economic benefits in the forms of jobs, taxes, royalties and economic output. This implies that the system is profitable for the American government. However, investments are required in the water treatment plants, to mitigate severe environmental problems. This would lead to a reduced net profit for the government. However, it is expected that shale gas will still remain profitable for the government, even with these investments.

So, the judgment on the profitability is not positive for operators, however it is positive for the U.S. government. For this reason it is possible that the U.S. government will (again) provide economic incentives which decrease the costs of production for operators and therewith increase their profitability, in order to keep the exploration of shale gas going.

6.8.5. Technical feasibility

According to the operators the hydraulic fracturing system is feasible. However, it appears that if the system would not be technically feasible, it may not be made public. This because this could lead to negative public perception, since people could feel as if the operators are not able to control the processes they are handling. So, the validated answer for this question would require a deeper and foremost a different form of study than a literature study. Thus, the answer for this question can hardly be answered. Though, based on the data present from this literature study, it seems that Technical system is feasible, since the substance shale gas can be retrieved from the ground. The resistances posed by Nature have been overcome.

However, the waste water treatment system is not technical feasible. The treatment plans will have to undergo significant adjustments to become capable of processing the shale gas waste water and to not get obstructed. Furthermore improvements have to be done order to make the plants more effective in removing the contaminants delivered by the waste water so that they effluent meets the desired quality standards.

However, since shale gas can be retrieved from the ground and can be used, one could say the Technical system is technical feasible. Therefore, the judgment on the technical feasibility of the substance shale gas as a resource is positive.

6.8.6. Strategy along socio-economic lines

In order to assess if the substance shale gas is congruent with the strategy of the U.S. government for energy resources, the Wants of the U.S. government are considered. The reason that these Wants are chosen as the starting point, is because it is challenging to identify the exact strategy the U.S. government is following. This strategy may not even be made public. These identified Wants of the U.S. government are:

- Want for energy security
- Want for energy independence
- Want for economic strength
- Want for profit
- Want for a cost effective energy source
- Want for a clean energy source

One could say that the substance shale gas does qualify as a resource which suits their desired strategy concerning their energy resources. The reserves of shale gas are tremendous and do fulfill the Want for energy security for the Nation and the aim to become energy independent. Also, many jobs have been (indirectly) created due to the exploration activities of shale gas and income for the government is generated by means of taxes and royalties. So, shale gas is able to provide both economic strength and profitability for the government. However, the cost effectiveness of this resource could be subject of discussion, since it is depended on many factors, such as the properties of the shale play and the Henry Hub gas price. If the formation is challenging to drill and the gas price is low, the production costs can be higher than the revenue generated with the exploration, which decreases the cost-effectiveness of the resource. However, looking purely at the technology the substance shale gas can be generated in many plays for a reasonable cost price, according to informal sources. This is also underlined by the fact that shale gas is still being produced. If it would not be cost-effective in any area, there would not be any production. The final Want concerns the requirement for a clean energy resource. For this Want it is also challenging to provide one answer. The reason for this can be found in the properties of natural gas. Since natural gas, generates less emissions than coal or oil when used, the substance is considered ‘cleaner’ than these fossil fuels. Though, when compared to renewable sources of energy, the substance is less ‘clean’. Furthermore the production process, may not be considered clean, due to the production of emissions which may harm the environment and the risks posed to the ground and surface water and therefore towards the environment. So, if shale gas may be considered as a clean resource depends on the angle taken to look at it.

So overall, the usage, exploration and production of the substance shale gas meets the strategy of the U.S. government, except for the fact that the cost effectiveness depends on the play and gas price and that there is not unified answer on the question if shale gas may be considered as clean fuel. However, overall the substance shale gas is judged positive in fitting the strategy of the U.S. government.

6.8.7. Conclusion Societal appraisal

The results for the different judgment criteria for Societal appraisal for the resource shale as are:

- The substance shale gas is reasonably capable of satisfying the Wants for this substance
- There appears to be a lack of knowledge and understanding on the effects of the resource shale gas on the environment and human health
- At this moment the system to produce shale gas is not environmental feasible
- The profitability of the operators depends on production costs, which depends on the play to be explored
- The system could become more profitable if shale gas could be exported to countries with a higher gas price
- The total system seems to be profitable for the U.S. government due to the associated economic benefits
- The Technical system is feasible considering the fact that it is possible to extract the substance from the ground.
- The substance does fit in the strategy of the U.S., however the cost-effectiveness and the cleanness of this substance may be part of discussion.

Thus, at this moment even though the substance shale gas does satisfy several Wants, the societal judgment on the substance shale gas is negative, mainly due to the lack of knowledge and environmental feasibility. The technical feasibility is satisfactory in terms that the substance can be attained and used, the profitability is good enough to have exploration of the substance kept going and the substance does fit in the strategy of the U.S. government. Furthermore, the substance is capable of satisfying a reasonable amount of Wants. However, in order to attain a broad public acceptance, measures have to be taken in order to have the substance shale gas function in a more environmental friendly way. The negative effects as posed in this section have to be mitigated to such extent that shale gas can function as a resource in a way which has an acceptable effect on the environment. The reason that this is stated as acceptable is that all resources do have effects on the environment; it is impossible to use a substance and not pose any effect on the environment, especially if this resource is a natural-cultural resource and improvements have to be done to attain the substance. Even when the substance considers an apple, a natural resource for which no improvements have to be done to attain and use it, the obtainment of this apple will have a certain impact on the environment; it cannot be used for other functions in Nature. Though, when we consume the apple, this effect is accepted since it is not an effect which will disturb the environment to great extent. So, the aim is not to have any effects on the environment at all when obtaining and using a resource, but to have an impact which is acceptable for all the stakeholders. The substance shale gas as a resource is not in the stage (yet). Therefore, the Societal appraisal of shale gas is negative. This is also summarized in table 3.

Table 3 Societal appraisal

Judgment criterion	Satisfied
State of Wants	Reasonable
Knowledge of facts	No
Environmental feasibility	No
Profitability	For the operators: dependable on the shale play For the government: Yes
Technical feasibility	Yes
Strategy along socio economic lines	Yes, though the cost-effectiveness and cleanness of the resource are debatable

6.9 Conclusion case-study

As stated before, the conclusion on the case study is provided in two parts. The first conclusion concerns the content of the case study; the development and functionality of shale gas in the U.S. The second concerns the validation of the framework.

6.9.1 Conclusion case study shale gas

Man has posed several Wants for the development of the substance shale gas as a resource. After addressing the Informal and Formal institutions, it appeared that the Technical system to attain the substance shale gas had little requirements to meet and that the institutions provided a supportive environment for the development of this Technical system. The last significant improvement in system to attain the substance, as used today, was achieved in 1990. It was in 2010, when the movie Gasland was released, that the first resistances evolved from the Informal institutions. People became aware of the shale gas explorations and started to evaluate the effects of shale gas as a resource. They feared that the exploration of shale gas posed negative effects for the environment and that these would reduce the safety of their living environment. Hereafter, the first lawsuits against drilling operators started. The Formal institutions, developed to safeguard the norms and values and other cultural aspects, was the system to response to these resistances posed by the Informal institutions. However, this response so far, is very minimal. With the current Formal institutions and Technical system it is possible that the Technical system indeed creates effects which have a negative influence on the environment and human health. Some of these effects have already turned into resistances in the Informal institutions; some have not (yet). So, in order to protect the citizens, safeguard their norms and values, and overcome the informal resistances, the Formal institutions have to be changed. With these changes, new limitations for the Technical system will be provided. These limitations are incentives for the Technical system to innovate and improve the system, which should lead to less negative effects of the resource shale gas to society. However, so far, almost no new limitations were posed towards the Technical system. This implies that processes are continuing almost the same as before. The result of this is that the informal resistances are still present and the Societal appraisal of the resource shale gas is negative, which results in a lack of public acceptance for the resource shale gas.

So, the pressure to improve the shale gas system in the U.S and create a resource which is judged positive in the Societal appraisal and is accepted by the major share of the stakeholders, lays on the Formal institutions. Unless these institutions are altered, no changes (unless voluntarily) in the Technical system are expected. The institutions have to become congruent again; the Formal institutions have to protect the content of the Informal institutions again, in order to overcome the resistances and improve the shale gas system. Until these institutions are congruent again, citizens can lose their trust in the government and agitation in the country towards the resource shale gas can be expected.

What can be learned from this case is that the development of a Technical system depends on the conditions set in the institutions. How environmentally friendly the Technical system will be depends on the boundaries in which the system has to be developed. Also, it presents that unless (new) limitations are set by the institutions, it is unlikely that innovations in the Technical system are achieved. This implies that the Technical system in other countries, in which the institutions are different, will be subject to different limitations and possibilities wherefore the development of this Technical system is also expected to be different. To compare the shale gas case in the U.S. with the shale gas case in the Netherlands, it is unexpected that these two cases will evolve the same way since the institutions of the countries are very different. To start the Informal institutions are different, the counting norms and values in the countries are different; where, for instance, in the U.S. the environment lacks priority, the environment is of high importance in the Netherlands. Second, the Formal institutions are different. In the Netherlands, for instance, the environment is well protected and studies on the effects of certain developments have to be done in advance of the development instead of after. For this reason, the knowledge and understanding of these effects is expected to be more significant in the Netherlands than in the U.S. Because of the difference in institutions, the Technical system has to meet different requirements than the technical system in the U.S., which than obviously also creates different effects. It cannot be stated that the development, exploration and functionality of shale gas (or another resource) in different countries will not show similarities, however it can be stated that the situation will not be perfectly equal. Because of the difference in institutions and Technical system the effects of the resource and the associated resistances will be different in these countries as well. Thus, when using the shale gas case in the U.S. As an example to understand what will happen when shale gas is developed in another country, it should be understood that to what extent the cases will be equal, depends for a great extent on the similarities in institutions. One should consider which effects of the case in the U.S. are the result of the present institutions and if this effect could also be present in another country. In addition it should be considered what the influence of the institutions, in the evaluated country, on the Technical system and therewith on the effects of the resource will be. This last aspect can be challenging, since the effect of institutions is not always predictable, as can be seen in the shale gas case in the U.S. There it took 20 years before a response from the institutions came on the technical developments.

6.9.2 Conclusion validation framework

The framework provided a beneficial tool for the research on the development and functionality of shale gas in the U.S. It provided a structured approach which data had to be acquired. Furthermore, it presented how the gathered data was interrelated. Therefore, the framework was useful to create an understanding of what the effects of events or aspects in a specific system on another system are. The development of the timeline for the Informal institutions, Formal institutions and Technical system also proved beneficial to understand how the different systems react on each other. Therefore the creation of a timeline for the three systems can be recommended when the framework is used.

When executing the case study on shale gas, no data were found which could not be located under any of the factors in the framework. For this reason is can be concluded that no factors are missing in the framework. However, another case study on another resource, possibly in another country, to confirm this conclusion would be recommended.

Second, the relations in the framework proved beneficial to understand the relations between the content of the different factors. The framework is a valuable tool to understand why resistances towards a resource evolve. By means of the relations, it provides the understanding that the effects of resources are evaluated in the Informal institutions, where they could lead to resistances which can be overcome by the creation of more stringent Formal institutions. In addition it provides the understanding that if the Formal institutions are not adjusted, it is unlikely that the Technical system will be adjusted. The negative effects of the resource will then not be mitigated and therewith the resistances will not be overcome.

Third, the framework was usable, though a lot of data could be attained under the different factors. This can lead to confusion for the user. Therefore, it is important to develop a clear scope for the research in advance.

Fourth, the framework proved valuable. If the framework would not have been used it would have been challenging to understand which factors determined the development and functionality of shale gas as a resource. The whole range of factors would then be open, which would increase the amount of information that has to be processed. In addition it would not be clear how the different factors are interrelated. By making use of the framework, the information present in scientific theories is used to define which factors have to be analyzed to assess the development and functionality of a resource. Also, the relations between the different factors are provided and are based on scientific theories. So, the framework provides a scientific approach to analyze if substances can function as resources. If one would not use the framework, the analysis would probably be less structured. Furthermore, it is expected that the analysis would be done more in a more intuitive and less scientific approach. This could lead to the fact that important information could be missed. In addition, the result could become less accepted by the scientific world, since the research may not be founded on scientific theories. However, in the end it could be that the same information could be acquired without using the framework. Though the framework provides the user with two advantages; a structured and scientific approach for the research and the understanding which factors influence the development and functionality of a resource and how these are interrelated. This could significantly decrease the required time of the research and prevent important aspects from being missed.

So, the usage of the framework helps to assess the right information if one wants to understand why resources can develop and function as they do. Overall, no necessary alterations to the framework were identified during this case study.

7. Conclusion, discussion and further research

In this chapter the answers on the research questions are provided. First the answers on the sub questions are presented, where after research questions one and two will be answered. With the information on these research questions, the main question will be answered. The conclusion is followed by the insights which can be generated with the framework and the insights which are attained on the shale gas case in the U.S. Hereafter a discussion on the downsides and the value of the framework is provided and recommendations on the usage of the framework is provided. This chapter will be finalized with a reflection on the research and research process.

7.1 Answers Research questions

7.1.1 Research question 1

1. ***What does a Modernized Zimmerman framework look like and to what extent does it help to frame and explain the functionality and development of a resource?***
   i. *Which factors evolve from the analysis and systemization of the theory of E.W. Zimmerman as factors which are of influence on the development and functionality of a resource and should be included in the framework?*
   ii. *Which of these factors are internal and which factors are external?*
   iii. *How can the modern institutional theories be integrated in order to improve the 'Zimmerman framework'?*

7.1.1.1 Sub question 1i

i. *Which factors evolve from the analysis and systemization of the theory of E.W. Zimmerman as factors which are of influence on the development and functionality of a resource and should be included in the framework?*

The operationalized 'Zimmerman framework', based on the theory on of E.W. Zimmerman from his book *World industries and resources*, is presented below. The readable version of this framework can be found in appendix VI.

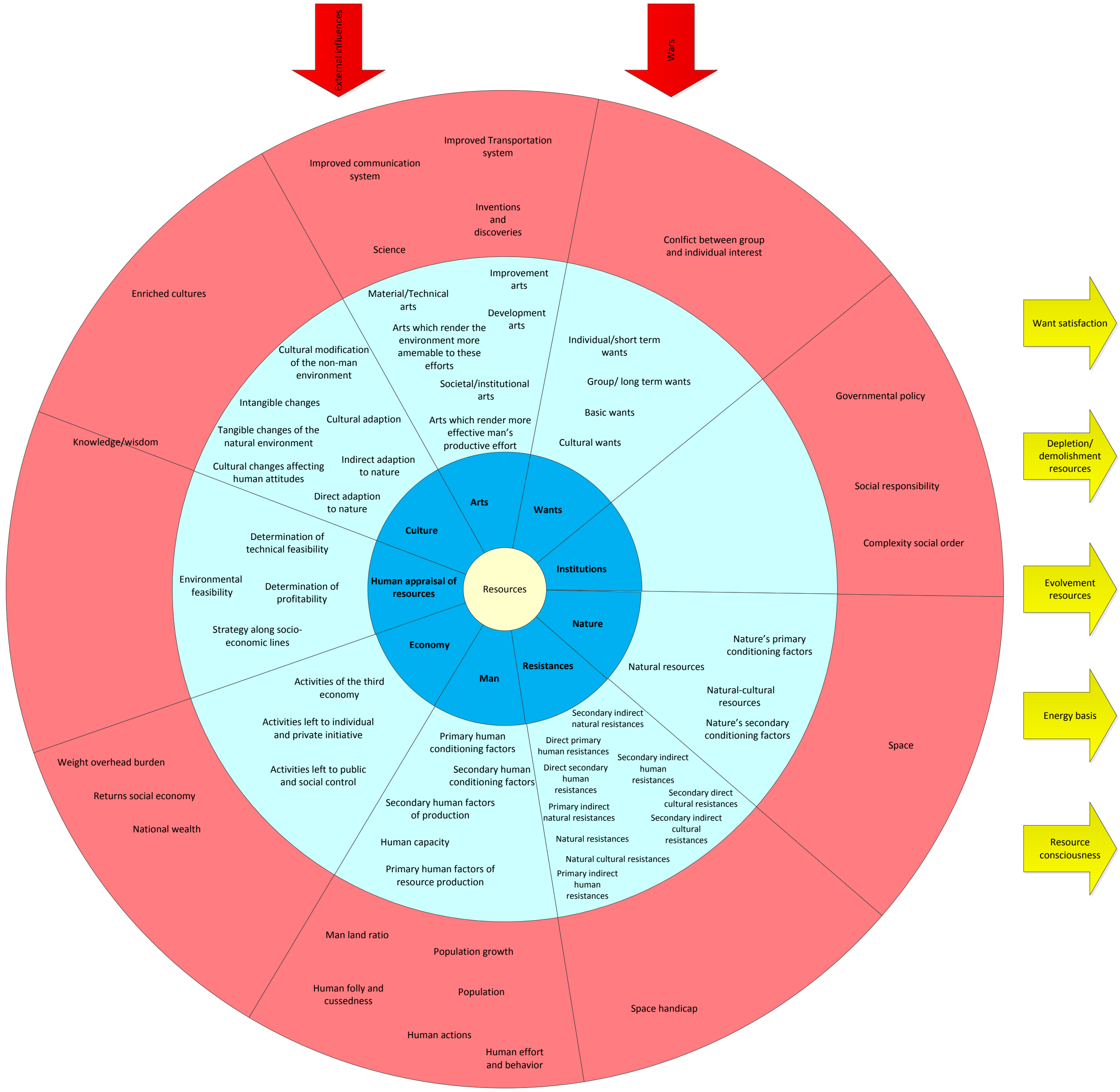


Figure 32 Operationalized Zimmerman framework

The primary factors, placed in the inner circle, are the factors that are of influence the development and functionality of resources, according to Zimmerman. These primary factors are:

- Resources
- Arts
- Wants
- Institutions
- Nature
- Resistances
- Man

- Economy
- Human appraisal of resources
- Culture

These primary factors are the most important factors in Zimmerman's theory and present the core of his theory. The factor 'Resources' is placed in the center, since all the other primary factors are of influence on the development and functionality of this factor. The factors, which could be categorized under the primary factors, are placed in the two rings around the primary factors. The second ring contains those factors which are more specified versions of the primary factors, also referred to as the sub-factors. The factors located in the third ring are the factors which are the effects and products of the primary factors or are of influence on the primary factors.

The external factors are placed in the red arrows and are factors such as war and crises, aspects which are considered external since they challenging to manage from the view of one government. The outgoing arrows present the possible effects of the interaction of the primary factors. First, Wants may be satisfied if substances can function as a Resource. Second, Resources may either evolve or be destroyed due to the interaction of the primary factors. Third, the substances which function as resource in a specific society determine the energy basis of that society. This energy basis describes which substances are used as energy sources. Finally, certain actions and developments in the primary factors may lead to resource consciousness.

7.1.1.2. Sub question 1ii

i. *Which of these factors are internal and which factors are external?*

The factors placed inside the framework are internal. The factors present in the red arrows, the external influences and war, are external.

7.1.1.3. Sub question 1iii

i. *How can the modern institutional theories be integrated in order to improve the 'Zimmerman framework'?*

In order to improve the 'Zimmerman framework' the institutional levels of the four layered model of Williamson and the updated model of Groenewegen and Koppenjan, are integrated in the 'Zimmerman framework' which creates the 'Institutionalized and Modernized Zimmerman framework'. These levels deliver abstract and comprehensive terms for the institutional elements of the framework, which complete the framework in terms of institutions and the replace the somewhat vague terms Zimmerman uses. The Zimmerman term 'Culture' is replaced by the four layered term 'Informal institutions'. Second, since the Informal institutions now are presented as a separate variable, the Zimmerman term 'Institutions' now only represent the Formal institutions. Here fore, the term 'Institutions' is replaced by the term 'Formal institutions'. Third, the level Institutional arrangements can be considered as a sub-factor of both the Formal institutions and Informal institutions and can therefore be placed in the second ring under the primary factors 'Formal institutions' and 'Informal institutions'. Fourth, the variable which is considered level four in the model of Williamson and Groenewegen and Koppenjan, the 'Decision of the individual actor' is placed under the primary factor Economy. This because the individual decides what they want for which price and what the total amount of the demanded product will be. Therefore the 'Decision of the individual actor' is a factor in the economic processes.

Hereafter, the 'Institutionalized and Modernized Zimmerman framework' is used to create the 'Modernized Zimmerman framework'. The relations between the different levels of institutions are integrated in this 'Modernized Zimmerman framework'. According to the four layered model, the Informal institutions provide limits for the Formal institutions and the Formal institutions provide feedback to the Informal institutions. These relations are also presented in the 'Modernized Zimmerman framework'. First, the Informal institutions provide limits for the formal institutions; these limits can be considered as the boundaries of what is allowed in a society. In order to protect these boundaries, Formal institutions have to be created. Thus, with the consent of Informal institutions, the Formal institutions are developed. Second, the feedback of the Formal institutions will also in this framework arrive at the Informal institutions, though this will happen through the (adjusted) effect of the resources. If adjustments are done in the Formal institutions, which pose in most cases and incentive for the Technical system to adjust, the effect of the resource on society will change. This changed effect forms the feedback for the Informal institutions from the Formal institutions. So, for the feedback from the Formal institutions to arrive at the Informal institutions a 'Round' within the framework has to be finished.

What is also present in the framework is the input of Koppenjan and Groenewegen on institutional design. They perceive that the institutions should be designed around complex Technical systems. In this research the institutions are not designed, however the understanding that institutions are of influence on the Technical system and that this Technical system evolves within the boundaries of these institutions is integrated in the framework. This understanding is represented by the arrow between the Formal institutions and the Technical system, which presents that the Technical system is created within the limits of the institutions. In addition the understanding that the Technical system has an effect on society and therewith may lead to (required) adjustments in the institutions is also integrated. The relation between the Technical system and the Informal institutions, with the factor Resource and its effects integrated, represent this insight. Therefore the input from Koppenjan and Groenewegen, that the Technical system and the institutions are not independent and, in order to function in an optimal way, should be well adjusted to another is presented in the framework.

With the relations and understandings of the four layered model added, the 'Modernized Zimmerman framework' becomes a dynamic framework in which guidance is provided on the direction and content of the relations between the factors.

Finally, the insights attained that Informal institutions are hard to change and may therefore be considered as conditions and that institutions should be congruent in order to maintain stable are valuable insights to be able to understand why resistances evolve in the Informal institutions and why the necessary solutions to overcome these resistances in most cases can be found and are started in the Formal institutions instead of in the Informal institutions.

7.1.1.4. Research question 1

What does a Modernized Zimmerman framework look like and to what extent does it help to frame and explain the functionality and development of a resource?

The modernized Zimmerman framework is presented in figure 33.

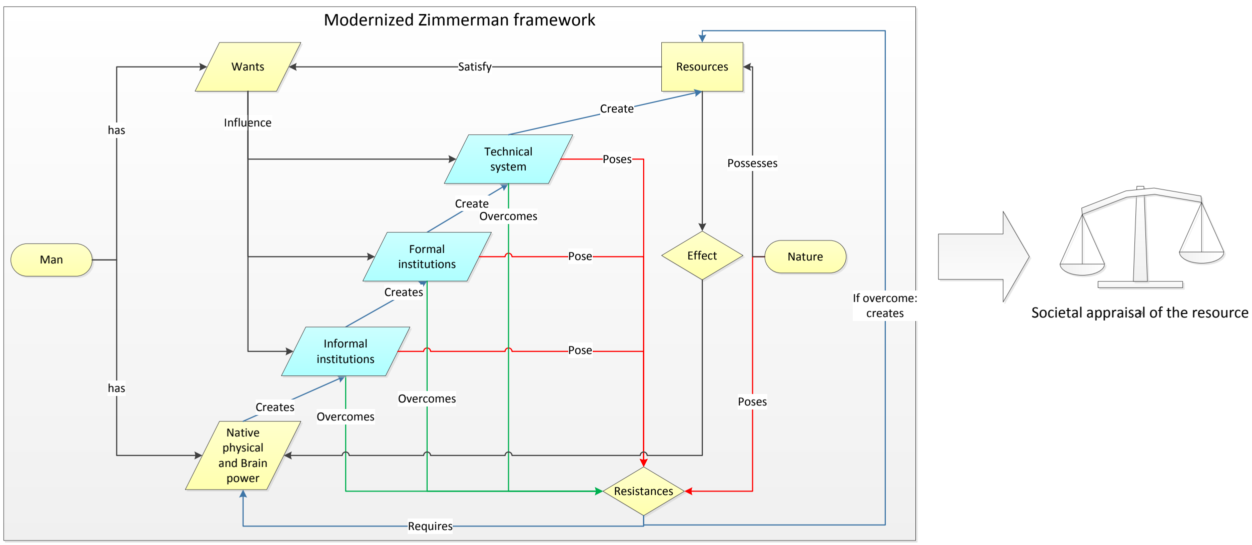


Figure 33 Modernized Zimmerman framework

The factors, included in this framework that are of influence on the development and functionality of a resource are:

- Man
- Wants
- Nature
- Informal institutions
- Formal institutions
- Technical system
- Resources
- Resistances
- Economics

The factor Economics is not present in the framework in the form of a factor, but in the form of the relation between the factors Wants and Resources. This relation could be seen as an economic relation since the factor Wants can be seen as the demand for a substance and the factor Resource as the supply which can satisfy this demand.

The factor Societal appraisal is considered the final judgment of society, a group of human beings living together, on the resource. Even though, a substance can function as a resource and satisfies at least one Want, this does not imply that the substance is judged positive as a resource, and therefore accepted, by society. The six criteria on which the resource is judged to determine the Societal appraisal of a resource are:

1. State of Wants
2. Knowledge of facts
3. Environmental feasibility
4. Profitability
5. Technical feasibility
6. Strategy along socio-economic lines

The Societal appraisal provides an understanding on the likelihood resource gets accepted by Society and on which aspects improvements are necessary to increase the level of acceptance.

The blocks 'Native physical and brain power' and 'Effects' are not factors, but elements which increase the understanding of the dynamics in the framework. The block 'Native physical and brain power' is the start of the factors 'Informal institutions', 'Formal institutions' and 'Technical system'. From this block the systems within the framework (Informal institutions, Formal institutions, and Technical system) evolve. The block does not provide new information; it provides an element in the framework which helps to understand the relation between 'Resources' and the 'Informal institutions', 'Formal institutions' and 'Technical system'. The same accounts for the block 'Effect'.

The Modernized Zimmerman framework provides a structured guidance to assess the development and functionality of resources. Often it is clear that problems appear in the field of resource development, though it may be hard to identify where these problems evolve and if these issues could be mitigated. Furthermore, it may be challenging to identify how the developments, issues and important events in the different factors are interrelated. For this reason the search for solutions for the problems, associated with the development and functionality of resources, can become very complex and time consuming.

The 'Modernized Zimmerman Framework' poses the factors which should be considered when analyzing the development and functionality of a resource. Furthermore, it shows how these factors are interrelated. It provides guidance on what may happen in the next system, if events and improvements take place in the previous system. Third, it helps to analyze why a resource is developed and if this substance is capable of meeting these demands and functions as a resource. Fourth, the framework helps to understand what the role and importance of institutions is for the development and functionality of resources. Fifth, by means of the framework it can be understood why the Technical system to attain and use a resource is developed as it is in a specific society. Sixth, it provides the understanding which factors are of influence on the effects the Resource poses on society. Seventh, it helps to understand which (Natural) resistances have to be overcome before a substance can function as a resource. Eight, understanding can be attained on which resistances are still present, even though the substance already functions as a resource. Ninth, it provides insights on how and why these resistances evolve. Tenth, it presents in which factors alterations are required if the resistances are to be overcome. Eleventh, the framework provides the understanding that the development and functionality of resources is a dynamic process which depends on many factors. If the content of one factor changes, this will also have effect on the content of the other factors. This provides the understanding the adjustments of one factor, will create different effects of the resource, which may lead to new resistances. These dynamic process will not stop until the substances is not wanted anymore, the substance becomes unavailable because of resistances which cannot be overcome or the substance is depleted of demolished.

Finally, the framework provides guidance on what can be expected from the public acceptance. The factor Societal appraisal helps to identify where the problem areas for a resource appear and in which areas improvements are necessary to increase the level of acceptance. Furthermore, the amount and importance of the resistances which are not overcome provide a strong indication if public acceptance can be expected. If there are still many resistances to overcome and the resource scores poor on the Societal appraisal it is expected that many stakeholders will not accept substance in its function as a resource. In addition, the incongruence on the institutions can lead to resistances from the informal institutions as well as to agitation of citizens and distrust in the government. Incongruence between the institutions can appear if Formal institutions are not capable of protecting the norms and values in the Informal institutions, which can be then be violated by the effects of the resource. When this happens, resistances may be posed by the Informal institutions and it may be challenging for the government to attain the trust of citizens again and lift the resistances coming from informal institutions.

As for the shale gas case, it helps to understand why the public acceptance of a resource is low, so measures can be taken to increase this level of public acceptance.

The 'Modernized Zimmerman framework' is a more useful tool to analyze the development and functionality of resources compared to the usage of the theory of Zimmerman or the 'Zimmerman framework' because the 'Modernized Zimmerman framework':

1. Provides a clear and comprehensive view of the complicated and unstructured theory of Zimmerman and only presents the core of Zimmerman's theory
2. The today's knowledge on institutions is integrated, which makes the framework modern and up to date, which was not the case with the theory of Zimmerman and 'Zimmerman framework'
3. Provides guidance on the relations between the factors in the framework, where the 'Zimmerman framework' did not
4. Presents that the process of development and functionality of resources is a dynamic process, influenced by the changing content of the factors, something which not became clear in the 'Zimmerman framework'.
5. Provides a strong guidance for research towards the development and functionality of a resource, while theory of Zimmerman provided very little guidance due to its lack of structure and complexity and the 'Zimmerman framework' did not provide guidance on the relations between the factors
6. Provides a tool to understand how resistances evolve and which factors can be addressed to overcome these resistances. This was not possible with the theory of Zimmerman or with the 'Zimmerman framework'

7. Provides insights in the level of congruency of the institutions and if the Formal institutions are capable of safeguarding the norms and values in the Informal institutions. This information is valuable to understand how resistances can evolve. These insights could not be attained with the theory of Zimmerman or the ‘Zimmerman framework’
8. Provides insights to what extent people are protected from the negative effects of resource, because both the effects of the resource and the Formal institutions, present to provide incentives to mitigate unaccepted effects, are analyzed with the framework. This provides insights in the ‘gap’ between the (unaccepted) effects and the present Formal institutions
9. Can be a valuable tool to decrease the required time for a research, while the usage of theory of Zimmerman could strongly increase this time because of the complexity of this theory.
10. Provides a scientific approach which includes important elements of both functional and institutional theories to analyze the development and functionality of resources, which can provides a strong basis for a research. The theory of Zimmerman and the ‘Zimmerman framework’ did not provide a complete approach for the analysis of the development and functionality of resources.

7.1.2 Research question 2

To what extent can we arrive at a formal description of the development and functionality of shale gas in the U.S.?

iii. To what extent is it possible to describe the development and functionality of shale gas in the U.S. with the use of the ‘Modernized Zimmerman framework’?

iv. Should the framework be adjusted, and how, in order provide a complete view on the development and functionality of shale gas in the U.S.?

7.1.2.1 Sub question 2i

i. To what extent is it possible to describe the development and functionality of shale gas in the U.S. with the use of the ‘Modernized Zimmerman framework’?

The ‘Modernized Zimmerman framework’ provides a valuable tool to describe the development and functionality of shale gas in the U.S. It was possible to describe all the relevant aspects in the development and functionality of shale gas. There was no important information found during the research, which could be not be categorized under the specified factors. Furthermore, none of the factors or relations was considered abundant.

With the framework an increased understanding on the relations between the events and their effects in the different systems within the framework (Informal institutions, Formal institutions, Technical system) is accomplished. Because of this, it became clear how these systems were interrelated and why the Technical system could evolve as it did. In addition insights are attained on why resistances have been developed against shale gas. Furthermore it became clear which resistances are still present and which areas are the solutions for these resistances could be found. Finally, it became clear why the public acceptance is low in the U.S.

Thus, it was possible to describe the development and functionality of shale gas in the U.S. by means of the Zimmerman framework.

7.1.2.2 Sub question 2ii

i. *Should the framework be adjusted, and how, in order provide a complete view on the development and functionality of shale gas in the U.S.?*

The framework does not have to be adjusted in order to provide a complete view on the development and functionality of shale gas in the U.S. However, it could be improved in terms of usability. It may be challenging for users who are not familiar with the theories on institutions and Zimmerman's approach to use the framework. The framework lacks detail to provide guidance on the content of the factors present in the framework. Therefore, sub frameworks could be developed for the factors present in framework. This, to provide guidance on the content which can be placed under the factors in the framework. This development would make it easier for researchers, who are not familiar with the theories integrated in the framework, to the use the framework. The secondary and tertiary variables from the 'Zimmerman framework' could be used to develop these sub frameworks. Though, first it should be addressed if these sub factors provide a valuable addition. Also, 'new' factors could be created for the sub-frameworks. The creation of these sub-frameworks could be the subject of further research. In addition, the user of the framework requires a clear research scope, since the usage of the framework can generate a lot of data in which one could 'get lost'.

7.1.2.3. Research question 2

To what extent can we arrive at a formal description of the development and functionality of shale gas in the U.S.?

It is possible to arrive at a complete formal description of the development and functionality of shale gas in the U.S. The framework does not require adjustments to be able to arrive at this description.

The insights which are attained during the case study are presented in paragraph 7.3.

7.2 Main question

To what extent is it possible to develop an institutional framework based on the theory of E.W. Zimmerman and new institutional economists that is constructive to generate insights on the development and functionality of a resource?

It was possible to develop an institutional framework based on the theory of E.W. Zimmerman and new institutional economists, which is constructive to generate insights on the development and functionality of a resource. This framework is the 'Modernized Zimmerman framework' (presented in figure 33). The framework proved beneficial in the analysis of the development and the functionality of shale gas in the U.S.

The framework provides a structure to analyze the development and functionality of a resource in order to create an increased understanding why and how a resource is developed and which resistances are overcome and have to be overcome for a substance to function as a resource. Furthermore it presents how the different factors and therefore the resistances interrelate. This information is very valuable if it is desired to overcome these resistances and improve the functionality of a substance as a resource. In addition the framework proves valuable to provide insights in the congruency of institutions and to what extent the norms and values of citizens are safeguarded and residents are protected from the negative effects of the resource. Also, the information could be attained that the resistances cannot be overcome and that the substance is not able to function as a resource. Furthermore, the framework helps to increase the understanding that the development of the Technical system can be different in different societies. Furthermore, the framework provides a dynamic view on the development and functionality of resources instead of static approach, which is common for many studies on resources. Finally, the framework provides an indication on the level of public acceptance for a resource by means of the outcome of the Societal appraisal and the resistances which are not (yet) overcome. The resistances which are not (yet) overcome provide an important clue in which area the instrument to overcome these resistances is present. For these reasons, the framework could be of value for scientific studies done one the development and functionality of resources and for studies on the public acceptance of stakeholders.

7.3 Insights framework

In this paragraph first the general insights which can be attained by usage of the framework are summarized. Hereafter the most important insights that are attained by the usage of the framework for the shale gas case in the U.S. are presented.

7.3.1 General insights

With the usage of the framework understanding can be achieved on:

1. The factors which are of influence on the development and functionality of a resource
2. How the factors which determine the development and functionality of a resource are interrelated
3. The fact that the development and functionality of resources is a dynamic process, which only stops when the resources becomes unwanted, resistances cannot be overcome (anymore) or the substance is depleted or demolished
4. Why a resource is exploited and used and if this resource is able to satisfy these goals
5. Why a Technical system (at a certain location) can evolve as it does and which limitations were posed and which opportunities were present for the development
6. That the adjustments to a Technical system evolve from adjustments in the institutions
7. That adjustments in the Formal institutions are in most cases the effect of resistances posed by the Formal institutions
8. The importance and role of institutions in the development and functionality of resources
9. Which factors are of influence on the effects of resources
10. That the effect of a resource can lead to resistances if this effect violates the norms and values and is therefore evaluated as unaccepted in the Informal institutions
11. Which resistances are not overcome (yet) and which are currently present towards a resource
12. If it is possible to overcome resistances and in which field the solutions for these resistances can be found.
13. In which factors adjustments should be done to overcome the present resistances and create a functional resource, accepted by all stakeholders
14. If, and possibly, which resistances can evolve because of the conditions in Nature, the Informal institutions, the Formal institutions and the Technical system.
15. To what extent the Informal and Formal institutions are congruent

16. If the resources scores well or poor on the societal judgment of the resource, which can indicate in which areas improvements have to be accomplished and if public acceptance can be expected
17. If there are many resistances left, which could lead to a lack of public acceptance
18. Why the Technical system of a resource will be different in different countries
19. Why the effects of a resource are different in different countries
20. Why the resistances towards a resource are different in different countries

7.3.2 Insights shale gas case U.S.

- In 1990 the last important improvement was done to the Technical system, which makes it function as it does today
- The informal institutions were supporting the development of shale gas until 2010
- The reasons why the informal institutions provided a supportive climate were amongst others:
    - The presence of the mineral rights
    - The entrepreneurial mind
    - The lower priority of the environment
    - The abundance of land
    - The easy credit available and the accustomedness towards loans
- Also the Formal institutions were supporting until 2010. They posed only two limitations:
    - A permit has to be attained for the usage of Diesel during hydraulic fracturing.
    - Shale gas waste water cannot be directly discharged into a water body
- Since the release of movie Gasland in 2010, the stakeholders are posing resistances. They fear that the exploration and production of shale gas can be of harm for the safety and cleanness of their environment
- For a large extent, this is true. The current (federal) Formal institution are not adequate in mitigating the following negative effects:
    - Ground water contamination
    - Contamination surface water, due to the discharge of POTW's and CWT's
    - Risk water scarcity in certain areas
    - Possible risk for the human health and environment, due to a lack of understanding of the effect and types of chemicals used during hydraulic fracturing
    - Possible risk for the human health and environment, due to a lack of understanding of the impact of hydraulic fracturing on drink water sources
- Therefore, the Formal institutions are not congruent with the Informal institutions, they are not capable of protecting the norms and values of society
- To mitigate these negative effects and overcome the informal resistances, the following adjustments have to be done to the Formal institutions:
    - The exemption of oil and gas activities under the RCRA should be lifted
    - The exemption of hydraulic fracturing under the UIC program should be lifted
    - Pretreatment standards for shale gas waste water, delivered to POTW's should be developed and enacted
    - Effluent guidelines and water criteria should be updated for the new contaminants present in shale gas waste water

    - The NPDES permits of CWT's and POTW's should be updated with the updated ELG and water criteria
    - The Frac act should be enacted
    - The speed of the report on the impact of hydraulic fracturing in drink water should be increased
    - Regulation on water usage of drilling sites in some areas should be considered
- The Formal institutions are lacking response to mitigate these negative effects. Therefore there are no incentives for the Technical system to improve
- Therefore the only changes in the Technical system can be expected on voluntary basis
- Therefore, it is unexpected that significant improvements in the Technical system will be accomplished which can mitigate the negative effects and overcome the informal resistances
- It can be considered that Man is making the same mistakes again, as he has done with the development of other resources. Again he handles with a lack of knowledge on the effects of the exploration and usage of the resource shale gas. This can have significant effects on the availability of resources in the future and on the current environment as well as on human health
- The lack of public acceptance can be understood. This lack of acceptance is expected to maintain since the Societal appraisal of the resource shale gas is negative and many resistances of the informal institutions are not overcome
- The resource shale gas scores poor on the following criteria of the Societal appraisal:
    - Knowledge
    - Environmental feasibility
- Many of the Wants of the Government are satisfied, at least four out of six, while only half of the Wants of citizens is satisfied
- The satisfaction of governmental Wants probably forms the answer why shale gas is still being explored in the U.S., even though there are still many resistances present and the society does not accept shale gas in its function as a resource.

7.4 Discussion, recommendations and further research

7.4.1 Discussion

Downsides framework

When using the framework, knowledge on institutions is required. When one does not understand what institutions are and how the different levels of institutions interact, this framework will be very hard to both understand and use.

Furthermore, the framework provides quite a broad view on the development and functionality of a resource. The user could get lost in all the aspects which could be placed under the different factors. For instance it may be challenging to identify which aspects of the Technical system should be considered and which will fall out of the scope of the research. Therefore, understanding of how the framework should be used, background knowledge on what the different factors comprise and a clear scope of research are required. The problem of the lack of understanding what content should be considered under the different factors, which appears because of the lack of detail in the framework, could be reduced by the creation of sub frameworks which provide guidance on the data that should be acquired. In order to create these sub-frameworks further research would be necessary in order to define which factors should be integrated.

Also, in order to provide a founded statement on the development and functionality, quite some research is necessary. This is not reduced by the framework; it only provides guidance which areas the research should address. So, the research which has to be done can still be quite extended, however the required time for the research can be reduced by the guidance of the framework. Without the framework the researcher should first define which factors are involved in the development and functionality of a resource and how these factors are related. That step has now already been executed.

Value framework

So the framework provides guidance for the research towards the development and functionality of resources and can, when used correctly, provide insights in why and how a resource is developed, how the content, events and adjustments in one factor are of influence on the next factor, how resistance evolve and can be overcome and why a lack of public acceptance for a resource can be present. However it may be questioned what the value of this framework is. Is it not possible to gather these insights without the framework? In addition it may be questioned if the theory of Zimmerman was the best theory to be used and if there was not another theory which could have formed the basis of the framework.

The answer to the first question will depend on the researcher. A researcher with an extended knowledge on institutions and resources could possibly come up with some of the same insights as which can be generated with the framework, while a researcher who has no knowledge on institutions will most probably come up with very different results. This does not mean that these results are wrong; however it is unexpected that the same insights will be generated. This because it is expected that different factors will be assessed and that different relations may be applied between the factors. The reason that a user with extended knowledge on institutions could come up with some of the insights which can be generated with the framework, is that he probably understands the relations between the Informal and Formal institutions and the Technical system. This could provide him with the insight that a change in one system will cause a change in another. Furthermore, he could come up with the idea that resources are evaluated in the Informal institutions, according to counting norms and values of a society. Also, he could come up with the insight that the Formal institutions are not strict enough to protect society from the effects of a resource, and that problems can appear because people feel unprotected by the Government and that this creates agitation. Possibly he could also relate this to a lack of congruency between the institutions. Possibly he could even develop a ‘round ‘of these factors and their dynamic relations.

However, the chances are slim that he would come up with the assessment of the other factors and their associated relations in the framework, which determine why a resource can function as a resource; the factors Man, Economics, Nature, Resistances and Wants will probably not be assessed or in a very different way. These factors are the factors which have been introduced by Zimmerman. If another theory would have been used, these factors would have been different. This would not have led to a 'wrong' framework, though the insights which could have been attained with it would have been very different. Especially the factor Resistance is valuable aspect of the developed framework, since it increases the understanding why and how resources can evolve as they do and how associated problems can appear and could be overcome. The understanding that in order to obtain and use a resource, resistances have to be overcome and that the effects of resource can create new resistances provides an important step in understanding why certain things happen in the Informal institutions, Formal institutions and the Technical system. Also, the factor Resistances provides understanding why a lack of public acceptance can be present; many resistances have not been overcome. Furthermore the understanding that the resources are dynamic and that changes in one factor create effects for another, provides the awareness that one cannot change one factor and assume the problem is solved; also this adjustment will have effects and additional adjustment may again be required. This process will not stop until the resource is either physically demolished or have become unwanted. These insights are specific for the theory of Zimmerman and would not have been attained by using another theory. The writer is convinced, that especially because of the usage of the theory of Zimmerman and not of someone else, this framework is useful to provide original and valuable insights concerning the development and functionality of resource, which will be difficult to attain without it. Without the usage of Zimmerman's theory, the framework probably would have been more focused on the economic aspects of the development and functionality of a resource, as is common in many theories, instead of on the dynamics of the multiple elements which determine why a resource can function as it does.

Concluding, it will be challenging to attain the same original and valuable insights without the usage of the developed 'Modernized Zimmerman framework', however it is not impossible. In addition, insights attained while using a different approach may also be valuable, though it is likely that the focus of these insights will be slightly different since most probably different factors are assessed.

7.4.2 Usage and Policy recommendations

When using the framework, it should be understood what the different factors imply and what their role in the framework is. Therefore, it is advised to read at least chapter five of this report, when one plans to use the framework. In addition, it is advised to use the timelines, as provided in figure 25, to create an overview of the important events in the Informal institutions, Formal institutions and Technical system. This could be valuable in understanding why the resource could be developed as it is and function as it does in a specific society.

The framework could form a useful tool for a research towards the development and functionality of a resource. The framework provides a structured approach for the line of the research. It presents which factors should be assessed and how these factors interrelate in the form of 'rounds' in the framework. This could provide the researcher with a scientific approach for his research and reduce the required time for the research. Second, the framework could provide the structure for a discussion with stakeholders. By means of this structure the important factors can either be explained or together with the stakeholders assessed to identify how the resource is or can be developed, why it is able to function as a resource and why and how resistances have evolved and how these could be overcome. The usage of the framework could provide an important advantage because it can be challenging to apply a structure in a discussion, which can lead to lack of depth and assessment of the real important aspects. Also, the framework seems beneficial to provide an indication of the public acceptance, and the causes behind this (lack of) acceptance. Therefore, the framework could be beneficial for research towards the public acceptances of resources.

This framework can also be valuable tool for governments to arrive at an informed decision making process on whether or not they will start to use a substance as a resource. An example of a government who could use this framework is the Dutch Government. Currently they are deciding if they want to allow shale gas exploration in the Netherlands. A report on the effects of shale gas for the Netherlands is developed, which serves as the advice for the minister of economic affairs. In this report the case in the Netherlands is often compared to the case in the U.S. However, it may be questioned if the effect of the difference in institutions in these countries is thoroughly understood. The development of the Technical system to attain and use a resource in a country will for a large part depend on the present institutions. Therefore the effects of the resources and resistances which can evolve from these effects are also related to the institutions in a country. When the effect of the difference in the content of these institutions, is not fully understood, it will be challenging to provide a conclusion on the possibility to develop shale gas in the Netherlands, based on what happened in the U.S. The framework can help to understand why and how the resistances in the U.S. and in the Netherlands evolve and if the same resistances can be expected. For instance, the negative effects which related of the (lack of) regulation concerning to storage of shale gas waste water, are not expected in the Netherlands, since more stringent requirements for storage of shale gas waste water are present here. Therefore, the resistances which can evolve out if this effect are expected to be less in the Netherlands than in the U.S. where open pit storage is allowed. With the understanding on how and why resistances have evolved in the U.S., insights can be attained on if these resistances can evolve and can be overcome in the Netherlands and how this could be done. However, the assessment if it would be possible to overcome the resistances which are present in the U.S. would not be sufficient. It should also be considered which resistances can appear in the Netherlands based on the present institutions of this country. After the present resistances in the Netherlands and the possible resistances which can appear in this country are identified, it can be assessed if these resistances can be overcome and how. It is recommended to identify these possible resistances and their possible solutions before drilling operations are started. It is of high importance that these resistances and the effects of the resource which could become resistances are critically analyzed and understood. If it appears that these resistances cannot be overcome and that the resource poses unacceptable negative effects, it is expected that the public acceptance will be low for the resource. In addition, the resource could have negative effects on the environment, human health and resources of the future.

So, the framework could provide a valuable tool for governments to understand why and how a resource can be developed, what the effect of the difference in institutions between countries is on the effect of the resource on society as well as on the resistance which can evolve, how resistances evolve and which resistances can be expected and if these resistances could be overcome and how. This increased understanding could be beneficial in the decision making process on the usage of a substance as a resource.

7.4.3 Further research

In order to evaluate the generalization possibilities of the framework, further research is required. First, a case study on the development of shale gas in a different country should be done. This will be done in order to explore if the framework is also usable in other countries. Furthermore, this analysis could be used to identify to what extent the resistances for shale gas are different per country. This would provide the answer to the question if a difference in institutions indeed leads to different resistances, as is expected.

Second, a case study on another resource, already widely used and accepted by most stakeholders, should be analyzed with this framework. This case-study could provide insight to what extent resistances may still be present while the substance is accepted by the public as a resource and why this is the case. This could bring important insights to what extent resistances can still be present, while the resource can be used and integrated in society. This would provide valuable insights in the field of public acceptance of resources. It could be useful in forecasting if a resource can become accepted by the major share of stakeholders in a country.

Furthermore, a study could be done towards the exact wants of an energy resource of a society. In this research the Wants of the government were considered, however, as stated before, these Wants were actually more Wants which belonged to the substance of conventional natural gas. The government was looking for a substance which could satisfy the same Wants as conventional gas, though which could also provide them with energy security and energy independence. Further research on this subject, could provide valuable insights in the field of resource development on what society does exactly want from an energy resource. This could possible lead to other substance which could fulfill these Wants than the substances that are used today.

The development of sub-frameworks for the factors integrated in the framework would be beneficial to provide guidance for the user on what should and could be included in his research. This would decrease the amount of knowledge required to use the framework. Therefore further research would be beneficial to develop these sub-frameworks. The secondary and tertiary factors present in the 'Zimmerman framework' could be used in these sub-frameworks. Also, new factors may be added to these sub frameworks.

7.5 Reflection

In this final paragraph the reflection on the research is provided. First a reflection will presented on the different research phases, which are the development of the 'Zimmerman framework', the exploration of modern institutional theories, the development of the 'Modernized Zimmerman framework' and finally the case study on the development and functionality of shale gas in the U.S. using this framework. Second, a reflection will be provided on the process of the research.

7.5.1 Reflection research phases

7.5.1.1 Development Zimmerman framework

The development of the 'Zimmerman framework' was not an easy process. Zimmerman's theory is unstructured and complex and it was hard to define which variables meant the same and which variables added new information. The causal relation diagram and the tables in appendix I were necessary to be able to identify which variables meant the same and which were abundant for this research. With the definitions of the variables and the relations of the variables identified, it could be clarified why some variables could be combined into one and why some could be removed. Furthermore, the causal relation diagram was an important step to identify which factors formed the core of Zimmerman's theory and which were to be integrated in the 'Zimmerman framework'. The steps towards the 'Zimmerman framework' were very time consuming, though they were important, since if these would have been wrong, the results would have been wrong, which would have provided a wrong framework, which again would have formed the basis for a 'wrong' research. Furthermore, these steps show that the research was done in a systematic and considered way, and that it was not a guess which factors were important.

7.5.1.2 Exploration Modern institutional theories

The development of the Modern institutional framework was difficult in the sense that the theory on institutions is challenging to understand. Though, it was not hard to attain the right material, because of the lectures provided during the master *Systems Engineering Policy Analysis and Management*. Furthermore, with the increased understanding on the concept of institutions and with the right material and some guidance from the supervisors, the integration of the institutional elements to improve the Zimmerman framework was only challenging and interesting.

7.5.1.3 Development 'Modernized Zimmerman framework'

The development of the 'Modernized Zimmerman framework' was the most exciting step in this research. It was enjoyable to integrate all the factors, which were extracted in the previous phases, in the framework and to see that the framework became a valuable instrument to analyze the development and functionality of resources.

7.5.1.4 Case-study

The case study was a part of the research which was expected to consume a lot of time. So it did. With the amount of information present on the subject shale gas, it was sometimes hard to maintain the research focus. Furthermore, it was sometime challenging to separate the 'right' information from the 'wrong' information. This was because it was already difficult to find one source on various subjects, and often impossible to find a second source to confirm the information from the premier source. This problem was reduced by the informal interviews done with experts at conferences and hearings. They confirmed that the information presented in this research was aiming in the right direction, or they provided clues on missing aspects or aspects which were possibly wrongly interpreted. An example of this is presented by the role of the EPA, which was according to one of the experts not that 'objective' as presented. It appeared that not all information according the negative effects on hydraulic fracturing was presented by these institutions. This last problem was not a problem only related to the EPA. As always, it is hard to find correct negative information on for example drilling procedures. These negative aspects are often not published and are maintained for the company's information only. This may have led to a case study in which fewer problems are presented, than there are in real life. This introduces the next problem, the fact that this study will never be truly finished. Every found paper or fact, will lead to a new question. However, due to the time limit not all these questions could be answered. Therefore this leads to the idea for the writer that the research is not completed yet. One of these uncompleted aspects is for example the state law, which could not be integrated in the research due to the time limit. This leads to a gap in the Formal institutions. It is possible that some informal resistances have been handled by state law, though this was not part of the research. Therefore, the case-study was a very challenging part of the research in terms of making the right choices on what to include and what not and also led to the feeling that this research is not completely finished yet.

7.5.2 Reflection research process

When the whole research process is reflected, it can be stated that it was quite a journey. The issue which I found most difficult and frustrating was the development of the research proposal. I knew I wanted to graduate on shale gas, though on which area I did not. I found it very hard to make a forecast on what could be researched in the three month research period. It took a very long time until the final idea for my research was developed. Though, during this period I learned a lot about several aspects of shale gas which made it easier to do the case-study in a later stage.

When I finally had my kick-off, the process went quite well. However, I had underestimated the work load to develop the Zimmerman framework. Together with an illness of 2 weeks, this led to a delay of 5 weeks. Also, I had some problem with extracting the critical information for the case study, which also caused a delay.

Overall, the research was fun and challenging and I have achieved my goal in improving skills in the fields which were challenging during my study. The development of a clear and structured framework of something which is very complex posed this challenge. However, I think that the research was too big, for the time frame which was presented for it; I underestimated the work load for some of the aspects. Though due to my interest in the subject, the results I attained and the guidance of my supervisors I kept motivated to finish the research.

8 .References

Note: The elements in the text which have been printed in cursive are the literal words or statements as used in the references.

Arbingast, S. A., Ayres, C. E., & Blair, C. B. (1961). In memoriam Erich Walter Zimmerman.

Beirne, Maynard, Parsons, & L.L.P. (n.d.). Overview of Legal issues and litigation arising from shale gas development and Fracking. Beirne, Maynard & Parsons, L.L.P. Retrieved from http://www.bmpllp.com/files/cle_presentation_on_legal_issues_litigation_arising_from_shale_gas_and_fracing.pdf

Chevron. (2012). How we operate. Retrieved May 1, 2013, from http://www.chevron.com/deliveringenergy/naturalgas/shalegas/howweoperate/

Committee on Induced Seismicity Potential in Energy Technologies, Committe on Earth Resources, Committe on Geological and Geotechnical Engineering, Committe on Seismology and Geodynamics, Board on Eart Sciences and Resources, & Division on Eath and Life Studies. (2012). *Induced Seismicity Potential in Energy Technologies*. Washington DC. Retrieved from http://www.nap.edu/openbook.php?record_id=13355&page=R1

De Gregori, T. R. (2012). Resources Are Not ; They Become :, *21*(3), 1241–1263.

Delek Energy. (n.d.). Natural Gas Volumes Converter. Retrieved May 3, 2013, from http://www.delekenergy.co.il/?pg=calc&CategoryID=198

Economics & Statistics American Chemistry council. (2011). Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and US Manufacturing, (March). Retrieved from http://chemistrytoenergy.com/sites/chemistrytoenergy.com/files/ACC-Shale-Report.pdf

Economides, M. J., Oligney, R. E., & Lewis, P. E. (2012). U.S. natural gas in 2011 and beyond. *Journal of Natural Gas Science and Engineering*, *8*, 2–8. doi:10.1016/j.jngse.2011.10.007

Eden, S. (1996). Public participation in environmental policy : considering scientific , counter-scientific and non-scientific contributions, *5*, 183–204.

Entrepreneur.com. (n.d.). Retrieved from http://www.entrepreneur.com/encyclopedia/capital-equipment

Environmental Protection Agency. (n.d.-a). Safe Drinking Water Act (SDWA). Retrieved April 27, 2013, from http://water.epa.gov/lawsregs/rulesregs/sdwa/index.cfm

Environmental Protection Agency. (n.d.-b). Hydraulic Fracturing Under the safe Drinking Water Act. Retrieved April 24, 2013, from http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/hydraulic-fracturing.cfm

Environmental Protection Agency. (n.d.-c). Class II Wells - Oil and Gas Related Injection Wells (Class II). Retrieved May 21, 2013, from http://water.epa.gov/type/groundwater/uic/class2/index.cfm

Environmental Protection Agency. (n.d.-d). Effluent Limitations Guidelines and standards. Retrieved August 27, 2013, from http://cfpub.epa.gov/npdes/techbasedpermitting/effguide.cfm

Environmental Protection Agency. (n.d.-e). Clean air act. Retrieved April 29, 2013, from http://www.epa.gov/air/caa/

Environmental Protection Agency. (n.d.-f). Clean Water Act. Retrieved August 27, 2013, from http://cfpub.epa.gov/npdes/cwa.cfm?program_id=45

Environmental Protection Agency. (n.d.-g). Regulatory actions. Retrieved April 24, 2013, from http://www.epa.gov/airquality/oilandgas/actions.html#area

Environmental Protection Agency. (n.d.-h). Summary of Requirements for processes and equipment of natural gas well sites. Retrieved from http://www.epa.gov/airquality/oilandgas/pdfs/20120417summarywellsites.pd

Environmental Protection Agency. (n.d.-i). EPA's Study of Hydraulic fracturing and Its Potential Impact on Drinking Water Resources. Retrieved April 25, 2013, from http://www2.epa.gov/hfstudy

Environmental protection agency. (2012). FACT SHEET : Underground Injection Control (UIC) Program Permitting Guidance for Oil and Gas Hydraulic Fracturing Activities Using Diesel Fuels , UIC Program Guidance # 84 – Draft. Retrieved from http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/hfdieselfuelsfs.pdf

Environmental Protection Agency. (2012a). Oil and Natural Gas Sector: Standards and National Emission Standards for Hazardous Air Pollutants Reviews: Final Rule. Retrieved from http://www.gpo.gov/fdsys/pkg/FR-2012-08-16/pdf/2012-16806.pdf

Environmental Protection Agency. (2012b). Overview of final amendments to air regulations for the oil and natural gas industry. Retrieved from http://www.epa.gov/airquality/oilandgas/pdfs/20120417fs.pdf

Environmental Protection Agency. (2012c). EPA issues updated, Achievable Air Pollution Standards for Oil and Natural Gas. Retrieved May 2, 2013, from http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/c742df7944b37c50852579e400594f8f!OpenDocument

Environmental Protection Agency. (2012d). History of the Clean Air Act. Retrieved from http://epa.gov/oar/caa/caa_history.html

Environmental Protection Agency. (2012e). Implementation. Retrieved May 2, 2013, from http://www.epa.gov/airquality/oilandgas/implement.html

Environmental Protection Agency. (2013a). Natural Gas Extraction-Hydraulic Fracturing. Retrieved May 1, 2013, from http://www2.epa.gov/hydraulicfracturing

Environmental Protection Agency. (2013b). Natural Gas STAR Program. Retrieved May 2, 2013, from http://www.epa.gov/gasstar/

Environmental Protection Agency. (2013c). Benefits and Costs of the Clean Air Act. Retrieved May 1, 2013, from http://www.epa.gov/air/sect812/prospective2.html

Federal Judicial Center. (n.d.). The U.S. Legal System: A Short Description. Retrieved from http://www.fjc.gov/public/pdf.nsf/lookup/U.S._Legal_System_English07.pdf/$file/U.S._Legal_System_English07.pdf

Foster, D., & Perks, J. (2012). Climate impact of potential shale gas production in the EU Final Report, (2).

Free Dictionary. (n.d.). Retrieved from http://www.thefreedictionary.com

Geology.com. (n.d.-a). Mineral Rights. Retrieved May 2, 2013, from http://geology.com/articles/mineral-rights.shtml

Geology.com. (n.d.-b). Shale. Retrieved from http://geology.com/rocks/shale.shtml

Geology.com. (2010). What is shale gas? Retrieved November 14, 2012, from http://geology.com/energy/shale-gas/

Geology.com. (2013). Hydraulic fracturing of oil&gas wells drilled in shale. Retrieved from http://geology.com/articles/hydraulic-fracturing/

Ghorbani, A., Ligtvoet, A., Nikolic, I., & Dijkema, G. (n.d.). Using Institutional Frameworks to Conceptualize Agent-based Models of Socio-technical Systems. Delft.

Go Frac. (n.d.). Slick water solutions. Retrieved May 31, 2013, from http://www.gofrac.com/services/slick-water.html

Goodin, R. E. (1996). Institutions and their design. *The theory of institutional design* (pp. 21–43). Cambridge: Press syndicate of University of Cambridge. Retrieved from http://books.google.nl/books?id=nCSQtIzMBqcC&printsec=frontcover#v=onepage&q&f=false

Groenewegen, J., & Lemstra, W. (2007). Schools of Institutional Economics. Delft.

Haas, M. R., & Goulding, A. J. (1992). Impact of Section 29 Tax Credits on Unconventional Gas Development and Gas Markets. Washington DC.

Hammer, R., & Levine, L. (2012). *In Fracking ' s Wake : New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater Authors And development*.

Hodgson, G. M. (2005). Institutional Economics into the Twenty-First Century Institutional (pp. 1–19). Hertfordshire.

Hodgson, G. M. (2006). What are institutions. *Journal of economic issues*, *XL*(1), 1–25.

Kefferpütz, R. (2010). Shale Fever : Replicating the US gas revolution in the EU ? *Centre for European plicy studies, policy brief*, (210). Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1635280

Klijn, E.-H., & Koppenjan, J. F. M. (2006). Institutional design. *Public Management Review*, *8*(1), 141–160. doi:10.1080/14719030500518915

Koppenjan, J., & Groenewegen, J. (2005). Institutional design for complex technological systems, *5*(3), 240–257.

Legal Information Institute Regulations for state programs. Legal Information Institute. Retrieved from http://www.law.cornell.edu/uscode/text/42/300h

Martineau, D. F. (2007). History of the Newark East field and the Barnett Shale as a gas reservoir. *AAPG Bulletin*, *91*(4), 399–403. doi:10.1306/intro910407

Newman, N. (2012). The revolution will eat its children. *Shale gas investment guide/ Poland*, (winter 2012), 87–88.

North, D. C. (1990). *Institutions, institutional change and economic performance* (pp. 1–37). Cambridge: Cambridge university press. Retrieved from http://books.google.nl/books?id=oFnWbTqgNPYC&printsec=frontcover&dq=douglas+north+1990&hl=en&sa=X&ei=4lnIUKvlHOnE0QXR0oCwAg&ved=0CC8Q6AEwAA#v=onepage&q&f=false

Ostrom, E. (2005). *Understanding institutional diversity*. New Jersey: Princeton University press.

Overview of the Legal System. (n.d.). Retrieved from http://wwwhttp//law.sc.edu/library/circuit_riders/manual/overview_of_legal_system.pdf.fjc.gov/public/pdf.nsf/lookup/U.S._Legal_System_English07.pdf/$file/U.S._Legal_System_English07.pdf

Pierson, P. (2000). The Limits of Design: Explaining Institutional Origins and Change. *Governance: An International Journal of Policy and Administration*, *13*(4), 475–499. doi:10.1111/0952-1895.00142

Prohaska, M., & Thonhauser, G. (2012). The importance of Wellbore Integrity for Ground Water Protection in Shale Gas Well Construction. Retrieved from http://www.shale-gas-information-platform.org/categories/water-protection/knowledge-base/prohaska.html

ProPublica. (n.d.). What is hydraulic fracturing. Retrieved from http://www.propublica.org/special/hydraulic-fracturing-national

Sakmar, S. L. (2012). Overview of Environmental issues and US Regulatory Framework Pertaining to US Shale gas Development. Retrieved from http://www.shale-gas-information-platform.org/categories/legislation/expert-articles/sakmar-article.html

Schaliegasvrij Nederland. (n.d.). Schaliegasvrij Nederland. Retrieved August 20, 2013, from https://www.schaliegasvrij.nl/

Scott. (n.d.). *Crafting an analytical framework I three pillars of institutions* (pp. 47–71).

Shale gas information Platform. (n.d.). What are the benefits. Retrieved May 1, 2013, from http://www.shale-gas-information-platform.org/what-are-the-benefits.html

Stevens, P. (2012). briefing paper The " Shale Gas Revolution ": Developments and Changes, (August). Retrieved from http://www.chathamhouse.org/sites/default/files/public/Research/Energy, Environment and Development/bp0812_stevens.pdf

Thakre, P., & Shenkar, L. (2013). Shale Gas Boom Creates Market Opportunity To Clean Fracking Water. Retrieved May 4, 2013, from http://www.forbes.com/sites/ericagies/2011/08/23/game-changing-vacuum-creates-market-opportunity-to-clean-fracking-water/

The Scientific Alliance. (2010). Shale gas: good new or bad. Retrieved May 1, 2013, from http://www.scientific-alliance.org/scientific-alliance-newsletter/shale-gas-good-news-or-bad

Tiemann, M., & Vann, A. (2013). *Hydraulic Fracturing and Safe Drinking Water Act Regulatory Issues*.

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, *14*(3), 207–222. doi:10.1111/1467-8551.00375

U.S. Department of energy. (2013). Clean Construction USA. Retrieved May 2, 2013, from http://www.afdc.energy.gov/laws/law/US/324

U.S. department of the Interior, & U.S. geological Survey. (2013). *Map of Assessed Shale Gas in the United States , 2012 U . S .* Virginia. Retrieved from http://pubs.usgs.gov/dds/dds-069/dds-069-z/DDS-69-Z_pamphlet.pdf

U.S. Energy Information Administration. (2011). World Shale Gas Resources : An Initial Assessment of 14 Regions Outside the United States, (April). Retrieved from http://www.eia.gov/analysis/studies/worldshalegas/pdf/fullreport.pdf

U.S. Energy Information Administration. (2012). What is shale gas and why is it important. Retrieved from http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm

U.S. Energy Information Administration. (2013). Annual energy outlook. Retrieved May 3, 2013, from http://www.eia.gov/forecasts/aeo/MT_naturalgas.cfm#natgas_prices

United Nations. (2013). Status of Ratification of the Kyoto Protocal. Retrieved May 3, 2013, from drillers are spending two to five times their

Wikipedia. (n.d.). Retrieved from Wikipedia.org

Williamson, O. E. (1998). Transaction cost economics: how it works; where it is headed**, (1), 23–58.

Zimmerman, E. W. (1946a). *Resources of Latin America, A study in methodology*. University of Texas Institute of Latin-America studies.

Zimmerman, E. W. (1946b). Some Economic Aspects of Postwar Inter-American Relations. University of Texas Institute of Latin-American Studies.

Zimmerman, E. W. (1951). *World resources and industries,* (Revised.). New York: Harper and brothers, publishers, new york.

Zimmerman, E. W., Spahr, Walter, E., & (ed.). (1936). Economic principles and problems. *Economic principles and problems*, *1*, 186.

Appendixes

Appendix I Extracting Zimmerman’s theory

The causal relation diagram

In this chapter the initial causal relation diagram, based on the theory of E.W. will be clarified. The diagram is based on selected information on the development of resources from Zimmerman’s book *“World’s resources and industries, a functional appraisal of the availability of agricultural and industrial materials*”.

The initial causal relation diagram was developed from the information which Zimmerman has literally stated in his theory. No assumptions on possible combinations of variables and relations were done in this diagram. Due to this lack of assumptions, the diagram became large and poorly organized. This provides difficulties in the reading and understanding of this diagram. The initial causal relation diagram is presented below. A more readable version of this diagram is provided in appendix VI.

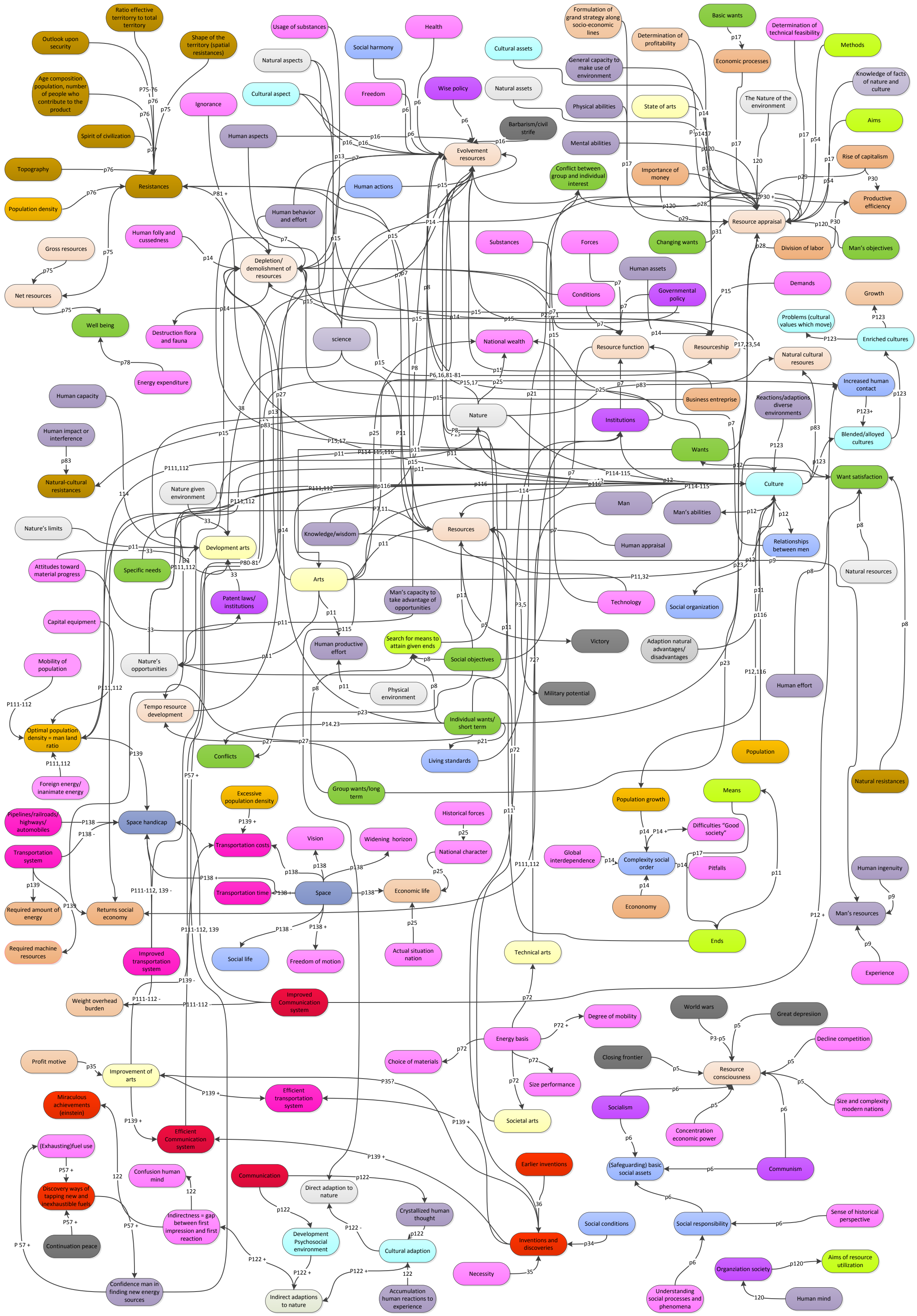


Figure 34 Initial causal relation diagram

In this chapter, all the variables which are used in the diagram will be clarified and their contribution to the diagram will be critically considered. As a result, some variables will be removed and some variables will be combined into new ones. Also, new relations between variables may be suggested.

The clarification of the variables will be done with help from the dictionary and the information which Zimmerman provides on the specific variables. First, the information which Zimmerman provides for the specific variable is stated. This is the information which is stated in cursive. The pages on which these statements can be found are presented after the statement. Then, if necessary a dictionary definition of (part of) the variable is provided. Third, a definition of the variable is created. This definition is developed from the information provided by Zimmerman, the dictionary and the relations of the variable with other variables, which are stated in the table underneath the definition. Fourth, a table with the relation(s) of the variable is provided. These relations are clarified by statements derived from the theory of Zimmerman. The information which is provided in cursive considers literal statements of Zimmerman. The pages, on which these statements can be found in the first column; *page*. The information printed in standard writing is information based on the information provided by Zimmerman or the information from the dictionaries. If quotes are provided instead of a statement, this means that the statement on relation with the previous variable, also counts for this variable. Fifth, if necessary, the contribution and other aspects of the variables are discussed under the heading 'Comments'. Finally, the changes and adjustments to the diagram, based on the previous steps, are determined and provided under 'Changes to initial causal relation diagram'.

The variables are organized in eighteen paragraphs. At the end of every paragraph a conclusion is provided, which poses the definitions of the variables considered in that paragraph and the possible alterations to the diagram derived from that paragraph.

Finally, a conclusion of all the definitions and alterations is provided in paragraph 19. The alterations presented in this conclusion form the input for the simplified causal relation diagram. This simplified causal relation diagram forms the input for the 'Zimmerman framework'.

The different categories of variables and therefore the paragraphs of this chapter are:

1. Resources
2. Resistances
3. Wants
4. Nature
5. Culture
6. Arts
7. Man
8. Inventions
9. Transport
10. Economy
11. Policy and institutions
12. Social
13. Methods and Means
14. External influences
15. Space
16. Communication
17. Population
18. Additional variables

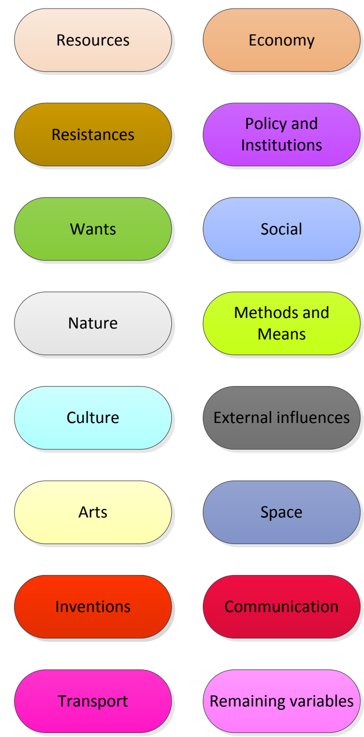


Figure 35 Legend causal relation diagram

These different categories all have their own color in the causal relation diagram. These colors are presented in the legend provided in figure 35.

1. Resources

1.1 Resource ship

"Resource ship" evolves out of the three-way interaction of natural-human and cultural assets." (p14).

"Resource ship stems from the purposeful interaction of natural, cultural and human aspects primed and kept going by demand based on availability for use." (p15)

Dictionary definition –ship*: Indicates a quality, state or condition* ("Free Dictionary," n.d.)

Definition Resource ship: The state or condition when tangible or intangible aspects can function as a resource, which evolves out of the interaction of natural, human and cultural aspects.

Table 4 Resource Ship

page	Variables influencing resource ship	Variables influenced by resource ship	Description
14	Natural assets		*"Resource ship" evolves out of the three-way interaction of natural, human and cultural assets.*
14	Human assets		*"*
14	Cultural assets		*"*
15	Demands		*Resource ship stems from the purposeful interaction of natural, cultural and human aspects primed and kept going by demand based on availability for use.*
15	natural aspects		*" "*
15	human aspects		*" "*
15	cultural aspects		*" "*

Comments:

- Since Zimmerman describes "Resource ship" both as the result from the interaction of human, cultural, and natural aspects as the result from the interaction of human, cultural and natural assets, it is possible to assume that Zimmerman implies the same with aspects as with assets.
- If these variables can and will be combined will be discussed in the explanation of these variables.

Changes to the initial causal relation diagram: -

1.2 Resource function

"To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects-such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together." (p6)

"Likewise unfortunate is the tendency to think of resources in terms of a single asset, e.g., coal rather than in terms of the whole complex of substances, forces, conditions, relationships, institutions, policies, etc., which alone help to explain the way coal functions as a resource at a given time and place." (p7)

"The word 'resource' does not refer to a thing or a substance but to a function which a thing or a substance may perform or to an operation in which it may take part, namely the function or operation of attaining a given end such as satisfying a want. In other words, the word "resource" is an abstraction reflecting human appraisal and relating to a function or operation." (p7)

Dictionary definition function:

1) "The action for which a person or thing is particularly fitted or employed.

2) The natural action or intended purpose of a person or thing in a specific role." ("Free Dictionary," n.d.)

Definition Resource function: The action or purpose of a substance which makes it suitable for the fulfillment of the role as a resource.

Table 5 Resource function

page	Variables influencing Resource function	Variables influenced by Resource function	Description
7	Conditions		*Likewise unfortunate is the tendency to think of resources in terms of a single asset, e.g., coal rather than in terms of the whole complex of substances, forces, conditions, relationships, institutions, policies, etc., which alone help to explain the way coal functions as a resource at a given time and place.*
7	Governmental politics		" "
7	Institutions		" "
7	Substances		" "
7	Forces		" "
7	Relationships between man		" "
7		Resources	" "

Comments

- When looking at the definition of "Resource ship" it seems possible to combine this variable with the variable "Resource function". The variable "Resource ship" indicates the state or condition when a substance or thing may function as a resource. The variable "Resource function" implies the action or purpose of a substance of which makes it suitable to fulfill its role as a resource.

This means that when a substance fulfills is role as a resource it is in state of resource ship. In order to simplify the diagram, it is suggested to combine these two variables into one.

Changes to the initial causal relation diagram:

- The variable “Resource ship” and “Resource function” may be combined into one variable.

1.3 Resources

“Resources are living phenomena, expanding and contracting in response to human effort and behavior. They thrive under rational harmonious treatment. They shrivel in war and strife. To a large extent, they are man’s own creation.” (p7)

“The word ‘resource’ <u>does not refer to a thing or a substance but to a function which a thing or a substance may perform or to an operation in which it may take part</u>, namely the function or operation of attaining a given end such as satisfying a want. In other words, the word “resource” is an abstraction reflecting human appraisal and relating to a function or operation.” (p7)

“Resources are living phenomena, expanding and contracting in response to human effort and behavior.” (p7)

“One has but to recall some of the most precious resources of our age – electricity, oil, nuclear energy- to see who insist that “resources are”, or the defender of the dynamic, functional, operational school who insists that “resources become.” (p11)

“Resources are dynamic not only in response to increased knowledge, improved arts, expanding science but also in response to changing individual wants and social objectives. Resources were defined as means of attaining given ends, i.e., individual wants and social objectives. Means take their meaning form the ends which they serve. As ends change, means must change also. Thus resources must reflect every change in the purpose of the appraiser.” (p11).

“Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife.” (p16)

“The word ‘resource’ has been called a term of appraisal. It reflects human judgment as to want-satisfying capacity, utility.”(p21)

“One may distinguish between primary or original aspects of nature, i.e. free gifts of nature, and secondary of derived aspects, i.e. aspects which become available for use by man as a result of improvements made by him. These improvements are called culture. Secondary or derived natural aspects are therefore, strictly speaking, natural-cultural resources.” (p83)

Dictionary definition Resources*:*

a) "The total means available for economic and political development, such as mineral wealth, labor force and armaments.

b) The total means available to a company for increasing production or profit, including plant, labor and raw material; assets.

C) Such means considered individually." ("Free Dictionary," n.d.)

Definition Resource: Resources are things or substances which function or perform as means to attain specific ends, given by individual wants and social objectives.

Table 6 Resources

page	Variables influencing Resources	Variables influenced by Resources	Description
3,5	-	Military potential	*A world that has not forgotten two World Wars and is worried over the possibility of a third is bound to be a resource-conscious world. Nor is this concern over resources confined to the "military potential' in the narrow sense of the term (p3). Modern total war calls for total mobilization of resources, and military potential differs from economic potential in little sense but objective (p5)*
5	-	Victory	*This awareness of the causal nexus between resources and victory continues during so-called cold wars and is epitomized in this country in the National Security Resources Board*
7	Human appraisal		*In other words, the word "resource" is an abstraction reflecting human appraisal and relating to a function or operation*
7	Resource function		*The word 'resource' does not refer to a thing or a substance but to a function which a thing or a substance may perform or to an operation in which it may take part, namely the function or operation of attaining a given end such as satisfying a want. In other words, the word "resource" is an abstraction reflecting human appraisal and relating to a function or operation.*
7	Resistances	Resistances	*There must be resistances when there are resources. The two words should be as inseparable as Siamese twins in all resource thinking, just as supply and demand, profit and loss, assets and liabilities are together by strong bonds of logic.*
	Knowledge		*Man's own wisdom is his premier resource-the*

7,11	wisdom		*key resource that unlocks the universe. (p7) Resources are dynamic not only in response to increased knowledge, improved arts, expanding science but also in response to changing individual wants and social objectives (11)*
11	Ends		*Resources were defined as means of attaining given ends, i.e., individual wants and social objectives. Means take their meaning form the ends which they serve. As ends change, means must change also.*
11	Social objectives		*Resources are dynamic not only in response to increased knowledge, improved arts, expanding science but also in response to changing individual wants and social objectives.*
11	Arts		" "
11	Individual wants/short term		" "
11	Science		" "

Comments:

- Zimmerman states that the word resource refers *to "A function which a thing or substance may perform or to an operation in which the substance or thing may take part* ". The function or operation of the substance or thing is to attain a given end. This means that a substance is only a resource when it functions or performs in order to attain an objective. This would imply that if a 'resource' does not have a function it is not a resource. This means that the variable "Resources" actually should be named "Substances or things which function or perform to attain a given end". However, in order to keep the diagram simple and easy to understand, the variable "Resources" will be used. However, this means that the variables "Resource function" and "Resources" imply the same thing, namely substances which function or operate in such a way to attain a given end.
- Moreover, if substances are able to function as a resource depends on the variables which are of influence on the variable "Resource function". So, actually these variables should be of direct influence on the variable "Resources". Therefore, and because of the meaning of the variable "Resources" it is suggested to have the variable "Resource function" combined with the variable "Resources".
- In the part on the variable "Resource function", it was already concluded that the variables "Resource ship" and "Resource function" could be combined into one. Since both variables imply the state or condition in which a substance can function in such a way that it can attain certain ends. Moreover, since it was concluded that variable "Resource function" should be combined with the variable "Resources", it follows that the variable "Resource ship" should also be combined with these two variables into the variable "Resources".

- It is not literally described by Zimmerman, but a valid assumption would be that the “Evolvement of resources” is of influence on the amount of resources available, so on the variable “Resources”. This due to the fact the when more substances or things become suitable to serve as means to attain ends, more substances or things will function as a resource, so the total amount of substances of things which function as a resource increases. Therefore it is suggested to add a positive relation from the variable “Evolvement of resources” to “Resources”.
- A second, action, not literally described by Zimmerman, but which seems valid, is that “Depletion/demolishment” of resources has a negative influence on the amount of “Resources”. This because when resources are destroyed or depleted, they can either not function to attain objectives anymore, because they are depleted or destroyed or the substances or things do not function as a resources anymore because the ‘resource’ for example is not necessary anymore. When this happens, the resource is converted back into ‘neutral stuff’. When less substances or things are able to function as a resource, the total amount of substances or things which function to attain a given end decreases. Therefore it is suggested to add a negative relation between the variables “Depletion/demolishment resources” and “Resources”.
- In order to provide a more clear and simple diagram the variable “military potential” and “victory” may be accumulated to one variable. This variable could be named “Military potential”, since military potential could cause victory. Also, in these days the military potential is often more important than the victory itself, because it is the threat of potential which may prevent a war.

Changes to the initial causal relation diagram:

- The variable “Resource function” and “Resources” may be combined into the variable “Resources”.
- Add a positive relation between “Evolvement Resources” and “Resources”.
- Add a negative relation between “Depletion/demolishment resources” and “Resources”.
- The variables “Military potential” and” Victory” should be combined into the variable “Military potential”.

1.4 Resource appraisal

“In other words, the word “Resource” is an abstraction reflecting human appraisal and relating to a function or operation.” (p7)

“Two sets of interdependent criteria may be distinguished in the appraisal of resources:

1. *The state of wants: the expression of human needs, individual wants, social objectives, higher aspirations.*
2. *The state of the arts: as the summation of human capacities along lines of both technology and social organization.” (p17)*

“The word “Resource” has been called a term of appraisal. It reflects human judgment as to want-satisfying capacity, utility. The appraisal seeks to determine whether an aspect of the environment

provides or supports or serves as a source of supply of desirable goods and services. Appraisal is therefore at the heart of the resource process." (p21)

"Thus to the basic wants are added more refined and sophisticated desires .To the nature wants are added culture wants. Individual wants, through established habit and social sanction, tend to crystallize into group standards of living. Once such standards have become established, any force which threatens them is fiercely resisted. The people of the earth differ widely in living standards, and hence in their appraisal of a given environment." (p21)

"The wants of the individual are the foundations of all resource appraisal; but they are not all, for man seldom, lives alone. Group life promotes efficiency and security. The resource appraisal of the environment, therefore, must be enlarged or modified to take these social wants or objectives." (p21)

Resource appraisal –that is, the appraisal of the usefulness of the environment to man- must therefore be *studied from two different angles; first, from the standpoint of individual human wants, and second, from that of social objectives.* (p23)

"The resource appraisal of our environment depends on our own wants, aims, and methods." (p54)
Definition dictionary appraisal*: "An assessment or estimation of the worth, value or quality of a person or thing"* ("Free Dictionary," n.d.)

Definition Resource appraisal: The human judgment on the want satisfying capacity of the environment.

Table 7 Resource appraisal

page	Variables influencing Resource appraisal	Variables influenced by Resource appraisal	Description
17	Knowledge of facts of nature and culture		The appraisal of resources proceeds from: 1. The knowledge of facts of nature and culture to 2. The determination of technical feasibility to 3. The determination of profitability 4. The formulation of the grand strategy along socio-economic lines.
17	Determination of technical feasibility		" "
17	Determination of profitability		" "
17	Formulation of grand strategy		" "
17	Wants		*Two sets of interdependent criteria may be distinguished in the appraisal of resources:*

			1. *The state of wants: the expression of human needs, individual wants, social objectives, higher aspirations.* 2. *The state of the arts: as the summation of human capacities along lines of both technology and social organization.*
17,31	State of arts		*Two sets of interdependent criteria may be distinguished in the appraisal of resources:* *1. The state of wants: the expression of human needs, individual wants, social objectives, higher aspirations. 2. The state of the arts: as the summation of human capacities along lines of both technology and social organization. (p17) Resource appraisal, besides being affected by changing wants and social objectives, ultimately depends on the state of arts rather than on the supply of equipment. (p31)*
21	Economic processes		*These basic wants are the starting point of the economic process and consequently of resource appraisal.*
21	Living standards		*The people of the earth differ widely in living standards, and hence in their appraisal of a given environment.*
23	Individual wants/short term		*The wants of the individual are the foundations of all resource appraisal.*
23, 31	Social objectives		*Group life promotes efficiency and security. The resource appraisal of the environment, therefore, must be enlarged or modified to take these social wants or objectives. The environment must not only yield that which satisfies individual wants, but serve as the reliable basis of continued group life. (p23) Resource appraisal, besides being affected by changing wants and social objectives, ultimately depends on the state of arts rather than on the supply of equipment. (p31)*
28	Conflict between group and individual interests		*The process of appraisal which is largely dominated by the conflict between group and individual interests has lost much of its original straight-line simplicity*
28	Division of labor		*Three phases deserve special mention because of their revolutionary effect on resource appraisal : The division of labor*
29	Importance of money		*Three phases deserve special mention because of their revolutionary effect on resource appraisal: The rise of capitalism.*

29	Rise of capitalism		*Three phases deserve special mention because of their revolutionary effect on resource appraisal: The increasing importance of money.*
31	Changing wants		*Resource appraisal, besides being affected by changing wants and social objectives, ultimately depends on the state of arts rather than on the supply of equipment.*
54	Wants		*The resource appraisal of our environment depends on our own wants, aims, and methods.*
54	Aims		" "
54	Methods/means		" "

Comments

- It should be considered if the variables “Division of labor”, “Importance of money” and “Rise of capitalism” should be maintained in the diagram. The contribution of these variables is not very clear. Moreover these variables indicate important historical developments which were of influence on how the world looks today. However, if these variables still have influence on the appraisal of resources of today may be questioned. If these variables will be removed from the diagram will be further discussed in the explanation of these variables.
- Since the term appraisal of resources considers the human judgments on the want satisfying capacity of a substance, it may be questioned if the variables “Resources appraisal” and “Human appraisal” possibly indicate the same thing. This possibility is considered in the part on the variable “Human appraisal”.

Changes to the initial causal relation diagram: -

1.5 Human appraisal

“In other words, the word “resource” is an abstraction reflecting human appraisal and relating to a function or operation.” (p7)

“The word ‘resource’ has been called a term of appraisal. It reflects human judgment as to want-satisfying capacity, utility. The appraisal seeks to determine whether an aspect of the environment provides or supports or serves as a source of supply of desirable goods and services. Appraisal is therefore at the heart of the resource process.” (p21)

“Moreover, if resources are merely expressions of the human appraisal of nature, how can the human element are eliminated from the resource concept? For human appraisal depends as much man’s objectives and upon his mental and physical abilities, his general capacity to make use of his environment, as upon the nature of the environment. Any change therefore, which goes on in the human mind, which affects the organization of society, which influences the aims of resource utilization, injects into the resource aspects of nature a human element which is inseparable from it.” (p120)

Dictionary definition appraisal: *" An assessment or estimation of the worth, value or quality of a person or thing."* ("Free Dictionary," n.d.)

Definition Human appraisal: The human judgment on the want satisfying capacity of the environment.

Table 8 Human appraisal

page	Variables influencing Human appraisal	Variables influenced by Human appraisal	Description
7	-	Resources	*In other words, the word "resource" is an abstraction reflecting human appraisal and relating to a function or operation.*
120	General capacity to make use of environment		*Moreover, if resources are merely expressions of the human appraisal of nature, how can the human element be eliminated from the resource concept? For human appraisal depends as much man's objectives and upon his mental and physical abilities, his general capacity to make use of his environment, as upon the nature of the environment.*
120	The Nature of the environment		" "
120	Physical abilities		" "
120	Mental abilities		" "
120	Man's objectives		" "

Comments:

- The term 'resource' reflects the human appraisal on if a substance is capable of fulfilling a function or operation to attain certain ends and to satisfy a want. So, human appraisal is the assessment of the capability of substances to be a resource.
- Considering the definitions given for "Resource appraisal", it appears that resource appraisal may be considered as the process of assessing substances from a human point of view. When taking into account the fact that Zimmerman states that *"Resources are merely an expression of human appraisal"* it appears that the variable "Resource appraisal" and "Human appraisal" imply the same thing, namely the human judgment on the capability of substances or thing to attain given end and therefore satisfy wants. Therefore it seems valid to combine the variables "Human appraisal" and "Resource appraisal" into one variable.
- The variable in which the two variables will be combined will be named the "Human appraisal of resources".

Changes to the initial causal relation diagram:

- Combination of the variable Human appraisal" and "Resource appraisal" into the variable "Human appraisal of resources"

1.6 Evolvement resources

"To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects-such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors." (p6).

"All of these examples prove the same basic fact: Resources are not, they become: they are not static but expand and contract in response to human wants and human actions." (p15)

"Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife." (p16)

Dictionary definition evolvement:

1)" To develop or achieve gradually

2) To develop (a characteristic) by evolutionary processes." ("Free Dictionary," n.d.)

Definition Evolvement resources: The development or achievement of resources in response to (changing) ends accomplished by the dynamic interaction of multiple (tangible and intangible) factors.

Table 9 Evolvement resources

page	Variables influencing Evolvement resources	Variables influenced by Evolvement resources	Description
6	Health (intangible aspects)		*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects-such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors.*
6	Social harmony (intangible aspects)		*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects-such as*

			health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors.
6	Wise policy (intangible aspects)		*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects-such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors.*
6,16, 80-81	Knowledge (intangible aspects)		*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects-such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors (p6). Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife (p16) The social scientist is concerned not with the totality of nature for man, with that ever-changing portion of nature which is known to man and which affects his existence. That portion is both expanding and contracting. It expands in response to an increase in knowledge and improvement of the arts. (80-81)*
6	Freedom (intangible aspects)		*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects-such as*

			health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors.
7	Human effort and behavior		*Resources are living phenomena, expanding and contracting in response to human effort and behavior.*
8	Search for means to attain given ends		*The dictionary definitions show that resources result from an interaction between (1) man (a) searching for means to attain given ends (such as the satisfaction of individual wants and the attainment of group or social objectives) and (b) possessed of the capacity to take advantage of opportunities or to extricate himself from difficulties, and (2) something outside of man which for the time being will be called nature.*
8	Man's capacity to take advantage of opportunities		*" "*
8	Nature		*" "*
11,116	Culture		*So long as the human race continues to climb upward to higher cultural levels, culture is bound to become increasingly important as the dynamic force in the creation of resources. (11) Culture has the dual function of enlarging resources and reducing resistances. (116)*
15	Governmental policy		*But other forms of human action at times become determinant as resource makers or destroyers, overshadowing the influence of the inventor and the entrepreneur. One of the most important of these is <u>governmental policy.</u>*
15	Business enterprise		*Resources <u>are</u> not, they <u>become:</u> they are not static but expand and contract in response to human wants and human actions. In these examples, two forms of human actions were prominent: technics and business enterprise.*
15	Human actions		*Resources are not, they become: they are not static but expand and contract in response to human wants and human action*s.
15	Science		*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff".*
15	Technology		*" "*
15,17	wants		*Resources <u>are</u> not, they <u>become:</u> they are not static but expand and contract in response to human wants*

			and human actions. (p15)Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff" (p15) Yet, while changed or expanding wants create new resources, others are destroyed. Progress always means a net gain but seldom a pure gain. Creating the better, we must often destroy the good. (p17)
16	cultural aspects		*Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife (p16)*
16	human aspects		*" "*
16	natural aspects		*" "*
80-81	Improvement arts		*The social scientist is concerned not with the totality of nature for man, with that ever-changing portion of nature which is known to man and which affects his existence. That portion is both expanding and contracting. It expands in response to an increase in knowledge and improvement of the arts.*

Comments

- When considering the statement *"Resources become*", defended by the dynamic, functional, operational school, one has to wonder if the two variables "Evolvement of resources" and "Resources" do imply different things. Especially since resources are considered dynamic according to Zimmerman, which means that are constantly subject to evolvements and demolishment. However, in this diagram the variable "Resources" implies those substances and things which function or perform in order to attain given ends. This is different from the variable "Evolvement of resources" which implies the process which makes substances suitable to fulfill to function or operation to achieve an objective.
- Moreover, it assumed the variable "Evolvement of resources" has a positive influence on the total amount of "Resources available", which indicates that these variables do have different meanings. (See part on Resources). ". Furthermore, in order to be able to present which variable are of influence on the evolvement and demolishment of resources, it decided to maintain these separate variables and not combine everything in the dynamic variable "Resources". Therefore, the variables "Resources" and "Evolvement of resources" will be maintained as separate variables, even though it could be defended to combine them into the variable "Resources
- The variables "Business enterprise", "Technology" and "Governmental policy" are all examples of human actions. In the diagram, these three variables could therefore be combined with the variable "Human actions". However, it is decided not to do this, because these three examples add important information to the diagram. These variables illustrate the different and some of the most important types of human action and are important to explicitly name in the diagram.

However, since the most important human actions are then named, one can wonder if the variable “Human actions” still brings a significant contribution to the diagram. Even though, Human actions do comprise more than the examples named, it is questioned if these are other actions which also have an important influence on the evolvement and demolishment of resources. However, it is assumed that that this is the case , and therefore the variable “Human actions” is maintained in the diagram

Changes to the initial causal relation diagram:

- Adding of the positive relation between “Evolvement resources” and “Resources”.

1.7 Depletion/demolishment resources

Dictionary definition depletion: *“The use or consumption of a resource, especially a natural resource, faster that it is replenished.”*(“Free Dictionary,” n.d.)

Definition Depletion/demolishment resources: The use of resources in a way that these resources will not be able to be used again.

Table 10 Depletion/demolishment resources

page	Variables influencing Depletion/demolishment resources	Variables influenced by Depletion/demolishment resources	Description
7	Human effort and behavior		*Resources are living phenomena, expanding and contracting in response to human effort and behavior.*
13	Human folly and cussedness		*But a far greater destruction is wrought by man not in the orderly process of rational resource use, but because of human folly and cussedness. As was mentioned the individual tends to take a short-sighted view of things.* The consequences are often ignored, especially when these count for other which may not even be born.
13		Destruction fauna and flora	*The proper use and care of complex natural processes that are governed by the laws of ecology presuppose a high degree of scientific knowledge which has been reached only very recently, after centuries of blind groping and foolish blundering. Soil erosion caused by faulty methods of farming, of overgrazing, or unscientific cutting of timber comes readily to mind. The destruction of fauna and flora which interferes with nature’s creative work through natural selection and the variation of species limit or even blocks the progress of the plant and animal breeder (p13). Soil erosion caused by faulty methods of farming, of overgrazing, or*

			unscientific cutting of timber comes readily to mind. The destruction of fauna and flora which interferes with nature's creative work through natural selection and the variation of species limit or even blocks the progress of the plant and animal breeder.
13	Arts		*Man cannot help that coal and oil are dissipated in use. He cannot use such minerals without using them up. Less obvious is the destruction of resources by man induced obsolescence. When Kekule (German Chemist) dreamed up the "carbon ring" out of the smoke of his pipe and thus paved the way for the coal-tar industries, he indirectly caused the destruction of entire branches of agriculture, especially those producing vegetable in indigo in India and madder root in France.* Also thousands of ore deposits became uneconomical.
13	Usage of substances		*Man, the great culture-builder, is not only a creator of resources, he is also a destroyer. Man cannot help that coal and oil are dissipated in use. He cannot use such minerals without using them up.*
14	Individual wants/short term		*But a far greater destruction is wrought by man not in the orderly process of rational resource use, but because of human folly and cussedness. As was mentioned the individual tends to take a short-sighted view of things.* The consequences are often ignored, especially when these count for other which may not even be born.
15	Technology		*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff"* (p15) All of these examples prove the same basic fact: resource are not, they become: they are not static but expand and contract in response to human wants and human actions. In these examples, two forms of human actions were prominent: technics and business enterprise.
15	Specific needs		*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff".*
15	Governmental policy		*But other forms of human action at times become determinant as resource makers or destroyers, overshadowing the influence of the inventor and the entrepreneur. One of the most important of*

			these is governmental policy.
15	Business enterprise		*All of these examples prove the same basic fact: resources are not, they become: they are not static but expand and contract in response to human wants and human actions. In these examples, two forms of human actions were prominent: technics and business enterprise.*
15	Science		*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff".*
15,17	Wants		*Resources are not, they become: they are not static but expand and contract in response to human wants and human actions. (p15)Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff" (p15) Yet, while changed or expanding wants create new resources, others are destroyed. Progress always means a net gain but seldom a pure gain. Creating the better, we must often destroy the good (p17).*
16	Barbarism/civil strife		*Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife.*
81	ignorance		*Nature's contributions are also subject to contraction, by usage, becoming useless by obsolescence or damage by man beyond repair, mainly because of ignorance, especially of the laws of ecology.*

Comments:

- The same comment as stated at the "Evolvement of resources" can also be stated here. Since, resource are not, but become and are dynamic according to Zimmerman, one can wonder if the "Depletion/demolishment of resources" is a variable on its own. However, since the total amount of substances which can function to attain objectives can change by the demolishment of the possibilities of this substance to attain the objectives, the total amount of substances which function as resources may change. Furthermore, since it is decided to maintain the separate variables of demolishment and evolvement of resources, to provide insight in which variables are of influence on these factors and therefore on resources, the variable "Depletion/demolishment resources" will be maintained.

- Since the amount of resource available decreases due to depletion or demolishment of resources, the variable “Depletion/demolishment of resources” has a negative influence on the variable “Resources”.
- So, next to the fact that “Depletion/demolishment of resources” is considered to have a different meaning than the variable “Resources” it is also suggested to add a negative relation between “depletion/demolishment resources” and “Resources”.

Changes to the initial causal relation diagram:

- Adding of negative relation between “Depletion/demolishment resources” and the “Resources”.

1.8 Man’s resources

“The story of the rise of man from the animal to the human stage is of the utmost significance of the meaning and nature of MAN’s resources as distinguished from resources of animals. MAN’s resources, to an overwhelming extent, are NOT natural resources.

It is true that nature provides the opportunity for MAN to display his skill and apply his ever-expanding knowledge. But nature offers freely only and infinitesimal fraction of her treasure; she not only withholds the rest, but seems to place innumerable and, in many cases, well-nigh insurmountable obstacles in the way of resource-seeking and resource-creating MAN. The bulk of MAN’s resources are the result of human ingenuity aided by slowly, patiently, painfully acquired knowledge and experience.

To be sure, coal is found in nature. But coal readily accessible and available for human use is rare indeed. Without the aid of power driven machinery, human inventions and man-made contraptions, mankind long ago would have run out of coal. Coal occurs in nature, to be sure, but not coke, or sulfate of ammonia, tar, dyes, aspirin, nylon. All the elements are found in nature; but this is of no value to man, who is not even aware of their existence and even less capable of isolating and utilizing them.”(p9)

Definition Man’s resources: That part of natural resources which are made usable for the desired ends by men due to human ingenuity, experience and knowledge.

Table 11 Man's resources

page	Variables influencing Man’s resources	Variables influenced by Man’s resources	Description
9	Human ingenuity		*The bulk of MAN’s resources are the result of human ingenuity aided by slowly, patiently, painfully acquired knowledge and experience.*
9	Experience		*“ “*
9	Knowledge wisdom		*“ “*

Comments: -

Changes to the initial causal relation diagram: -

1.9 Natural resources

"Those aspects of nature which man can utilize in the satisfaction of his creature wants (without contributions made by MAN), may be called natural resources" (p9) (Zimmerman, 1946a)*).*

"MAN's resources, to an overwhelming extent, are NOT natural resources. It is true that nature provides the opportunity for MAN to display his skill and apply his ever-expanding knowledge. But nature offers freely only and infinitesimal fraction of her treasure; she not only withholds the rest, but seems to place innumerable and, in many cases, well-nigh insurmountable obstacles in the way of resource-seeking and resource-creating MAN. (p9)

"One may distinguish between primary or original aspects of nature, i.e. free gifts of nature, and secondary of derived aspects, i.e. aspects which become available for use by man as a result of improvements made by him. These improvements are called culture. Secondary or derived natural aspects are therefore, strictly speaking, natural-cultural resources." (p83)

Definition Natural resources: Those aspects of nature, which can be utilized without efforts or improvements, in order to satisfy man's creature wants.

Table 12 Natural Resources

page	Variables influencing Natural resources	Variables influenced by Natural resources	Description
8		Want satisfaction	*Those aspects of nature which man can utilize in the satisfaction of his creature wants (without contributions made by MAN), may be called natural resources. The extent of want satisfaction is a function of resources and resistances, not of resources alone.*

Comments: -

Changes to the initial causal relation diagram: -

1.10 Gross resources

"Chapter 1 brought out the basic facts that a sharp distinction should be made between gross resources and net resources, net resources being defined as those available for the promotion of real wealth, or well-being, after resistances have been overcome. Well-being is not directly related to gross resources, but to net resources. Nations differ widely as to the portion of their gross resources which must be devoted to overcoming resistances." (p75)

Definition Gross resources: Possible resources for which obstacles and resistances still need to be overcome, before these can be used for the well-being of men.

Table 13 Gross resources

page	Variables influencing gross resources	Variables influenced by gross resources	Description
75		Net resources	*Chapter 1 brought out the basic facts that a sharp distinction should be made between gross resources and net resources*, net resources *being defined as those available for the promotion of real wealth, or well-being, after resistance have been overcome.*

Comments:

- Since gross resources are the potential resources, the resources which include obstacles which need to be conquered by man before man can use these resources; it appears like this variable means the same as the variable "Natural resources". Especially since the amount of gross resources has influence on the amount of net resources which maybe can be seen as the variable "Man's resources". However, natural resources are the free gift of nature, those resources which can be retrieved without effort, while gross resources include both the natural resources as the natural-cultural resources, for which improvements have to be done to attain and use these resources. Therefore, gross resources and natural resources are not the same.

Changes to the initial causal relation diagram: -

1.11 Net resources

"Chapter 1 brought out the basic facts that a sharp distinction should be made between gross resources and net resources, net resources *being defined as those available for the promotion of real wealth, or well-being, after resistances have been overcome. Well-being is not directly related to gross resources, but to net resources. Nations differ widely as to the portion of their gross resources which must be devoted to overcoming resistances." (p75)*

Definition Net resources: Aspects of nature for which obstacles and resistances have been overcome and which are available are for the usage of men for their well-being.

Table 14 Net Resources

page	Variables influencing Net resources	Variables influenced by Net resources	Description
75	Gross resources		*Chapter 1 brought out the basic facts that a sharp distinction should be made between gross resources and net resources*, net resources *being defined as those available for the promotion of real wealth, or well-being, after resistance have been overcome.*
75	Resistances		" "
75		Well being	" "

Comments:

- The variables “Net resources” and “Man’s resources” both indicate the resources which are available for men. They both indicate those resources which are made available by the overcoming of the resistances and obstacles which were concerned with the substances or things. Therefore it seems valid to state that the variables “Net resources” and “Man’s resources” both indicate the same and may therefore be combined into one variable.

Changes to the initial causal relation diagram:

- Combination of the variables “Net resources” and “Man’s resources”.

1.12 Natural-cultural resources

“One may distinguish between primary or original aspects of nature, i.e. free gifts of nature, and secondary or derived aspects, i.e. aspects which become available for use by man as a result of improvements made by him. These improvements are called culture. Secondary or derived natural aspects are therefore, strictly speaking, natural-cultural resources.” (p83)

Definition Natural cultural resources: Those aspects of nature which are made available for utilization by man achieved by the improvements done by men.

Table 15 Natural cultural resources

page	Variables influencing Natural-cultural resources	Variables influenced by Natural-cultural resources	Description
83	Nature		*One may distinguish between primary or original aspects of nature, i.e. free gifts of nature, and secondary of derived aspects, i.e. aspects which become available for use by man as a result of improvements made by him. These improvements are called culture. Secondary or derived natural aspects are therefore, strictly speaking, natural-cultural resources.*
83	Culture		*“ “*

Comments:

- Natural-cultural resources are those natural resources which are made available by the improvements done by men. They do not concern the free gifts of nature, which are described as the natural resources. Therefore the variable “Natural-cultural resources” seems quite familiar with the variable "Man’s resources” and the variables “Net resources”. The variables “Man’s resources” implies the gross resources for which the resistances are conquered and the variable. The variable “Net resources” indicates the resources which are available for man and for which resistances have been won over. Therefore it seems valid to say that “Natural-cultural resources” indicates the same as the variables “Man’s resources” and “Net resources”, namely substances or things which can function to attain given ends, after the resistances to attain or use these substances have been overcome.

- Therefore it is suggested to combine the variables “Man’s resources”, “Net resources” and “Natural-cultural resources” into one variable. The name of this variable will be “Natural-cultural resources”, since this name emphasizes the fact that these resources have become resources due to improvements, which are together form the culture of society.

Changes to the initial causal relation diagram:

- Combination of the variables “Man’s resources”, “Net resources” and “Natural-cultural resources” into the variable “Natural-cultural resources”.

1.13 Resource consciousness

Dictionary definition consciousness:

1. *“Special awareness or sensitivity*
2. *Alertness to or concern for a particular issue or situation”* (“Free Dictionary,” n.d.).

Definition Resource consciousness: The acknowledgement and alertness on the importance of resources.

Table 16 Resource consciousness

page	Variables influencing Resource consciousness	Variables influenced by Resource consciousness	Description
6	Communism		*Both socialism and communism are resource conscious.*
6	Socialism		*“ “*
3,5	World wars		*A world that has not forgotten two World Wars and is worried over the possibility of a third is bound to be a resource-conscious world. (p3) The two World Wars contributed materially to resource consciousness in many parts of the world and through wide strata of its population. Modern total war calls for total mobilization of resources, and military potential differs from economic potential in little sense but objective. This awareness of the causal nexus between resources and victory continues (p5) Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness. (p5)*
5	Closing frontier		*Undoubtedly, one of the events which stirred the American people to resource consciousness and with it to a recognition of the fact business appeared to be neglectful of the basic social assets was the “closing of the frontier” in the sense of the completion of the settlement of the continent the end of free land. (p5)*

			Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness. (p5)
5	Great depression		*Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness.*
5	Size and complexity modern nations		*Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness. They are by no means the only forces responsible for this new awareness. A number of quiet, slowly moving trends have contributed materially to the change in attitude. The growing size and complexity of modern nations is one of them. It points, with perhaps inevitable logic, toward a strengthening of the power of the central government. In so far as this growing complexity is due to a merging of once local or regional activities and interest into national concerns, the increased need for central – in the United States, federal- controls is evident. Another vital trend is marked by the decline of competition and by its corollary, the concentration of economic power.*
6	Decline of competition		*" "*
6	Concentration economic power		*" "*

Comments: -

Changes to the initial causal relation diagram: -

1.14 Tempo resource development

Definition Tempo resource development: The speed for which resources are developed and prepared for usage.

Table 17 Tempo resource development

page	Variables influencing Tempo resource development	Variables influenced by Tempo resource development	Description
27	Group wants/long term		*The conflict between social and private interests develops from a fundamental difference in the nature of the group and of the individual. The group represents a succession of generations, and therefore its life must be longer than that of the individual. As a result of such conflicting attitudes, social and private interests cannot agree on the "tempo" of resource development. He who regards the interest of future generations, who interprets human progress in the light of broad historical developments, is not as easily drawn into the whirlpool of profit chasing or the excitement of markets place as is the man who lives from hand to mouth, knows no other happiness than immediate enjoyment, and whose motto is, "after us, the deluge." The social view stresses the long-run aspects of resource appraisal; the individual is interested in immediate results. His is the short-run view.*
27	Individual wants/short term		" "
27		Conflict between group and individual interest	" "

Comments:-

2. Resistances

2.1 Resistances

"Well-being is not directly related to gross resources, but to net resources. Nations differ widely as to the portion of their gross resources which must be devoted to overcoming resistances". (p75)

"Nations differ widely as to the portion of their gross resources which must be devoted to overcoming resistances (p75):

- *Countries differ in the configuration or shape of the territory and that difference greatly affects the resistances, especially spatial resistances, to be overcome.* The shape of France is for example very good, while the shape of chili makes transport very hard (p75).
- *The ratio of effective territory to total territory.* (which parts of the country is used and which is mass, causing energy leaks) (p75-76)
- *Population density*, *this affects the expenditures of energy required to establish "the civilizing contracts". Higher population density of geographical distribution affects the energy requirements of transportation.*
- *Topography,* it depends on the topography of an area how fast resources can travel. This creates differences in energy need in for example the mountains and the desert. *Topography is another element affecting energy needs, If welfare were a direct and accurate function of energy expenditure, one wonders how much better off we would be if the Rocky Mountains were twice as high. Energy expenditure depends much on speed and welfare is very complex. Much speed spells a purely useless expenditure of energy. The manner in which the bulky earth materials like coal and ores, limestone, clay etc., are distributed over the map affects what may be called instrumental energy expenditure.*
- *Age composition of the population, age composition affects the number of those who contribute to the social product as well as the numbers among whom this product is divided. Well- being is apt to suffer when "the cake" made by the few must be cut in to many slices.*
- *Outlook upon security, Well-being is apt to be the greatest, relative to total energy expenditure, in countries which, because of location or for other reasons, feel most secure and hence must divert a minimum of energy to the unproductive tasks of armaments and military preparedness. Similarly homogenous social groups in which there is relatively little tension and causes for civil strife are bound to enjoy a more favorable ratio of energy expenditure to well-being than less favorable ones.*
- *The spirit of civilization is affected by the amount and nature of available energy and that spirit more than any factor determines what energy expenditure means. (p76). Human energy is the key stone of the energy arch (p77)."*

Dictionary definition Resistances:

1. *"The act or an instance of resisting or the capacity to resist*
2. *A force that tends to oppose or retard motion"* ("Free Dictionary," n.d.)

Definition Resistances: Things or forces which have the capacity to resist.

Table 18 Resistances

page	Variables influencing Resistances	Variables influenced by Resistances	Description
7	Resources	Resources	*Finally one more misconception needs to be brought out: the failure to realize that just as truly as there must be shade when there is light, so also must there*

			be resistances when there are resources.
75		Net resources	*Chapter 1 brought out the basic facts that a sharp distinction should be made between gross resources and net resources, net resources being defined as those available for the promotion of real wealth, or well-being, after resistance have been overcome. Well-being is not directly related to gross resources, but to net resources. Nations differ widely as to the portion of their gross resources which must be devoted to overcoming resistances.*
75	Shape of the territory (spatial resistances)		*Countries differ in the configuration or shape of the territory and that difference greatly affects the resistances, especially spatial resistances, to be overcome.*
75-76	Ratio effective territory		Points at which parts of the country are used and which is mass not used and which are causing energy leaks.
76	Population density		*Higher population density of geographical distribution affects the energy requirements of transportation.*
76	Topography		It depends on the topography of an area how fast resources can travel. This creates differences in the energy expenditure in, for example, the mountains and the desert.
76	Age composition population, number who contribute to the product		Affects the number of those who contribute to the social product as well as the numbers among whom this product is divided. Well- being is apt to suffer when "the cake" made by the few must be cut in to many slices.
76	Outlook upon security		*Well-being is apt to be the greatest, relative to total energy expenditure, in countries which, because of location or for other reasons, feel most secure and hence must divert a minimum of energy to the unproductive tasks of armaments and military preparedness. Similarly homogenous social groups in which there is relatively little tension and cause for civil strife is bound to enjoy a more favorable ratio of energy expenditure to well-being than less favorable ones.*
76	Spirit of civilization		*Is affected by the amount and nature of available energy and that spirit more than any factor determines what energy expenditure means.*
116		Culture	*Culture has the dual function of enlarging resources and reducing resistances. It is a cushioning device that does not abolish hurricanes and earthquakes but cushions the impact of natural disasters on man. (p116) Man creates culture with the aid of, "advice, and consent" of nature, out of substances found in nature, and with the aid of energies supplied in*

			nature. The point made here is that the desire to economize effort often leads man to adapt himself consciously and willingly to nature. Nature, so to speak, advises man to choose what natural conditions render easiest to produce. Nature does not consent to men living at the North Pole or on the top of the mount Everest. (p114-115) This means that man chooses the alternatives with the resistances which are the easiest to overcome; this forms an important input for the culture of men.

Comments:

- It seems like the resistances in this table are an accumulation of several types of resistances, such as natural resistances, and cultural resistances and human resistances. It has to be considered, which of these terms will be placed in the framework, since they are overlapping. The term Resistances accumulates all these types of resistances, so this term would be the most complete term to use.
- The variables "Shape of territory", "Ratio effective territory", Population density", Topography", "Age composition", "Population", "Outlook upon security" and "Spirit of civilization" are examples of resistances. In order to have a clear diagram which is easy to read, these examples will be removed from the diagram. They still will be present in the variable "Resistances", since the variables are all examples of this variable.

Changes to the initial causal relation diagram:

- Removal of the different examples of resistances from the diagram in order to clarify the diagram. These examples are:
    - "Shape of territory"
    - "Ratio effective territory" " Population density"
    - "Topography"
    - "Age composition"
    - "Population"
    - "Outlook upon security"
    - "Spirit of civilization"

2.2 Natural resistances

"Those aspects of nature which harm or hinder man may be called natural resistances" (p8) (Zimmerman, 1946a).

"Primary or original natural resistances- e.g. catastrophes such as hurricanes, earth quakes, volcanic eruptions, tidal waves, floods, etc., and disease, plant pests, poisonous plants and animals ." (p83)

Definition Natural resistances: Those original natural aspects which harm or hinder man.

Table 19 Natural resistances

page	Variables influencing Natural resistances	Variables influenced by Natural resistances	Description
8		Want satisfaction	*The extent of want satisfaction is a function of resources and resistances, not of resources alone.*

Comments:-

Changes to the initial causal relation diagram: -

2.3 Natural-cultural resistances

"Secondary or derived natural resistances, i.e. those that are the result of human interference with or impact in nature. The latter may be properly referred to as natural-cultural resistances" (p83).

Definition Natural-cultural resistances: Natural resistances which are the result from the human interference or the human impact with nature.

Table 20 Natural-cultural resistances

page	Variables influencing Natural-cultural resistances	Variables influenced by Natural-cultural resistances	Description
83	Human interference		*Similarly one may make a distinction between primary or original natural resistances- e.g. catastrophes such as hurricanes, earth quakes, volcanic eruptions, tidal waves, floods, etc., and disease, plant pests, poisonous plants and animals, etc.-and secondary or derived natural resistances, i.e. those that are the result of human interference with or impact in nature. The latter may be properly referred to as natural-cultural resistances.*
	Nature		*" "*

Comments: -

Changes to the initial causal relation diagram: -

3. Wants and objectives

3.1 Wants

"Those aspects of nature which man can utilize in the satisfaction of his creature wants (without contributions made by MAN), may be called natural resources." (p8) (Zimmerman, 1946a)

"The state of wants: the expression of human needs, individual wants, social objectives, higher aspirations." (p17)

"Human wants may be divided into two groups: basic, nature, creature, or existence wants, and cultural wants. Existence wants must be satisfied if the life on the individual and of the group is to go on. These basic wants are the starting point of the economic process and consequently of resource appraisal. But human desires seldom, if ever, stop when basic wants are satisfied. Man tends to eat and drink more than is absolutely necessary for mere existence. He craves variety and adds touches of refinement to the form and content of basic want satisfaction. A taste for the beautiful develops. Thus to the basic wants are added more refined and sophisticated desires .To the nature wants are added culture wants. Individual wants, through established habit and social sanction, tend to crystallize into group standards of living. Once such standards have become established, any force which threatens them is fiercely resisted. The people of the earth differ widely in living standards, and hence in their appraisal of a given environment." (p21)

Dictionary definition want: *"To desire greatly; wish for."*

Definition Wants: A desire or human need for something.

Table 21 Wants

page	Variables influencing Wants	Variables influenced by Wants	Description
11		Human productive effort	*The physical environment appraised both quantitatively and viewed as changing relationships of trends and forces rather than as static conditions, therefore is at all times the foundation of human productive effort. Arts, no matter how highly developed, and wants, no matter how urgent or sophisticated, are helpless in a vacuum. Without acting on and drawing from physical nature they are unproductive.*
12	Culture		*Not only wants and abilities of the individual man and of groups of men are affected by culture- education, training, experience, sophistication, degeneration, eugenics, etc. - but the relationships between men, social organizations, and societal institutes also come under its spell.*
15,17		Depletion/demolishment resources	*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff" (p15) resources are not, they become: they are not static but expand and contract in response to human wants and human actions.(p15) Yet, while changed or expanding wants create new resources, others are destroyed.(p17)*
15,17		Evolvement resources	*Resources are not, they become: they are not static but expand and contract in response to human wants and human actions. (p15) Not only do*

			modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff" (p15) Yet, while changed or expanding wants create new resources, others are destroyed. Progress always means a net gain but seldom a pure gain. Creating the better, we must often destroy the good. (p17)
17, 23, 54		Resource appraisal	*Two sets of interdependent criteria may be distinguished in the appraisal of resources: 1. The state of wants: the expression of human needs, individual wants, social objectives, higher aspirations. (p17) Nevertheless, as a rule, culture wants are not quite as insistent in the lower ranges of consumption, nor is a saturation point reached as soon or as certainly as in the case of basic wants. This difference in the nature of wants is of vital importance in resource appraisal. (p23) The resource appraisal of our environment depends on our own wants, aims, and methods. (p54)*

Comments:

- Zimmerman distinguishes four categories of wants: Individual and group wants and Basic/creature/existence and cultural wants. He does name the effects of Individual wants and group wants, but barely the different effects of basic or cultural wants. The relations stated in the above are all relation considering Wants in general. From the information provided, it is hard to define about which kind of Want Zimmerman is reasoning. Therefore the general term "Want" will be maintained in the causal relation diagram for the relations which concern general Wants or for which is not clear which kind of Want is involved.
- It is not literally described by Zimmerman, but from the information provided on the relationship between "Wants" and "Human productive effort" it appears that the variable "Wants" together with the variable "Arts" creates the variable "Human productive effort". Zimmerman states that human wants or efforts are helpless in a vacuum, i.e. when these wants and efforts are not present in combination with one of the other variables or the content of the variables is not developed with consent of nature, So, when used in combination with the physical environment, the variable "Wants" is of influence on the "Human productive effort.

Changes to the initial causal relation diagram: -

3.2 Basic wants

Basic wants:

- Subject to limitations (minima and maxima, food for example)
- Existence wants are generally recurring, and therefore constant (p22)

Definition wants: A desire or human need for something.

Definition Basic wants: The needs of human beings which need to be fulfilled for the continuation of their existence.

Table 22 Basic Wants

page	Variables influencing Basic wants	Variables influenced by Basic wants	Description
21		Economic processes	*These basic wants are the starting point of the economic process and consequently of resource appraisal.*

Comments: -

Changes to the initial causal relation diagram: -

3.3 Individual wants/short term wants

"The dictionary definitions show that resources result from an interaction between man searching for means to attain given ends (such as the satisfaction of individual wants and the attainment of group or social objectives)." (p8)

"Resources were defined as means of attaining given ends, i.e., individual wants and social objectives." (p11)

"The state of wants: the expression of human needs, individual wants, social objectives, higher aspirations." (p17

"Individual wants, through established habit and social sanction, tend to crystallize into group standards of living." (p21)

"The wants of the individual are the foundations of all resource appraisal." (p23)

"In an ideal society, the attainment of social objectives is assumed to result in a fuller satisfaction of individual wants, in theory at least, run parallel towards the same goal. In reality however, the social and private interests frequently clash in head-on collision."(23)

Definition Individual wants: The expression of individual desires and objectives.

Table 23 Individual wants

page	Variables influencing Individual wants/short term	Variables influenced by Individual wants/short term	Description
8		Search for means to attain given ends	*The dictionary definitions show that resources result from an interaction between (1) man (a) searching for means to attain given ends (such as the satisfaction of individual wants and the*

			attainment of group or social objectives).
11		Resources	*Resources are dynamic not only in response to increased knowledge, improved arts, expanding science but also in response to changing individual wants and social objectives.*
14,23		Conflicts	*Scientific progress offers many remedies but does not wholly remove the problem of conflicts between short-run individual and long-run group interests. (p14). In an ideal society, the attainment of social objectives is assumed to result in a fuller satisfaction of individual wants, in theory at least, run parallel towards the same goal. In reality however, the social and private interests frequently clash in head-on collision. (23)*
14		Depletion/demolishment resources	*But a far greater destruction is wrought by man not in the orderly process of rational resource use, but because of human folly and cussedness. As was mentioned the individual tends to take a short-sighted view of things.*
21		Living standards	*Individual wants, through established habit and social sanction, tend to crystallize into group standards of living. Once such standards have become established, any force which threatens them is fiercely resisted. The people of the earth differ widely in living standards, and hence in their appraisal of a given environment.*
23		Resource appraisal	*The wants of the individual are the foundations of all resource appraisal (p23) Resource appraisal – that is, the appraisal of the usefulness of the environment to man- must therefore be studied from two different angles; first, from the standpoint of individual human wants, and second, from that of social objectives (p23).*
27		Tempo resource development	*The conflict between social and private interests develops from a fundamental difference in the nature of the group and of the individual. The group represents a succession of generations, and therefore its life must be longer than that of the individual. As a result of such conflicting attitudes, social and private interests cannot agree on the "tempo" of resource development. He who regards the interest of future generations, who interprets human progress in the light of broad historical developments, is not as easily drawn into the whirlpool of profit chasing or the excitement of markets place as is the man who lives from hand to mouth, knows no*

			other happiness than immediate enjoyment, and whose motto is, "after us, the deluge." The social view stresses the long-run aspects of resource appraisal; the individual is interested in immediate results. His is the short-run view.

Comments: -

Changes to the initial causal relation diagram: -

3.4 Man's objectives

Dictionary definition objective: "Something work toward or strived for: a goal". ("Free Dictionary," n.d.)

Definition Man's objectives: The goals of the human population.

Table 24 Man's objectives

page	Variables influencing Man's objectives	Variables influenced by Man's objectives	Description
120		Resource appraisal	*For human appraisal depends as much man's objectives and upon his mental and physical abilities, his general capacity to make use of his environment, as upon the nature of the environment. Any change therefore, which goes on in the human mind, which affects the organization of society, which influences the aims of resource utilization, injects into the resource aspects of nature a human element which is inseparable from it.*

Comments:

- It seems that the variable "Man's objectives" indicates the desires and objectives of mankind, since Zimmerman uses the words *"His general capacity to make use of his environment*". Therefore, it seems that the variable has a generalization purpose and is can therefore be seen as the objectives of the whole human population.

Changes to the initial causal relation diagram: -

3.5 Group wants/long term

"Group life promotes efficiency and security. The resource appraisal of the environment, therefore, must be enlarged or modified to take these social wants or objectives."(p23)

"In an ideal society, the attainment of social objectives is assumed to result in a fuller satisfaction of individual wants, in theory at least, run parallel towards the same goal. In reality however, the social and private interests frequently clash in head-on collision." (p23)

Definition Group wants: Social wants or objectives desired by the groups of human beings

Table 25 Group wants

page	Variables influencing Group wants/long term	Variables influenced by Group wants/long term	Description
8		Search for means to attain given ends	*The dictionary definitions show that resources result from an interaction between (1) man (a) searching for means to attain given ends (such as the satisfaction of individual wants and the attainment of group or social objectives).*
14		Conflicts between group and individual wants	*Scientific progress offers many remedies but does not wholly remove the problem of conflicts between short-run individual and long-run group interests.*
23		Resource appraisal	*Group life promotes efficiency and security. The resource appraisal of the environment, therefore, must be enlarged or modified to take these social wants or objectives.*
27		Tempo Resource development	*The conflict between social and private interests develops from a fundamental difference in the nature of the group and of the individual. The group represents a succession of generations, and therefore its life must be longer than that of the individual. As a result of such conflicting attitudes, social and private interests cannot agree on the "tempo" of resource development. He who regards the interest of future generations, who interprets human progress in the light of broad historical developments, is not as easily drawn into the whirlpool of profit chasing or the excitement of markets place as is the man who lives from hand to mouth, knows no other happiness than immediate enjoyment, and whose motto is, "after us, the deluge." The social view stresses the long-run aspects of resource appraisal; the individual is interested in immediate results. His is the short-run view.*

Comments:

- Considering the definitions of "Man's objectives" and "Group wants/long term" it seems that these variables imply the same. They indicate the things mankind or a group of man wants to achieve, i.e. the goals of a human population. If the total human population is considered as 'The group', the variable "Man's objectives' and "Group wants/long term" both indicate the Wants and objectives of mankind. Since this research does not differentiate between human populations, because this would make the causal relation diagram and the final framework overly complicated, the assumption can be made that the 'group' in this diagram considers the whole human population, which is also indicated as 'Man'.

- This implies that the variables "Man's objectives" and "Group wants/long term" indicate the same and can therefore be combined into one variable.
- Moreover, both variables are of influence on the variable "Resource appraisal". This underlines that the variables imply the same, especially since the variable "Man's objectives" has only one relation (with resource appraisal) and is not of influence on other variables. Therefore, when the variable "Group wants/long term" is maintained, the content of the relation between "Man's objectives" and "Resource appraisal" is maintained, though presented in a different form.

Changes to the initial causal relation diagram:

- The variables "Man's objectives" and "Group wants/long term" will be combined into the variable "Group wants/long term"

3.6 Social objectives

"The dictionary definitions show that resources result from an interaction between man searching for means to attain given ends (such as the satisfaction of individual wants and the attainment of group or social objectives)." (p8)

"Resources were defined as means of attaining given ends, i.e., individual wants and social objectives." (p11)

"The state of wants: the expression of human needs, individual wants, social objectives, higher aspirations." (p17).

"Group life promotes efficiency and security. The resource appraisal of the environment, therefore, must be enlarged or modified to take these social wants or objectives." (p23)

"Resource appraisal, besides being affected by changing wants and social objectives, ultimately depends on the state of arts rather than on the supply of equipment." (p31)

Dictionary definition objectives: *"Something work toward or strived for: a goal".* ("Free Dictionary," n.d.)

Dictionary definition social:

- *"Living together in communities*
- *Relating to human society and its modes of organization "*("Free Dictionary," n.d.)

Definition Social objectives: Goals or ends desired of people living in human societies.

Table 26 Social objectives

Page	Variables influencing Social objectives	Variables influenced by Social objectives	Description
8		Search for means to attain given ends	*The dictionary definitions show that resources result from an interaction between man searching for means to attain given ends (such as the satisfaction of individual wants and the attainment of group or social objectives).*
11		Resources	*Resources are dynamic not only in response to increased knowledge, improved arts, expanding science but also in response to changing individual wants and social objectives.*
23,31		Resource appraisal	*Resource appraisal –that is, the appraisal of the usefulness of the environment to man- must therefore be studied from two different angles; first, from the standpoint of individual human wants, and second, from that of social objectives (p23) Resource appraisal, besides being affected by changing wants and social objectives, ultimately depends on the state of arts rather than on the supply of equipment. (p31)*
23		Conflict	*In an ideal society, the attainment of social objectives is assumed to result in a fuller satisfaction of individual wants, in theory at least, run parallel towards the same goal. In reality however, the social and private interests frequently clash in head-on collision.*

Comments:

- The variable the "Social objectives" indicates goals or ends set by a human society and the variable "Group wants/long term" reports desires and wants of a group. It is questionable if this is really something different. This due to the fact that the Wants of a group are the start of the objectives of a group. So the wants of the group will become its objectives if the Wants are necessary or just wanted to be achieved. Assuming that these group wants are required and will therefore be transformed into objectives, it seems that both variables indicate the same thing, namely the goals of a group of human beings.
- The variable "Social objective" is of influence on resources, while the variable "Group wants/long term" is not. However, it seems valid that the variable "Group wants/long term" could be combined with the variable "Social objectives" without changing the substance of the relation. The relation would than still indicate that resources are influenced by the objectives and wants of the human beings in a society.
- The variable "Group wants/long term" is of influence on the variable "Conflict". This conflict exists between the individual wants and the group wants. When group wants would be replaced

with social objectives in this sentence, it would still imply the same thing, that individual wants to not always comply with what is beneficial or wanted for the group.

- For the reasons given, it looks like that “Social objectives” and “Group wants/long term” imply the same thing. Since Zimmerman, has divided wants in individual wants and group wants and was not that explicit about the different types of objectives, the variable “Group wants/ long term” will be kept, and the variable “Social objectives” will be placed under this variable.
- Thus the variable “Group wants/long term” is now a combination of the variable “Group wants/long term”, “Social objectives” and “Man’s objectives”. This variable indicates the wants and objectives of a human population.

Changes to the initial causal relation diagram: -

- Combination of the variable s “Social objectives”, “Group wants/long term” and “Man’s objectives into the variable “Group wants/long term”.

3.7 Changing wants

Definition Changing wants: Changing desires.

Table 27 Changing wants

page	Variables influencing changing wants	Variables influenced by changing wants	Description
31		Resource appraisal	*Resource appraisal, besides being affected by changing wants and social objectives, ultimately depends on the state of arts rather than on the supply of equipment.*

Comment:

- This variable seems to be part of the variable “Wants”. The variable “Wants” is of influence on the resource appraisal of men. When these wants change the appraisal will change. However, the variable “Changing wants” does not bring an extra clarification. The diagram can sustain with the effects of “Wants” on resource appraisal which will include the possible changes which can occur in wants. Therefore, the variable “Changing wants” can be placed under the variable “Wants’”.

Changes to the initial causal relation diagram:

- The combination of the variable “Changing wants” and “Wants” into the variable “Wants”.

3.8 Conflict between group and individual interest

Dictionary definition conflict: *“A state of disharmony between incompatible or antithetical persons, ideas, or interests; a clash.”* (“Free Dictionary,” n.d.)

Definition Conflict between group and individual interests: A state of disharmony between group and individual interests.

Table 28 Conflict between group and individual interest

page	Variables influencing Conflict between group and individual interest	Variables influenced by Conflict between group and individual interest	Description
27	Tempo resource development		*The conflict between social and private interests develops from a fundamental difference in the nature of the group and of the individual. The group represents a succession of generations, and therefore its life must be longer than that of the individual. As a result of such conflicting attitudes, social and private interests cannot agree on the "tempo" of resource development. He who regards the interest of future generations, who interprets human progress in the light of broad historical developments, is not as easily drawn into the whirlpool of profit chasing or the excitement of markets place as is the man who lives from hand to mouth, knows no other happiness than immediate enjoyment, and whose motto is, "after us, the deluge." The social view stresses the long-run aspects of resource appraisal; the individual is interested in immediate results. His is the short-run view.*
27, 28		Resource appraisal	*The conflict between social and private interests develops from a fundamental difference in the nature of the group and of the individual. The group represents a succession of generations, and therefore its life must be longer than that of the individual. As a result of such conflicting attitudes, social and private interests cannot agree on the "tempo" of resource development. He who regards the interest of future generations, who interprets human progress in the light of broad historical developments, is not as easily drawn into the whirlpool of profit chasing or the excitement of markets place as is the man who lives from hand to mouth, knows no other happiness than immediate enjoyment, and whose motto is, "after us, the deluge." The social view stresses the long-run aspects of resource appraisal; the individual is interested in immediate results. His is the short-run view (p27).The process of appraisal which is largely dominated by the conflict between group and individual interests has lost much of its original*

			straight-line simplicity. (28)
14	Science		*Scientific progress offers many remedies but does not wholly remove the problem of conflicts between short-run individual and long-run group interests.*

Comments:

- Since the conflict exists between individual wants and social or group interest, the assumption can be made that individual wants and social objectives are of influence on this variable “Conflict between group and individual interest”. Therefore the suggestion is done to add relations between the variables “individual wants/short term” and “Conflict between group and individual interest” and between the variables “Group wants/long term” and “Conflict between group and individual interest”.

Changes to the initial causal relation diagram:

- Adding of the relation between “Individual wants/short term” and “Conflict between group and individual interest”.
- Adding of the relation between “Social objectives” and “Conflict between group and individual interest”.

3.9 Conflict

“In an ideal society, the attainment of social objectives is assumed to result in a fuller satisfaction of individual wants, in theory at least, run parallel towards the same goal. In reality however, the social and private interests frequently clash in head-on collision.” (p23)

Dictionary definition conflict: “*A state of disharmony between incompatible or antithetical persons, ideas, or interests; a clash.”* (“Free Dictionary,” n.d.)

Definition Conflict: A state of disharmony.

Table 29 Conflict

page	Variables influencing Conflict	Variables influenced by Conflict	Description
23	Individual wants/short term		*In an ideal society, the attainment of social objectives is assumed to result in a fuller satisfaction of individual wants, in theory at least, run parallel towards the same goal. In reality however, the social and private interests frequently clash in head-on collision.*
23	Social objectives		*In an ideal society, the attainment of social objectives is assumed to result in a fuller satisfaction of individual wants, in theory at least, run parallel towards the same goal. In reality however, the social and private interests frequently clash in head-on collision.*

Comments:

- Previously, it has been concluded that the variables “Social objectives” and “Group wants/long term” both indicate the same, namely the wants and objectives of a human population. This means that the variables “Conflict” and “Conflict between group and individual interest” both indicate the same issue, the disharmony between wants and objectives of a human population and individual interests. Therefore, the variables “Conflict” and “Conflict between group and individual interest” will be combined into one variable. Since, the variable “Conflict between group and individual interest” provides guidance on the content of this variable, this name is chosen for the combined variable.

Changes to the initial causal relation diagram:

- The combination of the variables “Conflict” and “Conflict between group and individual interest” into the variable “Conflict between group and individual interest”.

3.10 Specific needs

Dictionary definition need: *“Something required or wanted.”* (“Free Dictionary,” n.d.)

Definition Specific needs: Specific required or wanted aspects.

Table 30 Specific needs

page	Variables influencing Specific needs	Variables influenced by Specific needs	Description
15		Evolvement resources	*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff".*
15		Depletion/demolishment resources	*" "*
33		Development arts	*The peculiar nature of a given environment and of specific needs therefore determines the general lines along which the arts develop. Besides differences in environment and needs, differences in attitudes toward material progress and the crystallization of such attitudes in patent laws and similar institutions must be taken into consideration.*

Comments:

- Looking at the definition given in the dictionary a need can be something wanted or required. According to Zimmerman, some wants are required, such as basic and existence wants. This implies, when using the definition Zimmerman provides concerning basic/existence wants, that there is no difference between the concept of needs and basic and existence wants.
- Even though, Zimmerman also uses the term "Needs", this seems to present the same as the different kind of wants in his theory. The basic wants are for sure considered needs and the cultural wants could be considered as needs if people cannot live without the aspects wanted anymore. Therefore, it seems valid to place the variable "Specific needs" under the variable "Wants".

Changes to the initial causal relation diagram:

- The combination of the variables "Specific needs" and "Wants" into the variable "Wants".

3.11 Want satisfaction

Dictionary definition satisfaction: "*The fulfillment of gratification of a desire, need or appetite"* ("Free Dictionary," n.d.).

Definition Want satisfaction: The fulfillment of desires.

Table 31 Want satisfaction

page	Variables influencing Want satisfaction	Variables influenced by Want satisfaction	Description
8	Natural resistances		*The extent of want satisfaction is a function of resources and resistances, not of resources alone.*
8	Natural resources		*" "*
8	Human effort		*Within these limits he is free to select from the myriad possibilities offered by nature those which at a given and place promise the best results in terms of want satisfaction in return for the human effort applied there to.*
11	Opportunities nature		*To know, however, what particular opportunities a given physical environment has to offer at a given time and place, one must first learn what man CAN and WANTS to do with it. Nature sets the limits which man develop his arts to satisfy his wants. Within these limits he is free to select from the myriad possibilities offered by nature those which at a given and place promise the best results in terms of want satisfaction in return for the human effort applied there to.*
32	Arts		*Functionally arts may be divided in two groups; those which render more effective man's productive efforts, and those which render the environment more amenable to these efforts.* The end result is fuller satisfactions of human wants.

Comments:

- As stated before, the satisfaction of wants leads to well-being. Therefore it should be considered if the variables "Well-being" and "Want satisfaction" may imply the same. This will be considered in the next section on the variable "Well-being".

Changes to the initial causal relation diagram: -

3.12 Well-being

Dictionary definition well-being: "*State of being healthy, happy or prosperous; welfare".* ("Free Dictionary," n.d.)

Definition Well-being: A condition in which people are healthy and enjoying welfare.

Table 32 Well-being

page	Variables influencing well-being	Variables influenced by well-being	Description
75	Net resources		*Chapter 1 brought out the basic facts that a sharp distinction should be made between gross resources and net resources*, net resources *being defined as those available for the promotion of real wealth, or well-being, after resistance have been overcome. Well-being is not directly related to gross resources, but to net resources.*
78	Energy expenditure		*But for it should be equally clear that there is no greater force promoting well-being than energy expenditure.*

Comment:

- When wants are satisfied, this should lead to a condition of people wherein they feel a sense of happiness and welfare, i.e. the satisfaction of wants leads to Well-being.
- In order to keep the diagram simple and clear, it is suggested that the variables "Wants satisfaction" and "Well-being" are combined into one variable, since they both indicate a state of people in which their wants are satisfied and in which they are enjoying welfare.
- It is suggested to combine the variables in the variable "Want satisfaction", since the name of this variable explains the process towards well-being and presents that there is a relation between well- being or "want satisfaction" and the variable "Wants".

Changes to the initial causal relation diagram:

- The combination of the variables "Well-being" and "Want satisfaction" into the variable "Want satisfaction".

4. Nature

4.1 Natural resources

This variable is already presented under the category resources and can be found in paragraph 1.9 of resources.

4.2 The nature of the environment

Definition The nature of the environment: The physical environment offered by nature.

Table 33 The nature of the environment

page	Variables influencing the Nature of the environment	Variables influenced by the Nature of the environment	Description
120	Resource appraisal		*Moreover, if resources are merely expressions of the human appraisal of nature, how can the human element be eliminated from the resource concept? For human appraisal depends as much man's objectives and upon his mental and physical abilities, his general capacity to make use of his environment, as upon the nature of the environment.*

Changes to the initial causal relation diagram: -

4.3 Nature given environment

Definition Nature given environment: Physical environment offered by nature.

Table 34 Nature given environment

page	Variables influencing Nature given environment	Variables influenced by Nature given environment	Description
33		Development arts	*The peculiar nature of a given environment and of specific needs therefore determines the general lines along which the arts develop.*
116		Culture	*Culture varies in origin, form, and function according to the character of the natural environment and the relationship between the natural opportunities and the population.*

Comments:

- The variables "The nature of the environment" and the "Nature given environment" both indicate the physical environment offered by nature. Therefore it seems valid that these two variables may be combined into one.

Changes to the initial causal relation diagram:

- The combination of the variables "Nature given environment" and "The nature of the environment" into the variable "The nature of the environment".

4.4 Physical environment

Dictionary definition physical: *"Of or relating to material things; our physical environment."*("Free Dictionary," n.d.)

Definition Physical environment: The physical environment viewed as the changing relationships of trends and forces.

Table 35 Physical environment

page	Variables influencing Physical environment	Variables influenced by Physical environment	Description
11		Human productiveness	*The physical environment appraised both quantitatively and viewed as changing relationships of trends and forces rather than as static conditions, therefore is at all times the foundation of human productive effort.*

Comments:

- The physical environment seems to indicate the same as the variables "Nature given environment" and the "Nature of the environment", namely the physical environment offered by nature. However, this variable views this physical environment as the changing relationships of trends and forces. Though, these trends and relationships are both part of and form the natural environment. This indicates, that even though the variables "Nature given environment" and the "Nature of the environment" are described in a different way, they indicate the same as the "Physical environment". Therefore this variable will be combined with the variables "Nature of the environment" and the "Nature given environment" into the variable "The nature of the environment", which will indicate the physical and dynamic environment offered by nature.

Changes to the initial causal relation diagram:

- The combination of the variables "Nature given environment", "The nature of the environment" and "Physical environment into the "The nature of the environment".

4.5 Nature

"The point made here is that the desire to economize effort often leads man to adapt himself consciously and willingly to nature. Nature, so to speak, advises man to choose what natural conditions render easiest to produce. Nature does not consent to men living at the North Pole or on the top of the Mount Everest." (p114-115)

Definition dictionary nature:

1. *"The material world and its phenomena*
2. *The forces and processes that produce and control all the phenomena of the material world.*
3. *The world of living things and the outdoors".* ("Free Dictionary," n.d.)

Definition Nature: The physical environment which offers limits and opportunities for its population.

Table 36 Nature

page	Variables influencing Nature	Variables influenced by Nature	Description

8		Evolvement Resources	*The dictionary definitions show that resources result from an interaction between (1) man (a) searching for means to attain given ends (such as the satisfaction of individual wants and the attainment of group or social objectives) and (b) possessed of the capacity to take advantage of opportunities or to extricate himself from difficulties, and (2) something outside of man which for the time being will be called nature.*
12,114-115	Culture		*To appreciate fully the dynamic force of culture, one needs to be aware of the entire scope of its penetrating force. The effects of cultural progress on nature come readily to mind. (p12) Nature and man may be called the original resource factors. Culture is the derivative. It is joint product of man and nature. Man creates culture with the aid of, "advice, and consent" of nature, out of substances found in nature, and with the aid of energies supplied in nature. (114-115)*
25		National wealth	*National wealth depends, in the first place, on the natural environment itself, on the availability-or utility- of the untransformed aspects of nature. It depends, in the second place, on the arts and institutions to which that environment, in view of the racial and cultural characteristics of that human element, gives rise. Among these, the institutions surrounding population increase are of special importance, for the largess of nature may result either in an ever growing number of people at or near a point of minimum sustenance or in a rising living standard for a restricted number.*
83		Natural-cultural resistances	*Similar one may make a distinction between primary or original natural resistances- e.g. catastrophes such as hurricanes, earth quakes, volcanic eruptions, tidal waves, floods, etc., and disease, plant pests, poisonous plants and animals, etc.-and secondary or derived natural resistances, i.e. those that are the result of human interference with or impact in nature. The latter may be properly referred to as natural-cultural resistances.*
83		Natural-cultural resources	*One may distinguish between primary or original aspects of nature, i.e. free gifts of nature, and secondary of derived aspects, i.e. aspects which become available for use by man as a result of improvements made by him. These improvements are called culture. Secondary or derived natural aspects are therefore, strictly speaking, natural-cultural resources.*

111-112		Returns social economy	*The social economy may be considered subject to the law of diminishing returns. Returns may diminish because of an excess or deficiency or any one factor- nature, culture or man. But the triune interrelation of the factors must never be lost sight of.*

Comments:

- When considering the definitions of the variables “The nature of the environment”, “Nature given environment” and “Physical environment”, it appears that they all reason about the physical environment of nature and its trends and forces. So the variable “Nature” actually indicates the same, since the other variables, though not literally stated, also bring limits and opportunities by means of the physical environments. Consequently it appears that all these variables may be combined into one variable.
- This variable will be called “Nature”, since this name comprises all elements and it is clear what aspects the variable comprises. Moreover, Zimmerman reasons often about the interaction of Nature, Man and culture, it is chosen to maintain this name for the variable.

Changes to the initial causal relation diagram:

- Combination of the variables “The nature of the environment”, “Nature given environment”, “Physical environment” and the “Nature” into the variable “Nature”.

4.6 Natural aspects

Dictionary definition aspect: *“A distinct feature or element in a problem, situation, etc.; facet”.* (“Free Dictionary,” n.d.)

Definition Natural aspects: Elements or facets of nature.

Table 37 Natural aspects

page	Variables influencing Natural aspects	Variables influenced by Natural aspects	Description
15		Resource ship	*Resource ship stems from the purposeful interaction of natural, cultural and human aspects primed and kept going by demand based on availability for use.*
16		Evolvement resources	*Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife.*

Comments: -

4.7 Natural assets

Dictionary definition asset: *“A useful or valuable quality, person, or thing, an advantage of resource”*(“Free Dictionary,” n.d.)

Definition Natural assets: Valuable aspects of nature.

Table 38 Natural Assets

page	Variables influencing Natural assets	Variables influenced by Natural assets	Description
14		Resource ship	*"Resource ship" evolves out of the three-way interaction of natural-human and cultural assets.*

Comments:

- As stated in the part "Resource ship", Zimmerman most likely means the same with the variable "Natural aspects" as with the variable "Natural asset", since both terms are of influence on the variable "Resource ship" in almost the same way. Both variables interact with either cultural and human aspect or cultural and human assets. The only aspect which is different is use the terms "Aspect" and "Asset". This can be recognized in the following two statements provided by Zimmerman. *"Resource ship" evolves out of the three-way interaction of natural-human and cultural assets" (p14)* and *"Resource ship stems from the purposeful interaction of natural, cultural and human aspects primed and kept going by demand based on availability for use"(p15).*
- Considering the definition of "Assets" and "Aspect", the main difference seems to be that an asset is a valuable aspect. However, it is still an aspect. Therefore, and due to the way these variables are used by Zimmerman in their relation to the variable "Resource ship", it seems valid that these two variables may be combined into the variable "Natural aspects".

Changes to the initial causal relation diagram:

- The combination of the variable "Natural aspects" and "Natural assets" into the variable "Natural aspects".

4.8 Nature's opportunities

Dictionary definition opportunity:

1. *"A favorable, appropriate, or advantageous combination of circumstances.*
2. *A chance or prospect"* ("Free Dictionary," n.d.).

Definition Nature's opportunities: Chances or favorable circumstances brought by nature.

Table 39 Nature's Opportunities

page	Variables influencing Nature's opportunities	Variables influenced by Nature's opportunities	Description
3	Inventions and discoveries		*Then with the great discoveries and inventions there came a time of great change. The white race experienced an amazing expansion of opportunities. It was an age of empire building and colonizing, of swarming into wide-open spaces, but also an age of new industries, of new and better used for what nature had to offer.*
11	Men's capacity to take advantage of opportunities		*To know, however, what particular opportunities a given physical environment has to offer at a given time and place, one must first learn what man CAN and WANTS to do with it. <u>Nature sets the limits which man develop his arts to satisfy his wants</u>. Within these limits he is free to select from the myriad possibilities offered by nature those which at a given and place promise the best results in terms of want satisfaction in return for the human effort applied there to.*
11	Wants		*" "*
11	Arts		*" "*
11		Want satisfaction	*" "*
116		Culture	*Culture varies in origin, form, and function according to the character of the natural environment and the relationship between the natural opportunities and the population.*

Comments: -

Changes to the initial causal relation diagram: -

4.9 Nature's limits

Dictionary definition limit:

1. *"The point, edge, or line beyond which something cannot or may not proceed.*
2. *A confining or restricting object, agent of influence."*("Free Dictionary," n.d.).

Definition Nature's limits: The restricting forces of nature which pose boundaries for the opportunities.

Table 40 Nature's limits

page	Variables influencing Natural limits	Variables influenced by Natural limits	Description
11		Development arts	*<u>Nature sets the limits which man develop his arts to satisfy his wants</u>*

Comments: -

Changes to the initial causal relation diagram: -

4.10 Indirect adaption to nature

Dictionary definition adaptation: *"An alteration or adjustment in structure or habits, by which a species or individual improves its condition in relationship to its environment."* ("Free Dictionary," n.d.)

Definition Indirect adaption to nature: The indirect adjustments done by man to get adapted to his environment.

Table 41 Indirect adaption to nature

page	Variables influencing Indirect adaption to nature	Variables influenced by Indirect adaption nature	Description
122	Development cultural/physical environment		*Bernards refers to these (cultural) environments as psychosocial environments. Naturally all cultural environments are social environments because culture is a social product, the social heritage. They are called psychosocial- as distinguished from physic social and biosocial on the lower level- to stress the fact that on this upper level nature no longer acts directly in a straight-line fashion, on an ad hoc basis so to speak; now the human mind – the psyche- enters the reaction as an independent and modifying factor.*
122		Indirectness= gap between first impression and first reaction	*As communication advances from the halting and unsatisfactory level of gestures and sign language to the higher level of written, including printed, language, when books and libraries come into vogue, cultural adaption comes progressively more under the influence of established crystalized human thought and seeks adjustments not to nature directly, but to a growing accumulation of previous human reactions to experiences in life. This increased indirectness, this widening of the gap between first impression and final reaction, logically leads, on the top level of derivative control and institutions, to the miraculous achievements of an Einstein on the one hand, and to the confusion of the human mind so characteristic for the modern age.*
122	Cultural adaption		*Thus communication becomes a vital factor in the development of the psychosocial environment. As communication advances from the halting and unsatisfactory level of gestures and sign language to the higher level of written, including printed, language, when books and libraries come into vogue, cultural adaption comes progressively more under the influence of established crystalized human thought*

			and seeks adjustments not to nature directly, but to a growing accumulation of previous human reactions to experiences in life.

Comments:

- This variable poses an important aspect of Zimmerman's theory, the fact that the modern human being is not directly adapted to nature anymore and that many institutions have been developed which have made the adaptions of men to nature far more indirect.

Changes to the initial causal relation diagram: -

4.11 Direct adaption to nature

Definition Direct adaption to nature: The direct adjustments done by man to get adapted to his environment.

Table 42 Direct adaption to nature

page	Variables influencing Direct adaption to nature	Variables influenced by Direct adaption nature	Description
115	Culture		*Much of culture may be properly viewed as a device of adaption to nature.*
122	Cultural adaption		*Thus communication becomes a vital factor in the development of the psychosocial environment. As communication advances from the halting and unsatisfactory level of gestures and sign language to the higher level of written, including printed, language, when books and libraries come into vogue, cultural adaption comes progressively more under the influence of established crystalized human thought and seeks adjustments not to nature directly, but to a growing accumulation of previous human reactions to experiences in life.*

Comments:

- The variables "Direct adaption to nature" and "Indirect adaption to nature" indicate approximately the same thing, namely the adaption of humans to their environment. However, the difference is that culture leads to a direct adaption to nature and that the accumulation of human experience and the involvement of human thought (possibly in the form of institutions) lead to indirect adaption to the environment.

Changes to the initial causal relation diagram: -

4.12 Adaption natural advantages/disadvantages

Definition Adaption to natural advantages/disadvantages: The adjustments done by man to get adapted to his environment.

Table 43 Adaption Natural advantages/disadvantages

page	Variables influencing Adaption natural advantages/disadvantages	Variables influenced by Adaption natural advantages/disadvantages	Description
11		Culture	*Human culture as a rule is adaptive; that is, it reflects adaption to natural advantages or disadvantages* (Zimmerman et al., 1936). *(from Erich W zimmerman in walter E. Spahr (ed), Economic principles and problems, Farrar & Rinehart, New York, 3rd ed., 1936, vol.1 pp 165-166.))*

Comments:

- The variable "Adaption natural advantages/disadvantages" reasons about the adaption to the natural environment. It states that culture reflects the adaption to nature. This indicates that the natural advantages and disadvantages are of influence on culture, but not on the adaption itself, which can be considered as the reaction on the natural environment. Therefore the variable "Adaption natural advantages/disadvantages" actually indicates the influence of the natural environment on culture, instead of the effect of adaptions on nature. This implies that this variable may be assembled with the variable "Nature given environment".
- The variable "Nature given environment" is of influence on culture, in the same way as the variable "Adaption natural advantages/disadvantages". Therefore it seems possible to combine these variables into the variable "Nature given environment".
- The variable "Nature given environment" is already combined with the variable "The nature of the environment" and the variable "Physical environment.

Changes to the initial causal relation diagram:

- The combination of the variables "Adaption natural advantages/disadvantages", "Nature given environment", "Physical environment", "Nature" and the "Nature of the environment" into the variable "Nature".

5. Culture

5.1 Culture

"Man alone of all creatures can build culture. Culture building is a human prerogative. It stems from the human capacity to invent arts and artifacts and to elevate arts to the level of science, a capacity that derives from man's superior intellect and unique physical endowment. It is culture that permits man to inhabit every continent."(p114)

"Culture:

- *It permits man to imitate nature.*
- *Permits man to improve on nature.*

- *Enables man to create new substances nowhere found in nature.*
- *Gives men the power to release energies not available in nature." (p115)*

"Culture is the sum total of all the devices produced by man, with the aid, "advice, and consent" of nature, to assist him in the attainment of his objectives. These objectives are:

- *The survival of the race*
- *The provision for expanding population*
- *Provision of greater comforts and better material existence*
- *Quench the thirst that from the soul doth rises" to provide the highest values, the yearning for which is the main distinction between human beings and other living creatures." (p115)*

"Culture means education, learning, experience, religion, civilized behavior, suppression of vicious animal instincts, cooperation replacing conflict, the law of fair play and justice suppressing the law of the jungle." (p116)

"Culture functions in the form of education, sanitation, health service, training, church, government, etc."(p116).

Dictionary definition culture: *"The totality of socially transmitted behavior patterns, arts, beliefs, institutions, and all other products of human work and thought. "*("Free Dictionary," n.d.)

Definition Culture: The total sum of human products stemming from the human capacity to invent arts and artifacts in order to meet man's objectives.

Table 44 Culture

page	Variables influencing Culture	Variables influenced by Culture	Description
11		Evolvement resources	*Culture is bound to become increasingly important as the dynamic force in the creation of resources.*
11	Adaption natural advantages/disadvantages		*Human culture as a rule is adaptive; that is, it reflects adaption to natural advantages or disadvantages* (Zimmerman et al., 1936). *(from Erich W Zimmerman in walter E. Spahr (ed), Economic principles and problems, Farrar & Rinehart, New York, 3rd ed., 1936, vol.1 pp 165-166.))*
12		Social organization	*Not only wants and abilities of the individual man and of groups of men are affected by culture but the relationships between men, social organizations, and societal institutes also come under its spell.*

12		Relationships between men	" "
12		Man's abilities	" "
12		Wants	" "
12		Societal institutions	" "
12-119		Population growth	Also the size of the human population is affected by cultural change. First an increase is noticed by the expanding and improved culture. Later a decrease is noticed by the planned parenthood and birth control. (p12*) Culture even affects the most intimate of human mores, those governing reproduction. When culture reaches higher levels, unrestrained breeding against the means of sustenance yield to birth control and planned parenthood. (p119).*
111-112		Returns social economy	*The social economy may be considered subject to the law of diminishing returns. Returns may diminish because of an excess or deficiency or any one factor- nature, culture or man. But the triune interrelation of the factors must never be lost sight of.*
114-115	Man		*Nature and man may be called the original resources factors. Culture is the derivative. It is joint product of man and nature. Man creates culture with the aid of, "advice, and consent" of nature, out of substances found in nature, and with the aid of energies supplied in nature.*
114-115	Nature		*Nature and man may be called the original resources factors. Culture is the derivative. It is joint product of man and nature. Man creates culture with the aid of, "advice, and consent" of nature, out of substances found in nature, and with the aid of energies supplied in nature.*
114	Arts		*Culture building is a human prerogative. It stems from the human capacity to invent arts and artifacts and to elevate arts to the level of science, a capacity that derives from man's superior intellect and unique physical endowment.*
115		Direct adaption to nature	*Much of culture may be properly viewed as a device of adaption to nature.*

116	Nature given environment		*Culture varies in origin, form, and function according to the character of the natural environment and the relationship between the natural opportunities and the population.*
116	Nature's opportunities		*" "*
116	Population		*" "*
116		Evolvement Resources	*Culture has the dual function of enlarging resources and reducing resistances.*
114-115,116		Resistances	*The point made here is that the desire to economize effort often leads man to adapt himself consciously and willingly to nature. Nature, so to speak, advises man to choose what natural conditions render easiest to produce. Nature does not consent to men living at the North Pole or on the top of the mount Everest. (114-115) Culture has the dual function of enlarging resources and reducing resistances. (p116)*
123	Reactions/adaptions diverse environments		*Man, women and children live in social groups that develop their own cultures in separate culture areas. These cultures having evolved out of reactions and adaptions to diverse environments differ as these environments differ.*
123		Blended/alloyed cultures	*During the early stages of human existence, such cultural occurred in airtight compartments. As contacts increased and various group interrelations ensued-submission conquest, merging through intermarriage, etc. –cultures lost some of this pristine simplicity, and blended or alloyed cultures developed.*

Comments:

- The variable "Direct adaption to nature" states that culture is the instrument to adapt to the environment, which means that adaption is an effect of culture and not a not a cause.
- However, the variable "Reactions/adaptions diverse environments" states that culture evolves out of adaptions and reactions to diverse environments. Thus, here Zimmerman, states that adaptions and reactions on nature are of influence on culture.
- Therefore it can be concluded, that adaptions and reactions on nature are both on influence on culture as they are the effect of culture.

Changes to the initial causal relation diagram: -

5.2 Cultural assets

Dictionary definition asset: *"A useful or valuable quality, person, or thing, an advantage of resource"*("Free Dictionary," n.d.)

Definition Cultural assets: Valuable aspects of culture.

Table 45 Cultural assets

page	Variables influencing Cultural assets	Variables influenced by Cultural assets	Description
14		Resource ship	*"Resource ship" evolves out of the three-way interaction of natural-human and cultural assets.*

Comments: -

Changes to the initial causal relation diagram: -

5.3 Cultural aspects

Dictionary definition aspect: *"A distinct feature or element in a problem, situation, etc.; facet"*. ("Free Dictionary," n.d.)

Definition Cultural aspects: Elements or facets of culture.

Table 46 Cultural aspects

page	Variables influencing Cultural aspects	Variables influenced by Cultural aspects	Description
15		Resource ship	*Resource ship stems from the purposeful interaction of natural, cultural and human aspects primed and kept going by demand based on availability for use.*
16		Evolvement resources	*Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife.*

Comments:

- As stated in the part "Resource ship", Zimmerman most likely means the same with the variables "Cultural aspects" as with the variable "Cultural assets", since both terms are of influence on the variable "Resource ship" in almost the same way, namely in interaction with either natural and human aspect or natural and human assets. The only aspect which is different is the usage the terms "aspect" and "asset".

- When considering the definitions of “assets” and “aspect”, the main difference seems to be that an asset is a valuable aspect. However, it is still an aspect. Therefore it seems valid that the variable “Cultural aspects” and “Cultural assets” are combined into one variable. This variable will be “Cultural aspects” and will represent the valuable aspects of culture.

Changes to the initial causal relation diagram:

- The combination of the variables “Cultural aspects” and “Cultural assets” into the variable “Cultural aspects”.

5.4 Enriched Cultures

Dictionary definition enrich: *“To make fuller, more meaningful, or more rewarding”.* (“Free Dictionary,” n.d.)

Definition Enriched culture: A culture which has increased in fullness and richness.

Table 47 Enriched culture

page	Variables influencing Enriched cultures	Variables influenced by Enriched cultures	Description
123		Problems (cultural values which move)	*These intergroup contacts tend to enrich cultures and help to accelerate their growth. But they also create problems. (Japan). Cultures possess a certain inner coherence and inner logic. They cannot be chopped without killing the soul.*
123		Growth	" "
123	Blended/alloyed cultures		*During the early stages of human existence, such cultural occurred in airtight compartments. As contacts increased and various group interrelations ensued-submission conquest, merging through intermarriage, etc. –cultures lost some of this pristine simplicity, and blended or alloyed cultures developed. These intergroup contacts tend to enrich cultures and help to accelerate their growth.*

Comments: -

Changes to the initial causal relation diagram: -

5.5 Blended/alloyed cultures

Dictionary definition blended: *”To combine or mix so that the constituent parts are indistinguishable from one another.”*(“Free Dictionary,” n.d.)

Dictionary definition alloyed: “a mixture; an amalgam”. (“Free Dictionary,” n.d.)

Definition Blended/alloyed cultures: The combination or mixture of elements of several cultures.

Table 48 Blended/alloyed cultures

page	Variables influencing Blended/alloyed cultures	Variables influenced by Blended/alloyed cultures	Description
123	Culture		*Cultures having evolved out of reactions and adaptions to diverse environments differ as these environments differ. During the early stages of human existence, such cultural occurred in airtight compartments. As contacts increased and various group interrelations ensued-submission conquest, merging through intermarriage, etc. –cultures lost some of this pristine simplicity, and blended or alloyed cultures developed.*
123		Enriched cultures	*During the early stages of human existence, such cultural occurred in airtight compartments. As contacts increased and various group interrelations ensued-submission conquest, merging through intermarriage, etc. –cultures lost some of this pristine simplicity, and blended or alloyed cultures developed. These intergroup contacts tend to enrich cultures and help to accelerate their growth.*
123	Increased human contact		*" "*

Comments:

- The variable "Blended/alloyed culture" represents a culture which has been developed from several cultures. This could also be seen as an enriched culture. Therefore, it seems valid to combine the variables "Blended/alloyed cultures" and "Enriched culture" into one variable. This variable will be "Enriched culture" since this indicates a fuller and more meaningful culture due to influence from other cultures. Also, when looking at the variables these variables are of influence on, this combination seems rational.

Changes to the initial causal relation diagram:

- The combination of "Blended/alloyed cultures" and "Enriched cultures" into the variable "Enriched cultures".

5.6 Problems (with cultural values which move)

Definition Problems (with cultural values which move): The problems which appear when parts of culture are blended into other cultures due to the loss of the coherence of the cultural aspects and their logic.

Table 49 Problems

page	Variables influencing Problems (with cultural values which move)	Variables influenced by Problems with cultural values which move	Description
123	Enriched cultures		*These intergroup contacts tend to enrich cultures and help to accelerate their growth. But they also create problems. Cultures possess a certain inner coherence and inner logic. They cannot be chopped without killing the soul.*

Comments: -

Changes to the initial causal relation diagram: -

5.7 Development psychosocial environment

"Bernards refers to these (cultural) environments as psychosocial environments. Naturally all cultural environments are social environments because culture is a social product, the social heritage. They are called psychosocial- as distinguished from physic social and biosocial on the lower level- to stress the fact that on this upper level nature no longer acts directly in a straight-line fashion, on an ad hoc basis so to speak; now the human mind – the psyche- enters the reaction as an independent and modifying factor. Man reacts no longer with clean slate; the slate has been written on. The mind is grooved with impressions."(p122)

Dictionary definition psychosocial: *"Involving aspects of social and psychological behavior."*("Free Dictionary," n.d.).

Definition Psychosocial environment: A cultural environment in which the human mind has entered as a modifying factor.

Table 50 Psychosocial environment

page	Variables influencing development psychosocial environment	Variables influenced by development psychosocial environment	Description
122	Communication		*Thus communication becomes a vital factor in the development of the psychosocial environment.*
122		Indirect adaptions to nature	*They are called psychosocial- as distinguished from physic social and biosocial on the lower level- to stress the fact that on this upper level nature no longer acts directly in a straight-line fashion, on an ad hoc basis so to speak; now the human mind – the psyche- enters the reaction as an independent and modifying factor.*

Comments: -

Changes to the initial causal relation diagram: -

5.8 Cultural adaption

Dictionary definition adaptation: *"An alteration or adjustment in structure or habits, by which a species or individual improves its condition in relationship to its environment."*("Free Dictionary," n.d.)

Definition Cultural adaption: The indirect adjustments done by man to get adapted to his environment.

Table 51 Cultural adaption

page	Variables influencing Cultural adaption	Variables influenced by Cultural adaption	Description
122	Crystalized human thought		*Thus communication becomes a vital factor in the development of the psychosocial environment. As communication advances from the halting and unsatisfactory level of gestures and sign language to the higher level of written, including printed, language, when books and libraries come into vogue, cultural adaption comes progressively more under the influence of established crystalized human thought and seeks adjustments not to nature directly, but to a growing accumulation of previous human reactions to experiences in life.*
122		Indirect adaptions nature	" "
122		Direct adaption to nature	" "
122	Accumulation human reactions/experiences		" "

Comments:

- It seems that with the variable “Cultural adaption”, Zimmerman indicates the adaption to the environment done with the instrument culture. Cultural adaption is not another form of adaption. What is described here is that the adaption of man to his environment is influenced by the crystallization of human thoughts and the accumulation of previous experience. The cultural adaption does not seek adjustments to nature directly but seeks adjustments to a sum of previous human reactions on experiences. Therefore the adaption is indirect.
- Thus, the variable “Cultural adaption” could be described as an indirect adaption to nature. However, if the variable “Cultural adaption” would be placed under “Indirect adaption to nature” this would not clarify the diagram. This because “Cultural adaption” indicates the indirect adaptions to nature based on the growing accumulation of previous experiences. This is not the same as the indirect adaptions done to nature. Furthermore, it is stated that this adaption becomes more under influence of crystalized human thought. From this sentence, it may be concluded that the cultural adaption therefore also considers adaption to other aspects than the accumulation of human thoughts and experience. Therefore, it appears that the variable “Cultural adaption” also included direct adaptions to nature and not just indirect adaptions. So,

the cultural adaption defines both the amount of indirect and direct adaptions to nature. Therefore this variable will, be kept as "Cultural adaption".

Changes to the initial causal relation diagram: -

6. Arts

*"Functionally arts may be divided in two groups; those which render more effective man's productive efforts, and those which render the environment more amenable to these efforts. "*The end result is fuller satisfactions of human wants. "(p32)

6.1 Arts

Dictionary definition arts: "*Human effort to imitate, supplement, alter, or counteract the work of nature.*" ("Free Dictionary," n.d.)

Definition Arts: The skills and efforts of human to alter nature.

Table 52 Arts

page	Variables influencing Arts	Variables influenced by Arts	Description
11		Human productive effort	*The physical environment appraised both quantitatively and viewed as changing relationships of trends and forces rather than as static conditions, therefore is at all times the foundation of human productive effort. Arts, no matter how highly developed, and wants, no matter how urgent or sophisticated, are helpless in a vacuum. Without acting on and drawing from physical nature they are unproductive.*
11		Nature's opportunities	*To know, however, what particular opportunities a given physical environment has to offer at a given time and place, one must first learn what man CAN and WANTS to do with it. <u>Nature sets the limits which man develop his arts to satisfy his wants</u>. Within these limits he is free to select from the myriad possibilities offered by nature those which at a given and place promise the best results in terms of want satisfaction in return for the human effort applied there to.*
11		Resources	*Resources are dynamic not only in response to increased knowledge, improved arts, expanding science but also in response to changing individual wants and social objectives.*

25		National wealth	*National wealth depends, in the first place, on the natural environment itself, on the availability-or utility- of the untransformed aspects of nature. It depends, in the second place, on the arts and institutions to which that environment, in view of the racial and cultural characteristics of that human element, gives rise. Among these, the institutions surrounding population increase are of special importance, for the largess of nature may result either in an ever growing number of people at or near a point of minimum sustenance or in a rising living standard for a restricted number.*
32		Want satisfaction	*Functionally arts may be divided in two groups; those which render more effective man's productive efforts, and those which render the environment more amenable to these efforts.* The end result is fuller satisfactions of human wants.
114		Culture	*Culture building is a human prerogative. It stems from the human capacity to invent arts and artifacts and to elevate arts to the level of science, a capacity that derives from man's superior intellect and unique physical endowment.*

Comments:

- Even though not literally stated by Zimmerman, though based on the information from the variable "Human productive effort", the conclusion can be developed that arts are of influence on the human productiveness. This because Zimmerman states that Arts are helpless in a vacuum, they need a physical environment to be meaningful for the human productiveness. Therefore it is assumed that Zimmerman indicates that the combination of the "physical environment" and "Arts" is of influence on "Human productive effort". So, when Arts are used in combination with and adjusted to the physical environment, Arts are of influence on the Human productive effort. Therefore it is concluded the variable "Arts" is of influence on "human productive effort".

Changes to the initial causal relation diagram:

- Adding of the relation between "Arts" and "Human productive effort".

6.2 Development arts

Dictionary definition development:

1. *"To bring from latency to or toward fulfillment*
    a. *To expand or enlarge*
    b. *To aid in the growth of, strengthen*
    c. *To improve the quality of, refine.*
2. *To bring into being gradually.*
3. *To cause gradually to acquire a specific role, function, or form as:*
    a. *To make available and effective to fulfill a particular end or need*
    b. *To convert or transform"* ("Free Dictionary," n.d.)

Definition Development arts: The expansion and growth of the skills and efforts of humans to alter nature.

Table 53 Development arts

page	Variables influencing Development arts	Variables influenced by Developments arts	Description
11	Nature's limits		*Nature sets the limits which man develop his arts to satisfy his wants.*
33	Attitudes toward material progress		*Peculiar nature of a given environment and of specific needs therefore determines the general lines along which the arts develop. Besides differences in environment and needs, differences in attitudes toward material progress and the crystallization of such attitudes in patent laws and similar institutions must be taken into consideration.*
33	Patent laws/institutions		" "
33	Nature given environment		*The peculiar nature of a given environment and of specific needs therefore determines the general lines along which the arts develop.*
33	Specific needs		" "
38	Science		*As we have seen, the superiority of the scientific method manifests itself in a tremendous acceleration of the rate of progress of the arts.*
114	Human capacity		*Culture building is a human prerogative. It stems from the human capacity to invent arts and artifacts and to elevate arts to the level of science, a capacity that derives from man's superior intellect and unique physical endowment.*

Comments:

- Zimmerman does not describe the relation between the Development of arts and the presence of Arts. However, since the development of arts leads to new Arts or could make other Arts abundant due to inventions, this relation seems plausible. Therefore, it this relation between the variables “Development of Arts” and “Arts” will be applied in the causal relation diagram.

Changes to the initial causal relation diagram:

- Adding of the relation from the “Development of arts” to “Arts”.

6.3 Improvement of arts

Dictionary definition improving: “*To raise to a more desirable or more excellent quality or condition; make better*. “(“Free Dictionary,” n.d.)

Definition Improvement of arts: An increase in the quality of skills and efforts of humans to alter nature.

Table 54 Improvement of arts

page	Variables influencing Improvement of arts	Variables influenced by Improvement of arts	Description
35	Inventions and discoveries		*That in the beginning progress should be slow seems only natural. It should always be kept in mind that the first invention is infinitely more difficult than those that are bases upon it. For countless ages men improved his arts reluctantly, only under dire pressure. “Necessity is the mother of invention” became a commonly accepted truth.*
35	Profit motive		*Hence, we may say that the profit motive, the acquisitive instinct of “business man”- in short, pleonexy, the desire to have more for his own sake- is one of the strongest impulses to improvements of the arts.*
80-81		Evolvement resources	*The social scientist is concerned not with the totality of nature for man, with that ever-changing portion of nature which is known to man and which affects his existence. That portion is both expanding and contracting. It expands in response to an increase in knowledge and improvement of the arts.*
139		Efficient Transportation system	*Since excessive space is one great handicap under which north America labors, and since that handicap can be*

			neutralized through improved transportation and communication, it follows that every improvement of the arts , every invention and every discovery which make transportation and communication more efficient and therefore cheaper, mean most to that country which is most dependent on efficient transportation.
139		Efficient communication system	*" "*

Comments:

- The variables "Efficient transportation system" and "Efficient communication" are examples of arts already improved. These variables do not clarify anything else, which has not been clarified by other variables. Therefore these variables may be excluded from the diagram s. This will further elaborated when these variables are discussed

Changes to the initial causal relation diagram: -

6.4 State of arts

"The state of the arts: as the summation of human capacities along lines of both technology and social organization." (p17)

Dictionary definition state: *"A condition, or being in a state or form, as of structure, growth or development."* ("Free Dictionary," n.d.)

Definition State of the arts: The sum of human capacities.

Table 55 State of arts

page	Variables influencing State of arts	Variables influenced by State of arts	Description
17,31	Resource appraisal		*Two sets of interdependent criteria may be distinguished in the appraisal of resources: 1.The state of wants: the expression of human needs, individual wants, social objectives, higher aspirations. 2. The state of the arts: as the summation of human capacities along lines of both technology and social organization. (p17) Resource appraisal, besides being affected by changing wants and social objectives, ultimately depends on the state of arts rather than on the supply of equipment. (p31)*

Comments:

- The variables “State of arts” and “Arts” both indicate the total of human capacities to alter Nature. These capacities could be found both in the fields of technology and social organization. Moreover, in the relations provided in the tables the variable “Arts” could also have been used, without changing the substance of the relation. Therefore it seems valid to combine the variables “State of Arts” and “Arts” into the general term “Arts”.

Changes to the initial causal relation diagram: -

- The combination of the variable “State of the arts” and” Arts” into the variable “Arts”.

6.5 Societal arts

“Two categories of arts may be distinguished:

- *material or technical arts (abilities to utilize substances and energies) railroads, telephones*
- *societal and institutional arts (abilities to regulate and improve human relations) parliaments, churches*

The two groups of arts are branches of the same tree; they draw their strength from the same soil. Mutually dependent, they both contribute to the fuller growth of the three of civilization.” (p32)

Dictionary definition Societal: “*Of or relating to the structure, organization, or functioning of society.”* (“Free Dictionary,” n.d.)

Definition Societal arts: The sum of human capacities relating to the structure, organization or functioning of society in order to regulate and improve human relations.

Table 56 Societal Arts

page	Variables influencing Societal arts	Variables influenced by Societal arts	Description
72	Energy basis		*As a result, foreign trade and the export of capital assume increasing importance and thus broaden the resource basis of mobilized economy. We see, therefore, that the energy basis is truly the foundation of a civilization. It determines the choice of materials which can be utilized, it sets a definite limit to the size of performance, it governs the degree of mobility and, in general, controls the arts societal and technical, and through them shapes the institutions, material and non-material.*
72		Institutions	" "

Comments:

- In the relation to the energy basis and institutions, the societal and technical arts are both mentioned in the same way. When in this sentence, the variable “Arts” would have been used, the relation still indicates that the energy basis of a country is of influence on the Arts, both societal and technical, of a country. However, in that case there will be no discrepancy made between the types of Arts. It should be kept in mind that there are two kinds of Arts; however, it would not further clarify this diagram. Furthermore, Zimmerman uses the general term “Arts” often, and very rarely uses further specified Arts, so using the term Arts would better present the theory of Zimmerman. Therefore, it seems valid that the variable “Societal arts” can be placed under the label “Arts”. However, the existence the different types of arts should not be forgotten.

Changes to the initial causal relation diagram:

- The placement of “Societal Arts” under the general term “Arts”.

6.6 Technical arts

“Material or technical arts (abilities to utilize substances and energies) railroads, telephones.” (p32)

Dictionary definition technical: “*Of or relating to, or derived from technique.”* (“Free Dictionary,” n.d.)

Definition Technical arts: The sum of human capacities relating to material of technical abilities to utilize substances and energies.

Table 57 Technical arts

page	Variables influencing Technical arts	Variables influenced by Technical arts	Description
72	Energy basis		*As a result, foreign trade and the export of capital assume increasing importance and thus broaden the resource basis of mobilized economy. We see, therefore, that the energy basis is truly the foundation of a civilization. It determines the choice of materials which can be utilized, it sets a definite limit to the size of performance, it governs the degree of mobility and, in general, controls the arts societal and technical, and through them shapes the institutions, material and non-material.*
72		Institutions	" "

Comments:

- As stated in the part on “Societal arts”, in the relation to the energy basis and institutions, the Societal and Technical arts are both mentioned in the same way. It also accounts for the variable “Technical arts” that this variable can be placed under the general variable “Arts”.

Changes to the initial causal relation diagram:

- The placement of the variable "Technical Arts" under the general variable "Arts"

7. Man

7.1 Man

"Man is an abstraction. In reality, most cultural developments originate from social groups (tribes, nations, international groupings)" (p13) (Zimmerman, 1946b).

Dictionary definition man: *"The human race; mankind"*. ("Free Dictionary," n.d.)

Definition Man: Mankind

Table 58 Man

page	Variables influencing Man	Variables influenced by Man	Description
111-112		Returns social economy	*The social economy may be considered subject to the law of diminishing returns. Returns may diminish because of an excess or deficiency or any one factor-nature, culture or man. But the triune interrelation of the factors must never be lost sight of.*
114-115		Culture	*Nature and man may be called the original resources factors. Culture is the derivative. It is joint product of man and nature. Man creates culture with the aid of, "advice, and consent" of nature, out of substances found in nature, and with the aid of energies supplied in nature.*

Comments: -

Changes to the initial causal relation diagram: -

7.2 Human Assets

Dictionary definition assets: *"A useful or valuable quality, person, or thing, an advantage of resource"*("Free Dictionary," n.d.)

Definition Human assets: The valuable features of mankind.

Table 59 Human assets

page	Variables influencing Human assets	Variables influenced by Human assets	Description
17		Resource ship	*"Resource ship" evolves out of the three-way interaction of natural-human and cultural assets.*

Comments: -

Changes to the initial causal relation diagram: -

7.3 Human aspects

Dictionary definition aspect: *"A distinct feature or element in a problem, situation, etc.; facet".*

Definition Human aspects: The notable features of mankind.

Table 60 Human aspects

page	Variables influencing Human aspects	Variables influenced by Human aspects	Description
15		Resource ship	*Resource ship stems from the purposeful interaction of natural, cultural and human aspects primed and kept going by demand based on availability for use.*

Comments:

- As already described in the part on the variable "Resource ship", Zimmerman probably implies the same with the terms "Aspects" and "Assets". This is based on how he uses both terms to describe the variable "Resource ship". It is the combination of natural, human and cultural aspects or assets which are of influence on Resource ship.
- Considering the definitions of "Assets" and "Aspects" it appears that an asset is a valuable aspect. So the term aspect could also imply an asset. Therefore, when the variable "Human aspects" would be used, it would also cover the content of the variable "Human asset". From this information, it is concluded that the variables "Human aspects" and Human assets" may be combined into the variable "Human aspects".

Changes to the initial causal relation diagram: -

- The combination of the variables "Human aspects "and "Human assets" into the variable "Human aspects".

7.4 Science

Dictionary definition science:

1.

a) *“The observation, identification, description, experimental investigation, and theoretical explanation of phenomena.*

b) *Such activities applied to an object or inquiry or study*

2. *Knowledge especially that gained through experience. “*(“Free Dictionary,” n.d.)

Definition Science: Activities of investigation and explanation of phenomena in order to gain knowledge.

Table 61 Science

page	Variables influencing Science	Variables influenced by Science	Description
11		Resources	*Resources are dynamic not only in response to increased knowledge, improved arts, expanding science but also in response to changing individual wants and social objectives.*
15		Evolvement resources	*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into “neutral stuff”.*
15		Depletion/demolishment resources	*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into “neutral stuff”.*
14		Conflict between group and individual interest	*Scientific progress offers many remedies but does not wholly remove the problem of conflicts between short-run individual and long-run group interests.*
38		Development arts	*As we have seen, the superiority of the scientific method manifests itself in a tremendous acceleration of the rate of progress of the arts.*

Comments: -

Changes to the initial causal relation diagram: -

7.5 Knowledge/wisdom

Dictionary definition knowledge:

1. *“Familiarity, awareness, or understanding gained through experience or study.*
2. *The sum of range of what has been perceived, discovered or learned.*
3. *Specific information about something.”* (“Free Dictionary,” n.d.)

Dictionary definition wisdom:

1. *“The ability to discern or judge what is true, right, or lasting; insight.*
2. *Common sense; good judgment*

3. *The sum of learning through the ages; knowledge.* “(“Free Dictionary,” n.d.)

Definition Knowledge/wisdom: The understanding and awareness of information which has been discovered experienced or learned through the ages.

Table 62 Knowledge/wisdom

page	Variables influencing Knowledge/wisdom	Variables influenced by Knowledge/wisdom	Description
7,11		Resources	*Man’s own wisdom is his premier resource-the key resource that unlocks the universe. (p7) Resources are dynamic not only in response to increased knowledge, improved arts, expanding science but also in response to changing individual wants and social objectives (11)*
9		Man's resources	*The bulk of MAN’s resources are the result of human ingenuity aided by slowly, patiently, painfully acquired knowledge and experience.*
6,16,80-81		Evolvement resources	*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects-such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors (p6). Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife (p16) The social scientist is concerned not with the totality of nature for man, with that ever-changing portion of nature which is*

			known to man and which affects his existence. That portion is both expanding and contracting. It expands in response to an increase in knowledge and improvement of the arts. (80-81)

Comments:-

Changes to the initial causal relation diagram: -

7.6 Knowledge of facts of nature and culture

Dictionary definition knowledge:

1. *"Familiarity, awareness, or understanding gained through experience or study.*
2. *The sum of range of what has been perceived discovered or learned.*
3. *Specific information about something."*

Definition Knowledge of facts of nature and culture: The understanding and awareness of information on nature and culture.

Table 63 Knowledge of fact of nature and culture

page	Variables influencing Knowledge of facts of nature and culture	Variables influenced by Knowledge of facts of nature and culture	Description
17		Resource appraisal	The appraisal of resources proceeds from: 1. The knowledge of facts of nature and culture to 2. The determination of technical feasibility to 3. The determination of profitability 4. The formulation of the grand strategy along socio-economic lines

Comments:

- The variable "Knowledge of facts of nature and culture" specifies itself on nature on culture. However, this specified knowledge is still knowledge. Therefore, in order to simplify the diagram, the variable "knowledge of facts of nature and culture" could be placed under the general variable "Knowledge/wisdom".

Changes to the initial causal relation diagram: -

- Placement of the variable "Knowledge of facts of nature and culture" under the variable "Knowledge /wisdom"

7.7 Human capacity

Dictionary definition capacity:

1. *"Ability to perform or produce; capability*
2. *The power to learn or retain knowledge; mental ability."* ("Free Dictionary," n.d.)

Definition Human capacity: The human ability or capability.

Table 64 Human capacity

page	Variables influencing Human capacity	Variables influenced by Human capacity	Description
114	Development Arts		*Culture building is a human prerogative. It stems from the human capacity to invent arts and artifacts and to elevate arts to the level of science, a capacity that derives from man's superior intellect and unique physical endowment.*

Comments: -

Changes to the initial causal relation diagram: -

7.8 Man's capacity to take advantage of opportunities

Dictionary definition capacity:

1. *"Ability to perform or produce; capability*
2. *The power to learn or retain knowledge; mental ability."* ("Free Dictionary," n.d.)

Definition Man's capacity to take advantage of opportunities: The human ability or capability to take advantage of opportunities.

Table 65 Man's capacity to take advantage of opportunities

page	Variables Man's capacity to take advantage of opportunities	Variables influenced by Man's capacity to take advantage of opportunities	Description
8		Resources	*The dictionary definitions show that resources result from an interaction between (1) man (a) searching for means to attain given ends (such as the satisfaction of individual wants and the attainment of group or social objectives) and (b) possessed of the capacity to take advantage of opportunities or to extricate himself from difficulties, and (2) something outside of man which for the time being will be called nature.*
11		Nature's opportunities	*To know, however, what particular opportunities a given physical environment has to offer at a given time and place, one must first learn what man CAN and WANTS to do with it. <u>Nature sets the limits which man develop his arts to satisfy his wants</u>. Within these limits he is free to select from the myriad possibilities offered by nature those which at a given and place promise the best results in terms of want satisfaction in return for the human effort applied there to.*

Comments:

- The variables "Human capacity" and "Man's capacity to take advantage of opportunities" both indicate the human ability or capability. The difference is that variable "Man's capacity to take advantage of opportunities" describes the human capability to make use of the opportunities offered. However, when man is capable (to make use of his environment) he will obviously make use of the opportunities; this is part of his capacity. Therefore this addition does not add significant new information. Consequently, it seems that the variables "Human capacity" and "Man's capacity to take advantage of opportunities" both reason on human capacity and can therefore be combined in the variable "Human capacity".

Changes to the initial causal relation diagram:

- The combination of the variable "Human capacity" and "Man's capacity to take advantage of opportunities" into the variable "Human capacity".

7.9 General capacity to take advantage of opportunities

1. **Dictionary definition capacity:**:
   a. *"Ability to perform or produce; capability*
   b. *The power to learn or retain knowledge; mental ability."* ("Free Dictionary," n.d.)

Definition General capacity to take advantage of opportunities: The general human ability or capability to take advantage of opportunities.

Table 66 General capacity to take advantage of opportunities

page	Variables influencing General capacity to take advantage of opportunities	Variables influenced by General capacity to take advantage of opportunities	Description
120		Resource appraisal	*Moreover, if resources are merely expressions of the human appraisal of nature, how can the human element be eliminated from the resource concept? For human appraisal depends as much man's objectives and upon his mental and physical abilities, his general capacity to make use of his environment, as upon the nature of the environment.*

Comments:

- The variable "The general capacity to take advantage of opportunities" does, when compared to the variable "Man's capacity to take advantage of opportunities", only differs in the word general. This word implies that this capacity is applicable to all the members of mankind. Since the variable "Human capacity" also indicates the capability of all the members of mankind, and previously it has been concluded that taking advantage of the opportunities is part of the capacity, the variable "General capacity to take advantage of opportunities" does not indicate anything different than the previous two variables. Therefore, this variable can be combined with the variables "Human capacity" and "Man's capacity to take advantage of opportunities" into the variable "Human capacity".

Changes to the initial causal relation diagram:

- The combination of the variables "Human capacity", " Man's capacity to take advantage of opportunities" and" general capacity to take advantage of opportunities" into "Human capacity"

7.10 Man's abilities

Dictionary definition ability:

1. *"The quality of being able to do something, especially the physical, mental, financial, or legal power to accomplish something.*

2. *A natural or acquired skill or talent.*
3. *The quality of being suitable for or receptive to a specified treatment; capacity "*("Free Dictionary," n.d.)

Definition Man's abilities: The qualities, skills, or talents of man which make him accomplish certain goals.

Table 67 Man's abilities

page	Variables influencing Man's abilities	Variables influenced by Man's abilities	Description
12	Culture		*Not only wants and abilities of the individual man and of groups of men are affected by culture.*

Comments:

- The variable "Human capacity" is defined as the *Human ability or capability*. When comparing this definition of the variable "Man's abilities" it appears that the variables "Man's abilities" and "Human capacity" both indicate the capability of mankind. Consequently, these variables can be combined into one, which will be "Human capacity".

Changes to the initial causal relation diagram:

- Combination of the variables "Man's abilities" and "Human capacity" into the variable "Human capacity"

7.11 Mental abilities

Dictionary definition mental:

1. *"Of or relating to the mind, intellectual:*
2. *Executed or performed by the mind; existing in the mind."* ("Free Dictionary," n.d.).

Dictionary definition ability:

1. *"The quality of being able to do something, especially the physical, mental, financial, or legal power to accomplish something.*
2. *A natural or acquired skill or talent.*
3. *The quality of being suitable for or receptive to a specified treatment; capacity"* ("Free Dictionary," n.d.)

Definition Mental abilities: The qualities, skills or talents to accomplish something by use of or related to the mind.

Table 68 Mental abilities

page	Variables influencing Mental abilities	Variables influenced by mental abilities	Description
120		Resource appraisal	*Moreover, if resources are merely expressions of the human appraisal of nature, how can the human element be eliminated from the resource concept? For human appraisal depends as much man's objectives and upon his mental and physical abilities, his general capacity to make use of his environment, as upon the nature of the environment.*

Comments:

- Mental abilities are part of Man's abilities. It indicates the abilities of man accomplished by the mind. However, these are still Ma's abilities and there could l be placed under the variable "Man's abilities", in order to simplify the diagram.
- When observing the relation of "Mental abilities" on "Resource appraisal", it shows that this relation does not only include the variable "Mental abilities" of human beings, but also includes the variable "Physical abilities" of the human beings. Since man does not have any other abilities than the mental and physical abilities, the variable "Man's abilities" should present both of these two types of abilities. Therefor and in order to simplify the diagram, these two kinds of abilities may be summarized into the variable "Man's abilities", which then represents all man's abilities.
- Since the variable "Man's abilities" does not indicate anything different than the variable "Human capacity" both the variables "Mental abilities" and "Physical abilities" will be placed under the variable "Human capacity.

Changes to the initial causal relation diagram:

- Combination of the variables "Mental abilities" and "Physical abilities" with/into the variable "Man's abilities", which is already combined with the variable "Human capacity".

7.12 Physical abilities

Dictionary definition physical:

1. *"Of or relating to the body as distinguished from the mind or spirit.*
2. *Involving or characterized by vigorous bodily activity. "*("Free Dictionary," n.d.)

Dictionary definition ability:

1. *"The quality of being able to do something, especially the physical, mental, financial, or legal power to accomplish something.*
2. *A natural or acquired skill or talent.*

3. *The quality of being suitable for or receptive to a specified treatment; capacity"* ("Free Dictionary," n.d.).

Definition Physical abilities: The qualities, skills or talents to accomplish something by use of or related to the body.

Table 69 Physical abilities

page	Variables influencing physical abilities	Variables influenced by Physical abilities	Description
120		Resource appraisal	*Moreover, if resources are merely expressions of the human appraisal of nature, how can the human element be eliminated from the resource concept? For human appraisal depends as much man's objectives and upon his mental and physical abilities, his general capacity to make use of his environment, as upon the nature of the environment.*

Comments:

- See comments "Mental abilities"

Changes to the initial causal relation diagram:

- Combination of the variables "Mental abilities" and "Physical abilities" with/into the variable "Man's abilities", which is already combined with the variable "Human capacity".

7.13 Human mind

Dictionary definition mind: *"The human consciousness that originates in the brain and is manifested especially in thought, perception, emotion, will, memory, and imagination* ("Free Dictionary," n.d.).

Definition Human mind: The human consciousness developed in the brain which presents itself in thoughts, perceptions and actions.

Table 70 Human mind

page	Variables influencing Human mind	Variables influenced by Human mind	Description
120		Organization society	*Any change therefore, which goes on in the human mind, which affects the organization of society, which influences the aims of resource utilization, injects into the resource aspects of nature a human element which is inseparable from it.*

Comments: -

Changes to the initial causal relation diagram: -

7.14 Human effort

Dictionary definition effort: *"The use of physical or mental energy to do something; exertion."* ("Free Dictionary," n.d.)

Definition Human effort: The physical or mental energy put into a subject by man.

Table 71 Human effort

page	Variables influencing Human effort	Variables influenced by Human effort	Description
8		Want satisfaction	*Within these limits he is free to select from the myriad possibilities offered by nature those which at a given and place promise the best results in terms of want satisfaction in return for the human effort applied there to.*

Comments: -

Changes to the initial causal relation diagram: -

7.15 Human behavior and effort

Dictionary definition effort: *"The use of physical or mental energy to do something; exertion"* ("Free Dictionary," n.d.).

Dictionary definition behavior:

1. *"The manner in which one behaves.*
2. *The actions or reaction of person or animal to external or internal stimuli"* ("Free Dictionary," n.d.).

Definition Human behavior and effort: The energy put into a subject and the related actions or reactions of man.

Table 72 Human behavior and effort

page	Variables influencing Human behavior and effort	Variables influenced by Human behavior and effort	Description
7		Evolvement resources	*Resources are living phenomena, expanding and contracting in response to human effort and behavior.*
7		Depletion/ demolishment resources	*" "*

Comments:

- Since human effort is part in the variable "Human behavior and effort" it makes sense to place the variable "Human effort" under the variable "Human behavior and effort.

Changes to the initial causal relation diagram: -

- Combination of the variables "Human effort" and **"**Human behavior and effort" into the variable " Human behavior and effort"

7.16 Human productive effort

Dictionary definition productiveness: *"Effective in achieving specified result; originative"* ("Free Dictionary," n.d.).

Definition Human productive effort: The effectiveness of human energy and actions devoted to a specific subject.

Table 73 Human productive effort

page	Variables influencing Human productive effort	Variables influenced by Human productive effort	Description
11	Arts		*The physical environment appraised both quantitatively and viewed as changing relationships of trends and forces rather than as static conditions, therefore is at all times the foundation of human productive effort. Arts, no matter how highly developed, and wants, no matter how urgent or sophisticated, are helpless in a vacuum. Without acting on and drawing from physical nature they are unproductive.*
11	Wants		*" "*
11	Physical environment		*The physical environment appraised both quantitatively and viewed as changing relationships of trends and forces rather than as static conditions, therefore is at all times the foundation of human productive effort.*

Comments:

- The variable "Human productive effort" indicates the effectiveness of the variable "Human behavior and effort".
- However, it could be considered to combine the variables "Human effort" and "Human productive effort", since in the relation presented above reasons about the productive effort, as the effective part of human effort, though this effective part can still be considered as human effort.
- Since it would make the causal relation diagram easier to understand, the variable "Human effort" and "Human productive effort" will be combined.
- Since the variable "Human effort" is already combined with the variable "Human behavior and effort", the variable "Human productive effort" will be combined with "Human behavior and effort".

Changes to the initial causal relation diagram: -

- The combination of the variable "Human effort" and "Human productive effort" in the variable "Human effort".
- The variable "Human effort" is combined with the variable "Human effort and behavior" into the variable "Human effort and behavior".

7.17 Human actions

Definition Human actions: The things done by humans.

Table 74 Human actions

page	Variables influencing Human actions	Variables influenced by Human actions	Description
15		Evolvement resources	*Resources are not, they become: they are not static but expand and contract in response to human wants and human actions.*
15		Depletion/ demolishment resources	*" "*

Comments:

- As stated before, there variables "Business enterprise" and "Governmental policy" are also considered actions according to Zimmerman. In order to underline their remarkability and influence as human actions, these variables are not placed under the variable "Human actions".

Changes to the initial causal relation diagram: -

7.18 Crystallized human thought

Dictionary definition crystalized: *"To give a definite, precise, and usually permanent form to "* ("Free Dictionary," n.d.).

Definition Crystallized human thought: Precise and definite thoughts of mankind established by advanced communication.

Table 75 Crystallized human thought

page	Variables influencing Crystallized human thought	Variables influenced by Crystalized human thought	Description
122		Cultural adaption	*Thus communication becomes a vital factor in the development of the psychosocial environment. As communication advances from the halting and unsatisfactory level of gestures and sign language to the higher level of written, including printed, language, when books and libraries come into vogue, cultural adaption comes progressively more under the influence of established crystalized human thought and seeks adjustments not to nature directly, but to a growing accumulation of previous human reactions to experiences in life.*
122	Communication		*" "*

Comments:

- It could be reasoned that precise and definite human thoughts are part of the human mind.
- However, in this case the effect of the precise thoughts creates a different effect than the variable "human mind" since it is an important aspect in the cultural adaption. Furthermore the relation between advanced communication and the crystalized human thought implies that the crystallized human thought is something different than the 'average' human mind.

Changes to the initial causal relation diagram: -

7.19 Human ingenuity

Dictionary definition ingenuity: *"Inventive skill or imagination; cleverness."* ("Free Dictionary," n.d.)

Definition Human ingenuity: The human cleverness and skills which enable inventions.

Table 76 Human ingenuity

page	Variables influencing Human ingenuity	Variables influenced by Human ingenuity	Description
9		Man's resources	*The bulk of MAN's resources are the result of human ingenuity aided by slowly, patiently, painfully acquired knowledge and experience.*

Comments:

- It could be reasoned that the human ingenuity, Man's inventive skills, are part of the human capacity. However, in the variable "Human ingenuity" the inventive character of the human capacity is highlighted, and therefore indicates a special aspect of the human capacity. Since, this aspect is considered important and may not be directly associated with the variable "Human capacity" the variable 'Human ingenuity' will not be combined with the variable "Human capacity".

Changes to the initial causal relation diagram: -

7.20 Experience

Dictionary definition experience:

1.

a. "Active participation in event or activities, leading to the accumulation of knowledge or skill.

b. The knowledge or skill so derived

2.

a. An event or a series of events participated in or lived through

b. The totality of such events in the past of an individual or group." ("Free Dictionary," n.d.)

Definition Experience: The knowledge of skills derived after the participation or live through of certain events as a group or as an individual.

Table 77 Experience

page	Variables influencing Experience	Variables influenced by Experience	Description
9		Man's resources	*The bulk of MAN's resources are the result of human ingenuity aided by slowly, patiently, painfully acquired knowledge and experience.*

Comments: -

Changes to the initial causal relation diagram: -

7.21 Accumulation human reactions to experience

Dictionary definition accumulation: *"The process of collecting together or becoming collected".* ("Free Dictionary," n.d.)

Definition Accumulation human reactions to experience: The sum of human reactions on experiences.

Table 78 Accumulation Human reactions to experience

page	Variables influencing Accumulation human reactions to experience	Variables influenced by Accumulation human reactions to experience	Description
122		Cultural adaption	*Thus communication becomes a vital factor in the development of the psychosocial environment. As communication advances from the halting and unsatisfactory level of gestures and sign language to the higher level of written, including printed, language, when books and libraries come into vogue, cultural adaption comes progressively more under the influence of established crystalized human thought and seeks adjustments not to nature directly, but to a growing accumulation of previous human reactions to experiences in life.*

Comments:-

Changes to the initial causal relation diagram: -

7.22 Reactions/adaptions diverse environments

Dictionary definition adaption: *"An alteration or adjustment in structure or habits, by which a specie or individual improves its condition in relationship to its environment.* ("Free Dictionary," n.d.)

Definition Reactions/adaptions diverse environments: The adjustments and reactions of men to adapt to diverse environments.

Table 79 Reactions/adaptions diverse environments

page	Variables influencing Reactions/ adaptions diverse environments	Variables influenced by Reactions/ adaptions diverse environments	Description
123		Culture	*Man, women and children live in social groups that develop their own cultures in separate culture areas. These cultures having evolved out of reactions and adaptions to diverse environments differ as these environments differ.*

Comments:

- The definition of the variable “Direct adaption to nature” has been presented as: “The direct adjustments done by man to get adapted to his environment.” The difference between the variable “Reactions/adaptions diverse environments” and the variable “Adaption to nature” is that the variable “Reactions/adaptions diverse environments” also includes the reactions to nature and not just the adaptions. However, a reaction may be seen as part of an adaption; it may be considered as the premier stage before the adaption or as an activity which may be part of the adaption.
- Since the relation between the variable “Reactions/adaptions diverse environments” and “Culture” indicates the adaption to the environment which results in the development of culture, it appears that this adaption considers a direct adaption to the environment. It does not consider adaptions to previous experiences or institutions. Therefore, it seems that the variables “Reactions/adaptions diverse environments” and “Direct adaption to nature” implicate the same, the adjustments of man to get adapted to his environment, for which reactions are part of this adaption process.
- Furthermore, it appears that the meaning of the relation with the variable “Culture” would not change if the variable “Reactions/adaptions diverse environments” would be replaced by the variable “Direct adaption to nature”. The relations would still indicate that culture evolves out of the adaption of human beings to their environment. The term ‘reactions’ would not create new or significant information which would be of importance for the understanding of the development of culture out of adaptions to nature.
- Therefore it appears valid to combine the variables “Reactions/adaptions diverse environments” with the variable “Direct adaption to nature”.

Changes to the initial causal relation diagram:

- The combination of the variable “Reactions/adaptions diverse environment” and “Direct Adaption to nature” into the variable “Direct adaption to nature”

7.23 Confidence Man in finding new energy resources

Dictionary definition confidence: *“Trust or faith in a person or thing”*(“Free Dictionary,” n.d.)

Definition Confidence man in finding new energy resources: Man’s trust in finding new energy resources.

Table 80 Confidence man in finding new energy resources

page	Variables influencing Confidence man in finding new energy resources	Variables influenced by Confidence man in finding new energy resources	Description
57	Discovery ways of tapping new and inexhaustible fuels		*So great is the confidence of modern industrial man in his own capacity to create resources, to discover ways and means of tapping new sources of energy, or finding treasure chests buried more deeply than that containing the fossil fuels that he insists on keeping up the exhausting pace of fuel use. If, as seems possible, an increasing share of the vast energies now derived from exhaustible fuels is used to discover ways of tapping new and inexhaustible energies that confidence may well be justified.*
57		(Exhausting)fuel use	*" "*

Comments:-

Changes to the initial causal relation diagram: -

7.24 Human impact or interference

Dictionary definition impact: *"The effect or impression of one thing on another."* ("Free Dictionary," n.d.)

Dictionary definition interference: *"The act or an instance of hindering, obstructing or impeding."* ("Free Dictionary," n.d.)

Definition Human impact or interference: The effect or hinder of human beings on nature.

Table 81 Human impact or interference

page	Variables influencing Human impact or interference	Variables influenced by Human impact or interference	Description
83		Natural-cultural resistances	*Similarly one may make a distinction between primary or original natural resistances and secondary or derived natural resistances, i.e. those that are the result of human interference with or impact on nature. The latter may be properly referred to as natural-cultural resistances.*

Comments: -

Changes to the initial causal relation diagram: -

8. Inventions

8.1 Inventions and discoveries

Dictionary definition invention: *"A new device, method or process developed from study and experimentation".* ("Free Dictionary," n.d.)

Dictionary definition discovery: *"The act or an instance of discovering*" ("Free Dictionary," n.d.).

Definition Invention and discoveries: Something new discovered and/or developed from study and experimentation which serves a certain goal.

Table 82 Inventions

page	Variables influencing Inventions	Variables influenced by Inventions	Description
3		Nature's opportunities	*Then with the great discoveries and inventions there came a time of great change. The white race experienced an amazing expansion of opportunities. It was an age of empire building and colonizing, of swarming into wide-open spaces, but also an age of new industries, of new and better uses for what nature had to offer.*
34	Social conditions		The theory that inventions *are the results of social conditions is supported by the fact when the need for an invention is felt simultaneously in several places, similar inventions are the rule rather than the exception.*
35	Necessity		*For countless ages men improved his arts reluctantly, only under dire pressure. "Necessity is the mother of invention" became a commonly accepted truth.*
35		Improvement of arts	*That in the beginning progress should be slow seems only natural. It should always be kept in mind that the first invention is infinitely more difficult than those that are based upon it. For countless ages men improved his arts reluctantly, only under dire pressure. "Necessity is the mother of invention" became a commonly accepted truth.*
36	Earlier inventions		*The inventor of today stands on the shoulders of his predecessors and they, in*

			turn, reaped the benefits of past performances (p36). Every invention can be done, because of earlier inventions. Moreover, in the current times, inventions are faster wide spread and therefore *fall on fertile ground. (p36)*
139		Efficient transportation system	*Every invention and every discovery which make transportation and communication more efficient and therefore cheaper, mean most to that country which is most dependent on efficient transportation.*
139		Efficient communication system	*" "*

Comments: -

8.2 Earlier inventions

Dictionary inventions: *A new device, method or process developed from study and experimentation"* ("Free Dictionary," n.d.).

Definition Earlier inventions: Something which was previously new developed from study and experimentation which serves a certain goal and upon which other inventions may be built.

Table 83 Earlier inventions

page	Variables influencing Earlier inventions	Variables influenced by Earlier inventions	Description
36		Inventions	*The inventor of today stands on the shoulders of his predecessors and they, in turn, reaped the benefits of past performances (p36).* Every invention can be done, because of earlier inventions. Moreover, in the current times, inventions are faster wide spread and therefore *fall on fertile ground.*

Comments:

- Earlier inventions indicate those inventions which were developed previous of the current inventions. However, there will always be earlier inventions, because every invention done today will continue and may be based on those inventions done in the past.
- Moreover, these earlier inventions also started as inventions, they were not defined as 'Earlier inventions' when achieved. Furthermore, the inventions of today will become the 'earlier inventions' of the future.
- So, both the variable "Earlier inventions" and "Inventions" indicate inventions, but it depends on the time frame in which they are placed if they are "Earlier inventions "or "Inventions".

- In order to simplify the diagram and also considering the meaning of the variables "Inventions" and "Earlier inventions", these two variables will be combined into the variable "Inventions" which implicates something new or discovered.

Changes to the initial causal relation diagram:

- The combination of the variables "Inventions and discoveries" and "Earlier Inventions" into the variable "Inventions and discoveries"

8.3 Discovery ways of tapping new and inexhaustible fuels

Dictionary definition discovery: *"The act or an instance of discovering"*("Free Dictionary," n.d.)

Definition Discovery ways of tapping new and inexhaustible fuels: The discovery of possibilities in order to exploit new and inexhaustible fuels.

Table 84 Discovery ways of tapping new and inexhaustible fuels

page	Variables influencing Discovery ways of tapping new and inexhaustible fuels	Variables influenced by Discovery ways of tapping new and inexhaustible fuels	Description
57	Continuation peace		*So great is the confidence of modern industrial man in his own capacity to create resources, to discover ways and means of tapping new sources of energy, or finding treasure chests buried more deeply than that containing the fossil fuels, that he insists on keeping up the exhausting pace of fuel use. If, as seems possible, an increasing share of the vast energies now derived from exhaustible fuels is used to discover ways of tapping new and inexhaustible energies that confidence may well be justified. Much will depend on the continuation of peace.*
57	Exhausting fuel use		" "
57		Confidence in finding new energy sources	" "

Comments:

- The variable "Discovery of ways to tap new and inexhaustible fuels" may be seen as the discovery and developments of new things, also named referred to as an invention. Since an invention can be a new process, device or method to achieve certain goal, the variable "Discovery ways of tapping new and inexhaustible fuels", implicates the inventions related to new and inexhaustible fuels. Even though, it related to a specific type of inventions, it still implicates to the process of inventions.

- However, since the framework will be used to analyze the development of a ‘new’ fuels, such as shale gas, this variable will for now be maintained in the diagram, since it could provide information which would not be associated with just the variable “Inventions” .

Changes to the initial causal relation diagram:-

8.4 Miraculous achievements

Dictionary definition achievement: *“Something that has been accomplished, especially by hard work, ability, or heroism.”* (“Free Dictionary,” n.d.)

Dictionary definition miraculous: *“So astounding as to suggest a miracle; phenomenal”* (“Free Dictionary,” n.d.).

Definition Miraculous achievements: An astounding or phenomenal accomplishment.

Table 85 Miraculous achievement

page	Variables influencing Miraculous achievements	Variables influenced by Miraculous achievements	Description
122	Indirectness(= gap between first impression and first reaction)		*This increased indirectness, this widening of the gap between first impression and final reaction, logically leads, on the top level of derivative control and institutions, to the miraculous achievements of an Einstein on the one hand, and to the confusion of the human mind so characteristic for the modern age.*

Comments:

- The variable “Miraculous achievement” indicates a very special and rare achievement. However, it indicates an invention, something new or discovered.
- The relation present in the table indicates that indirectness could create achievements and inventions as well as confusion. When the variable “Indirectness (= gap between first impression and first reaction)” would lead to the variable “Invention” instead of to the variable “Miraculous achievement” the relation would still imply that indirectness could lead to new and smart things. However, it would also indicate that less miraculous innovations could also be done, due to indirectness. Since, it is assumed, this indeed is true, it seems possible to combine the variables “Miraculous achievements” and “Inventions and discoveries”
- So, in order to simplify the diagram, the variable “Miraculous achievements” will be placed under the variable “Inventions and discoveries”.

Changes to the initial causal relation diagram:

- The combination of the variable "Miraculous achievements" with the variable "Inventions and discoveries" into the variable "Inventions and discoveries".

9. Transport

9.1 Improved transportation system

Dictionary definition transport: *"To carry from one place to another, convey"* ("Free Dictionary," n.d.).

Dictionary definition system: *"A group of interacting, related, or interdependent element forming a complex whole"* ("Free Dictionary," n.d.).

Definition Improved transportation system: Improvements done in the group of the interacting elements which carry or convey things from one place to another.

Table 86 Improved transportation system

page	Variables influencing Improved transportation system	Variables influenced by Improved transportation system	Description
12		Increased human contact	*Improved means of communication and transportation bring always wider strata of humanity into contact.*
111-112		Weight overhead burden	*Every improvement in technique- and one might add in the management- of transportation and communication reduces the space handicap, lowers the weight of the overhead burden, and thus brings us closer to the optimum.*
111-112, 139		Space handicap	*Every improvement in technique- and one might add in the management- of transportation and communication reduces the space handicap. (p111-112) Since excessive space is one great handicap under which North America labors, and since that handicap can be neutralized through improved transportation and communication, it follows that every improvement of the arts , every invention and every discovery which make transportation and communication more efficient and therefore cheaper, mean most to that country which is most dependent on efficient transportation. (p139)*

Comments:

- Zimmerman does not state how the improvements in the transportation system are accomplished. However in follow up on his theory, the improvements in the transportation system can be accomplished by the improvements in arts, since arts are the starting point of new developments. Therefore, it would be useful to add the relation between the “Improvements in arts” and “Improvement transportation system”.
- Furthermore, when the transportation system would be improved, the population’s mobility would increase. Also, this relation is not literally stated but would be valid to add to the diagram. Therefore, this relation will be added.

Changes to the initial causal relation diagram:

- Adding of the relation between “Improvements of arts” to “Improvement of transportation system”.
- Adding of the relation between “Improvement transportation system” to “Mobility of population”.

9.2 Transportation system

Dictionary definition transport: *“To carry from one place to another, convey”* (“Free Dictionary,” n.d.).

Dictionary definition system: *“A group of interacting, related, or interdependent element forming a complex whole”* (“Free Dictionary,” n.d.).

Definition Transportation system: The interacting elements to carry or convey things from one place to another.

Table 87 Transportation system

page	Variables influencing Transportation system	Variables influenced by Transportation system	Description
138		Space handicap	Based on the story of Otis Smith and H. Quick, Zimmerman refers to America as an experiment in transportation. With their transport system they have overcome their handicap of the excess of space.
139		Required machine resources	According to Zimmerman America is not yet on its optimum, because of the burden that transport still puts on the country. This burden relates to the required transportation system and its required amount of energy and machine resources.
139		Required amount of energy	" "

Comments:

- The presence of the transport section in the causal relation diagram may be subject to discussion. This because Zimmerman reasons from an American angle concerning transport, which reduces the generalization possibilities of the causal relation diagram and the final framework for other countries. However, since for every country in the world, no matter how small the country is, transport has become very important, also between the different countries, the variables which Zimmerman introduces concerning transport will be maintained in the causal relation diagram. However, it is attempted to only use the variables, relations and information which may be generalized to other countries and situations.

Changes to the initial causal relation diagram:-

9.3 Pipelines/railroads/highways/automobiles

Definition Pipelines/railroads/highways/automobiles: Pipelines/railroads/highways/automobiles

Table 88 Pipelines/railroads/highways/automobiles

page	Variables influencing Pipelines/railroads/highways/automobiles	Variables influenced by Pipelines/railroads/highways/automobiles	Description
138		Space handicap	*Railroads, and highways, automobiles and pipelines, telephones and power transmission lines are the means of overcoming the space handicap and of creating prosperity in spite of excessive space.*

Comments:

- The variable "Pipelines/railroads/highways/automobiles" presents (part of) the transportation system. This variable presents the elements of the transportation system which carry or convey things to another place. Therefore, the transportation system could also represent this variable, however in a less detailed manner.
- The relation with the variable "Space handicap" would still imply the same, when the variable "Pipelines/railroads/highways/automobiles" will be replaced with the variable "Transportation system". The relation would still imply that the transportation system is able to reduce the space handicap. However, the specific elements of the transportation system will then not be named in the relation with variable "Space handicap".
- Therefore, in order to simplify the diagram, it seems valid to place the variable "Pipelines/railroads/highways/automobiles" under the variable "Transportation system".

Changes to the initial causal relation diagram:

- The placement of the variable “Pipelines/railroads/highways/automobiles” under the variable “Transportation system”.

9.4 Efficient transportation system

Dictionary definition efficient: *“Functioning or producing effectively and with the least waste of effort; competent”* (“Free Dictionary,” n.d.).

Definition transportation system: The interacting elements to carry thing from one place to another.

Definition Efficient transportation system: The interacting elements to carry or convey things effectively from one place to another.

Table 89 Efficient transportation system

page	Variables influencing Efficient transportation system	Variables influenced by Efficient transportation system	Description
139	Improvement of arts		*Since excessive space is one great handicap under which north America labors, and since that handicap can be neutralized through improved transportation and communication, it follows that every improvement of the arts, every invention and every discovery which make transportation and communication more efficient and therefore cheaper, mean most to that country which is most dependent on efficient transportation.*
139	Inventions and discoveries		""
139		Transportation costs	" "

Comments:

- Looking at the sentence in which Zimmerman uses the variable “Efficient transportation system”, it appears that he indicates the same with an improved transportation system as with an efficient transportation system, namely a transportation which is better than the current and which operates an in more (costs) effective way. Moreover, improving the efficiency and thereby minimizing the required costs can be also seen as an improvement. This indicates that an efficient transportation system can also be considered as an improved transportation system.
- The reason, that the variable “Efficient transportation system” was not directly included in the diagram under the variable “Improved transportation system” is that an improved transportation could include more than just improvements in efficiency and costs. However,

since an efficient transportation system is a type of an improved system, because the efficiency was developed by improvements of the system and an efficient system cannot be achieved without any improvement, an efficient system also has to be an improved system. Therefore, it seems valid to combine the variables "Improved transportation system" and "Efficient transportation system" into the variable "Improved transportation system".

- When the variable "Efficient transportation system" is combined with the variable "Improved transportation system", the variable "Improvements of arts" will be of influence on the variable "Improved of transportation system" because of the relation between the "Improvement of arts" and the variable "Efficient transportation system". The addition of this relation was already suggested in the section on the variable "Improved transportation system". However, due to the combination of the variables "Efficient transportation system" and "Improvements transportation system" this relation does not have to be added anymore.

Changes to the initial causal relation diagram:

- Combination of the variable "Efficient transportation system" with the variable "Improved transportation system" into the variable "Improved transportation system"

9.5 Transportation costs

Definition Transportation costs: Costs involved with the transportation of substances.

Table 90 Transportation costs

page	Variables influencing Transportation costs	Variables influenced by Transportation costs	Description
138	Space		*There is no gainsaying that an excess of space is one of the greatest luxuries, one of the most expensive possessions which a country may boost. (p138) The pulse of economic and social life would beat quicker, and much effort, time, and wealth could be saved if short direct connections could replace the circuitous journeys necessary at present.*
139	Excessive population density		*Excessive population density necessitates heavy transportation expenditure at least as much as does excessive sparsity, though for different reasons.*
139	Efficient transportation system		*It follows that every improvement of the arts, every invention and every discovery which make transportation and communication more efficient and therefore cheaper mean most to that country which is most dependent on efficient transportation.*

Comments: -

Changes to the initial causal relation diagram:-

9.6 Transportation time

Definition Transportation time: The amount of time needed to transport substances from one location to another.

Table 91 transportation time

page	Variables influencing Transportation time	Variables influenced by Transportation time	Description
138	Space		*The pulse of economic and social life would beat quicker, and much effort, time, and wealth could be saved if short direct connections could replace the circuitous journeys necessary at present*

Comments: -

Changes to the initial causal relation diagram:-

10. Economy

10.1 Economy

Dictionary definition economy: *"The system or range of economic activity in country, region, or community"*("Free Dictionary," n.d.).

Dictionary definition economics: *"The complex of human activities concerned with the production, distribution, and consumption of goods and services"* ("Free Dictionary," n.d.).

Definition Economy: System of human activities considering the production, distribution and consumption of commodities and services.

Table 92 Economy

page	Variables influencing Economy	Variables influenced by Economy	Description
14		Complexity social order	*Another source of trouble is the growing complexity of social order. As nations increase in size, as economies become more elaborate, and as global interdependence grows, the task of "living together well", of good neighborliness, of The Good Society, grows more difficult and the pitfalls become more numerous and deeper.*

Comments: -

Changes to the initial causal relation diagram:-

10.2 Business enterprise

Dictionary definition business enterprise:

1. *"A business organization*
2. *Industrious, systematic activity, especially when directed toward profit."* ("Free Dictionary," n.d.)

Definition Business enterprise: A business organization which is accounted with activity directed to profit.

Table 93 Business enterprise

page	Variables influencing Business enterprise	Variables influenced by Business enterprise	Description
15		Depletion/ demolishment of resources	*All of these examples prove the same basic fact: resources* <u>*are*</u> *not, they* <u>*become:*</u> *they are not static but expand and contract in response to human wants and human actions. In these examples, two forms of human actions were prominent: technics and business enterprise.*
15		Evolvement resources	*" "*

Comments:

- The variable "Business enterprise" has been posed as an example of human activities by Zimmerman. Therefore, it would be possible to develop the variable "Human activities" which would also represent the variable "Technology" (provided in the statement as *technics)* and "Governmental policy".
- However, since it may be unclear what kind of activities may be located under the variable "Human activities" and since these types of human activities were important and significant in the development and functionality of resources, the variables which represent these examples, such as the variable "Business enterprise", will be maintained in the causal relation diagram, even though the diagram could be simplified by replacing these variables with the variable "Human actions".

Changes to the initial causal relation diagram:

10.3 Determination profitability

Dictionary definition Determination: *"The act of making or arriving at a decision."*("Free Dictionary," n.d.)

Definition Determination profitability: The process of arriving at a decision about the profit yield of a substance or process.

Table 94 Determination profitability

page	Variables influencing Determination profitability	Variables influenced by Determination profitability	Description
17		Resource appraisal	*The appraisal of resources proceeds from:* *1. The knowledge of facts of nature and culture to* *2. The determination of technical feasibility to* *3. The determination of profitability* *4. The formulation of the grand strategy along socio-economic lines.*

Comments: -

Changes to the initial causal relation diagram:-

10.4 Formulation of grand strategy along socio economic lines

Definition Formulation of grand strategy along social-economic lines: The formulation of the overarching strategy in the social economic area.

Table 95 Formulation grand strategy

page	Variables influencing	Variables influenced by Determination profitability	Description
17		Resource appraisal	*The appraisal of resources proceeds from:* *1. The knowledge of facts of nature and culture to* *2. The determination of technical feasibility to* *3. The determination of profitability* *4. The formulation of the grand strategy along socio-economic lines.*

Comments: -

Changes to the initial causal relation diagram:-

10.5 Economic process

Dictionary definition economics: *"The complex of human activities concerned with the production, distribution, and consumption of goods and services"* ("Free Dictionary," n.d.).

Definition Economic process: The process which involves the human activities concerned with production, distribution and consumption of commodities and services.

Table 96 Economic process

page	Variables influencing Economic process	Variables influenced by Economic process	Description
21	Basic wants		*These basic wants are the starting point of the economic process and consequently of resource appraisal.*

Comments:

- Since, the definition of “Economy”, is stated as *the System of human activities considering the production, distribution and consumption of commodities and services*, it appears that the difference between the variables “Economy” and “Economic processes” considers the words ‘system’ and ‘processes’. However, since an economy or economic system consists of multiple economic processes, it seems valid to place the variable “Economic processes” under the variable “Economy”.

Changes to the initial causal relation diagram:-

- Placement of the variable “Economic processes” under the variable “Economy”.

10.6 Division of labor

“Prior to the division of labor, man appraised the environment as to its capacity to furnish him directly what he wanted. But after the division of labor separates a group into farmers and craftsmen, the directness of appraisal is partly lost. These functional divisions among individuals belonging to the same community develop into a division of labor among communities; this in time becomes interregional and international. States and nations specialize along agricultural, mining, or manufacturing lines; cities specialize in certain products. Thus wide areas lose their self-sufficiency and become dependent on interregional or international trade for the satisfaction of their wants and the attainment of their objectives. Exchange has raised many goods to “constructive” necessities, they are necessary to get food. *In a money economy, any commodity whose production enables men to men to earn the wages with which to buy the necessities of life is itself a necessity. Steel, coal, road, anything which keeps the wheels of modern world economy going are necessities (p28-29).”*

Definition Division of labor: The segmentation of different kinds of labor.

Table 97 Division of labor

page	Variables influencing Division of labor	Variables influenced by Division of labor	Description
28		Resource appraisal	Three phases deserve special mention because of their revolutionary effect on resource appraisal: The division of labor, the rise of capitalism, the introduction of money.
30		Productive efficiency	*One wonders why intelligent civilized man suffers such a condition, why he allows money thus to warp appraisal and destroy harmony. The explanation is found in the almost incredible stimulus to productive efficiency, furnished by the t of labor, capitalistic production technique and the use of money (or credit).*

Comments:

- One could wonder if it is really necessary to have this variable in the diagram. This because it considers a variable which had a revolutionary effect on resource appraisal. Today, it is not a variable anymore, it is something given, an agreement which (almost) the whole world has agreed to. It has been a significant development in world's history, however, the relevance of this variable in the diagram which should present the theory of Zimmerman, is too low. However, it is interesting back ground information and something which explains why the world functions as it does.
- Also, the information which is provided by the relation with "Productive efficiency" is interesting information on what has happened in the past and which influence it had. However, these variables can be seen as historical and explaining variables and do not seem not be in place in the causal relation diagram. They do not add enough new information concerning the theory of Zimmerman on resources.

Changes to the initial causal relation diagram:

- Removal of the variable "Division of labor".

10.7 Rise of capitalism

"The rise of capitalism: when formerly we wanted to eat, we would hunt or dig something up, now we have to get coal, iron, build farms, make railroad, flower mills and bakeries and banks to finance it. Resource appraisal today must follow this roundabout way of production. This makes us think whether we are more interested in the bread or in making things."(p29).

Dictionary definition capitalism: *"An economic system based on private ownership of the means of production, distribution, and exchange, characterized by the freedom of capitalists to operate or manage their property for profit in competitive advantages."*

Definition Rise of capitalism: The development of an economic system in which the producing, distributing and exchanging elements are in private or companies' possession which are allowed to manage these properties in order to achieve the highest profit.

Table 98 Rise of Capitalism

page	Variables influencing Rise of capitalism	Variables influenced by Rise of capitalism	Description
29		Resource appraisal	Three phases deserve special mention because of their revolutionary effect on resource appraisal: The division of labor, the rise of capitalism, the introduction of money.
30		Productive efficiency	*One wonders why intelligent civilized man suffers such a condition, why he allows money thus to warp appraisal and destroy harmony. The explanation is found in the almost incredible stimulus to productive efficiency, furnished by the division of labor, capitalistic production technique and the use of money (or credit).*

Comments:

- See the comment under the "Division of labor". The same comments can be applied here.

Changes to the initial causal relation diagram:

- Removal of the variable "Rise of capitalism".

10.8 Importance of money

"The increasing importance of money: The most decided break in the straight line of primitive direct appraisal; for money as the medium of exchange greatly facilitates and stimulates the division of labor and as the measure of value, makes the rise of capitalism not only easier but in many cases possible. It discredits abundances and puts scarcity on the throne instead. We find a conflict of interest between the buyer and the seller. The buyer craves abundance, the seller scarcity. Money turns subsistence economy into profit economy, use economy in exchange economy. Each seller would like to see the other sellers crippled and in their efforts by hailstorms and insects pests, if they are farmers, or by strikes and fires if they are manufacturers." (p29)

Definition Importance of money: The significance and influence of the presence of money on the world.

Table 99 Importance of money

page	Variables influencing Importance of money	Variables influenced by Importance of money	Description
29		Resource appraisal	Three phases deserve special mention because of their revolutionary effect on resource appraisal: The division of labor, the rise of capitalism, the introduction of money.
		Productive efficiency	*One wonders why intelligent civilized man suffers such a condition, why he allows money thus to warp appraisal and destroy harmony. The explanation is found in the almost incredible stimulus to productive efficiency, furnished by the division of labor, capitalistic production technique and the use of money (or credit).*

Comments:

- See the comments under the "Division of labor".

Changes to the initial causal relation diagram:

- Removal of the variable "Importance of money".

10.9 Productive efficiency

"One wonders why intelligent civilized man suffers such a condition, why he allows money thus to warp appraisal and destroy harmony. The explanation is found in the almost incredible stimulus to productive efficiency, furnished by the division of labor, capitalistic production technique and the use of money (or credit). For these man is willing to pay the price in terms of conflicting interest and warped appraisal because he finds it cheap in the light of the results achieved. Ten thousand years of civilization have completely changed resource appraisal. All values have become new." (p30)

Dictionary definition efficiency: *"The ratio of the effective or useful output to the total input in any system."*("Free Dictionary," n.d.)

Definition Productive efficiency: The proportion of effective output compared to the ineffective output of production.

Table 100 Productive efficiency

page	Variables influencing Productive efficiency	Variables influenced by Productive efficiency	Description
30	Division of labor		*One wonders why intelligent civilized man suffers such a condition, why he allows money thus to warp appraisal and destroy harmony. The explanation is found in the almost incredible stimulus to productive efficiency, furnished by the division of labor, capitalistic production technique and the use of money (or credit).*
30	Rise of capitalism		" "
30	Importance of money		" "

Comments:

- This variable explains why man has let the factors division of labor, capitalism and money into his life. This is important information to understand why different kinds of labor are done, why capitalism was able to grow and why we use money what the influence of money on society has been and still is. However, as already stated above, these historical developments contain important background information, but are not relevant enough for this diagram. Therefore, this variable does not explain something new or significant on the development and functionality of resources. Due to this reason and in order to simplify the causal relation diagram, this variable will be removed from the causal relation diagram.

Changes to the initial causal relation diagram:

- Removal of the variable “Productive efficiency”.

10.10 Profit motive

Dictionary definition motive: *“An emotion, desire, physiological need, or similar impulse that acts as an incitement to action.”*(“Free Dictionary,” n.d.)

Definition Profit motive: The reason to act derived from the desire to attain profit.

Table 101 Profit motive

page	Variables influencing Profit motive	Variables influenced by Profit motive	Description
35		Improvement of arts	*Hence, we may say that the profit motive, the acquisitive instinct of "business man"- in short, pleonexy, the desire to have more for his own sake- is one of the strongest impulses to improvements of the arts*

Comments: -

Changes to the initial causal relation diagram:-

10.11 Returns social economy

Dictionary definition return: *"To produce or yield (profit or interest) as a payment for labor, investment or expenditure"* ("Free Dictionary," n.d.).

Definition Returns social economy: The yield achieved by means of the social economy.

Table 102 Returns social economy

page	Variables influencing Returns social economy	Variables influenced by Returns social economy	Description
111-112	Nature		*The social economy may be considered subject to the law of diminishing returns. Returns may diminish because of an excess or deficiency or any one factor- nature, culture or man. But the triune interrelation of the factors must never be lost sight of.*
111-112	Culture		" "
111-112	Man		" "

Comments: -

Changes to the initial causal relation diagram:-

10.12 Weight overhead burden

Dictionary definition overhead: *"The operating expenses of a business, including the costs of rent, utilities, interior decoration, and taxes, exclusive of labor and materials"* ("Free Dictionary," n.d.).

Definition Weight overhead burden: The weight of the operating expenses.

Table 103 Weight overhead burden

page	Variables influencing Weight overhead burden	Variables influenced by Weight overhead burden	Description
111-112	Improvement Communication system		*Every improvement in technique- and one might add in the management- of transportation and communication reduces the space handicap, lowers the weight of the overhead burden, and thus brings us closer to the optimum.*
111-112	Improvements transportation system		" "

Comments: -

Changes to the initial causal relation diagram:-

10.13 Required amount of energy

Definition Required amount of energy: The amount of energy required.

Table 104 Required amount of energy

page	Variables influencing Required amount of energy	Variables influenced by Required amount of energy	Description
139	Transportation system		According to Zimmerman America is not yet on its optimum, because of the burden that transport still puts on the country. This burden relates to the required transportation system and its required amount of energy and machine resources.

Comments:

- When looking at the definition of overhead, this also includes utilities. Energy can be considered as a utility. The required amount of energy necessary for the transportation system places a burden on the United States.
- So, it could be stated that the required amount of energy is a part of the variable “Weight overhead burden”. As a result, it may be concluded that that the variable “Required amount of energy” can be relocated under the variable “Weight overhead burden”.

Changes to the initial causal relation diagram:

- The placement of the variable “Required amount of energy” under the variable “Weight overhead burden”.

10.14 Required machine resources

Definition Required machine resources: The necessary amount machine resources.

Table 105 Required machine resources

page	Variables influencing Required machine resources	Variables influenced by Required machines resources	Description
139	Transportation system		According to Zimmerman America is not yet on its optimum, because of the burden that transport still puts on the country. This burden relates to the required transportation system and its required amount of energy and machine resources.

Comments:

- When, again, taking the definition of overhead into account, it is noticed the variable "Required machine resources "could be part of the variable "Weight of overhead burden". This because the required machine resources are also part of the operation expenses of a country.
- However, according to definition of overhead, materials and labor are not part of the overhead. Machine resources could be seen as material. Though in this case it is assumed that with material, building materials such as sand are indicated, and not machines. With this assumption, the variable "Required machine resources" can also be located under the variable "Weight of overhead burden".

Changes to the initial causal relation diagram:

- Placement of the variable "Required machine resources" under the variable "Weight overhead burden"

10.15 Economic life

Dictionary definition economics: *"The complex of human activities concerned with the production, distribution, and consumption of goods and services."* ("Free Dictionary," n.d.)

Definition Economic life: The sum of human activities related to the production, distribution, and consumption of commodities and services.

Table 106 Economic life

page	Variables influencing Economic life	Variables influenced by Economic life	Description
25	National character		*The extent to which the state should interfere in private business s most debatable with regard to such activities affecting vital group assets. The power industry is another case in point. Nations differ widely with regard to their attitude towards this middle zone. Some nations practically absorb it into the province of free individual enterprise, leaving social control only a narrow fringe of public functions. Other nations take the very opposite attitude. Such attitudes are explained partly by historical forces which have molded national character, partly by differences in the actual situation which these nations are facing at a given time.*
25	Actual situation		" "
138	Space		*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways. But there is no gainsaying that an excess of space is one of the greatest luxuries, one of the most expensive possessions which a country may boost.* But the distances are also costly and when looking of the example Australia Zimmerman states: *The pulse of economic and social life would beat quicker, and much effort, time, and wealth could be saved if short direct connections could replace the circuitous journeys necessary at present.*

Comments:

- When the definition of “Economic life” and “Economy” are compared, it is noticed that these variables indicate the same, namely the system/sum of human activities related to the production, distribution and consumption of commodities and services. The only difference can be found in the words Sum and System. However, when looking at the relations in which these variables are involved, it looks like these variables indicate the same and could therefore be combined into one variable. This variable will be “Economy”.

Changes to the initial causal relation diagram:

- Combination of the variables "Economic life", "Economic processes" and "Economy" in the variable "Economy".

10.16 Growth

Dictionary definition growth:

1. *"The development from a lower or simpler to a higher or more complex form; evolution*
2. *An increase, as in size, number, value, or strength, extension or expansion"* ("Free Dictionary," n.d.).

Definition Growth: The development to a more complex, bigger, more valuable or stronger substance.

Table 107 Growth

page	Variables influencing Growth	Variables influenced by Growth	Description
123	Enriched cultures		*These intergroup contacts tend to enrich cultures and help to accelerate their growth.*

Comments: -

Changes to the initial causal relation diagram:-

11. Policy and institutions

11.1 Communism

Dictionary definition Communism: *"A system of government in which the state plans and controls the economy and a single, often authoritarian party holds power, claiming to make process toward a higher social order in which all goods are equally shared by the people"*("Free Dictionary," n.d.).

Definition Communism: A governmental system in which the state is in control and where all goods are equally distributed over the people.

Table 108 Communism

page	Variables influencing Communism	Variables influenced by Communism	Description
6		Safeguarding basic social assets	*Both socialism and communism are resource conscious. Both plan with a view to safeguarding and developing the basic social assets.*
6		Resource consciousness	*" "*

Comments:

- It may be wondered what the influence of a governmental system, such as communism, has on the development of today's resources. Communism has had a tremendous input on the way of thinking and acting of both government and citizens. However, the governmental systems of today often cannot be categorized under, for instance, communism and socialism anymore. Often the governmental systems of today are a mixture of elements of multiple systems. Therefore, it may be wondered, if in these times, when governmental systems cannot be easily labeled anymore, if this variable will still be relevant in the diagram.
- Though, since the influence of communism, grounded in the way of thinking and acting of citizens and government, does, if present, have an important effect on the development and functionality of resources, the variable "Communism" is maintained in the causal relation diagram.

Changes to the initial causal relation diagram:-

11.2 Socialism

Dictionary definition Socialism: *"Any of various of theories or systems of social organization in which the means of producing and distributing goods is owned collectively or by centralized government that often plans and controls the economy"* ("Free Dictionary," n.d.).

Definition Socialism: A system of social organization in which the producing and distributing agencies are possessed by the government which also designs and controls the economy.

Table 109 Socialism

page	Variables influencing Socialism	Variables influenced by Socialism	Description
6		Resource consciousness	*Both socialism and communism are resource conscious. Both plan with a view to safeguarding and developing the basic social assets.*
6		Safeguarding basic social assets	*" "*

Comments:

- As commented under the variable "Communism", it is questionable if these variables describing governmental and social systems should still be included in the diagram, since countries or governmental policies can often not be categorized under one system anymore. Most countries have evolved from one system into a mixture of several. Therefore it may be questioned if these variables should still be included in the diagram.
- Though, due to the important influence of socialism on the way resources are used, the variable will be maintained in the causal relation diagram.

Changes to the initial causal relation diagram:-

11.3 Wise policy

Dictionary definition Policy: *"A plan or course of action, as of a government, political party, or business, intended to influence and determine decisions, actions and other matters"* ("Free Dictionary," n.d.).

Definition Wise policy: A smart and informed course of action of a government in order to influence, to be able to make decisions and to take action.

Table 110 Wise policy

page	Variables influencing Wise policy	Variables influenced by Wise policy	Description
6		Evolvement resources	*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects- such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors.*

Comments:-

Changes to the initial causal relation diagram:-

11.4 Governmental policy

Dictionary definition Policy: *"A plan or course of action, as of a government, political party, or business, intended to influence and determine decisions, actions and other matters"* ("Free Dictionary," n.d.).

Definition Governmental policy: A course of action of a government in order to influence, to be able to make decisions and take action.

Table 111 Governmental policy

page	Variables influencing Governmental policy	Variables influenced by Governmental policy	Description
7		Resource function	*Likewise unfortunate is the tendency to think of resources in terms of a single asset, e.g., coal rather than in terms of the whole complex of substances, forces, conditions, relationships, institutions, policies, etc., which alone help to explain the way coal functions as a resource at a given time and place.*
15		Evolvement resources	*But other forms of human action at times become determinant as resource makers or destroyers, overshadowing the influence of the inventor and the entrepreneur. One of the most important of these is governmental policy.*
15		Depletion/demolishment resources	*" "*

Comments:

- When the definitions of the variables “Wise policy” and “Governmental policies” are compared, it shows that the difference between these definitions considers the fact that the “Wise policy” should be a smart and informed policy while the ‘normal’ policy does not necessarily has this characteristics. Though, one can reason that ‘normal’ governmental policy should also be a wise one. This should be a characteristic of any type of governmental policy. So the term wise, should be abundant.
- However, in this causal relation diagram, it is considered that this ‘normal’ governmental policy is also wise and that it is also perceived wise by all stakeholders. Even though, it may be that in real life this is not always the case.
- So, since it is considered that a governmental policy should always be wise, and that this characteristic is abundant, it can be stated that the variables “Wise policy” and “Governmental policy” both implicate the same, a wise course of action of a government.
- As a result, the variable “Wise policy” will be combined with the variable “Governmental policy”.

Changes to the initial causal relation diagram:

- The combination of the variable “Wise policy” and “Governmental policy” into the variable “Governmental policy”.

11.5 Institutions

Dictionary definition institutions:

1. *"A custom, practice, relationship, or behavioral pattern of importance in the life of a community or society*
2. *An established organization or foundation, especially one dedicated to education, public service, or culture"* ("Free Dictionary," n.d.).

Definition Institutions: The customs, practices, relationships and behavior patterns which are important for a country or organization and specific for that country or organization.

Table 112 Institutions

page	Variables influencing Institutions	Variables influenced by Institutions	Description
7		Resource function	*Likewise unfortunate is the tendency to think of resources in terms of a single asset, e.g., coal rather than in terms of the whole complex of substances, forces, conditions, relationships, institutions, policies, etc., which alone help to explain the way coal functions as a resource at a given time and place.*
12	Culture		*Not only wants and abilities of the individual man and of groups of men are affected by culture but the relationships between men, social organizations, and societal institutes also come under its spell.*
25		National wealth	*National wealth depends, in the first place, on the natural environment itself, on the availability-or utility- of the untransformed aspects of nature. It depends, in the second place, on the arts and institutions to which that environment, in view of the racial and cultural characteristics of that human element, gives rise. Among these, the institutions surrounding population increase are of special importance, for the largess of nature may result either in an ever growing number of people at or near a point of minimum sustenance or in a rising living standard for a restricted number.*
72	Societal Arts		*As a result, foreign trade and the export of capital assume increasing importance*

			and thus broaden the resource basis of mobilized economy. We see, therefore, that the energy basis is truly the foundation of a civilization. It determines the choice of materials which can be utilized, it sets a definite limit to the size of performance, it governs the degree of mobility and, in general, controls the arts societal and technical, and through them shapes the institutions, material and non-material.
72	Technical Arts		" "

Comments: -

Changes to the initial causal relation diagram:-

11.6 Patent laws/institutions

Dictionary patent laws: *"That branch of jurisprudence that studies the laws governing patents"* ("Free Dictionary," n.d.).

Definition Patents laws/institutions: The laws governing patents and the customs, practices, relationships and behavior patterns which are important to a country and which are specific for a country.

Table 113 Patents laws/institutions

page	Variables influencing Patent laws/institutions	Variables influenced by Patent laws/institutions	Description
33		Development arts	*Peculiar nature of a given environment and of specific needs therefore determines the general lines along which the arts develop. Besides differences in environment and needs, differences in attitudes toward material progress and the crystallization of such attitudes in patent laws and similar institutions must be taken into consideration.*
33	Attitudes toward material progress		" "

Comments:

- Zimmerman reasons about "*Patent laws and similar institutions*". With this he implies that patent laws are types of institutions. Since, the patent laws are types of institutions; this would imply that these types of institutions could also be represented by the general term Institutions. The content of the relations would not change if the variable "Patent laws/ institutions" would be replaced by the more general variable “Institutions”. So, the variable “Patent laws/institutions” could be combined with the variable “Institutions” without changing the content of the variable and its relations.

- So, in order to simplify and clarify the diagram the variables “Institutions” and “Patent laws/institutions” will be combined into the variable “Institutions”

Changes to the initial causal relation diagram:

- The combination of the variable “Patent laws/institutions” and “Institutions” into the variable “Institutions”.

11.7 Organization society

Dictionary definition society: *“A group of humans broadly distinguished from other groups by mutual interests, participation in characteristic relationships, shared institutions, and a common culture”* (“Free Dictionary,” n.d.).

Definition Organization society: The formation of a group of human beings, grouped by mutual interests, relationships, institutions and culture.

Table 114 Organizations society

page	Variables influencing Organization society	Variables influenced by Organization society	Description
120	Human mind		*Any change therefore, which goes on in the human mind, which affects the organization of society, which influences the aims of resource utilization, injects into the resource aspects of nature a human element which is inseparable from it.*
120	Aims of resource utilization		" "

Comments: -

Changes to the initial causal relation diagram:-

12. Social

12.1 Social responsibility

Dictionary definition social:

1.

a. “Living together in communities
b. Of or relating to communal living
c. Of or relating to human society and its modes of organization.

2. *Living together in organized groups or similar close aggregates*
3. *Involving all members of a confederacy*
4.
    a. *Inclined to seek out or enjoy the company of other; sociable*
    b. *Spent in or market by friendly relations or companionship*
    c. *Intended for convivial activities*
5. *Of, relating to, or occupied with matter affecting human welfare"* ("Free Dictionary," n.d.).

Dictionary definition responsible:

1. *"Liable to be required to give account, as of one's actions or of the discharge of a duty or trust.*
2. *Involving personal accountability or ability to act without guidance or superior authority'*
3. *Being a source or cause"* ("Free Dictionary," n.d.).

Definition Social responsibility: The accountability and liability for actions which are of influence on the human society.

Table 115 Social responsibility

page	Variables influencing Social responsibility	Variables influenced by Social responsibility	Description
6	Sense of historical perspective		*A rather subtle influence is what may be called a growing sense of social responsibility. This too helps too helps to explain the increased awareness of the basic social assets. This sense of responsibility is probably best explained in terms of a keener sense of historical perspective and a fuller understanding of social processes and phenomena.*
6	Understanding social processes and phenomena		*" "*
6		Safeguarding basic social assets	" "

Comments: -

Changes to the initial causal relation diagram:-

12.2 Social harmony

Dictionary definition Harmony:

1. *"Agreement in feeling or opinion; accord.*
2. *A pleasing combination of elements in a whole"* ("Free Dictionary," n.d.)

Definition Social harmony: A state of being wherein the people, who live in a society, live together in a state of agreement in feeling and opinion.

Table 116 Social harmony

page	Variables influencing Social harmony	Variables influenced by Social harmony	Description
6	Evolvement resources		*One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects- such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors.*

Comments:

- The contribution of this variable may be questioned. The variable provides an example of intangible aspects important for the world and which also form an input for the evolvement of resources.
- Some of these intangible aspects, such as knowledge and wise policies (placed under governmental policies) are already present in the diagram. The others do not influence any other variable than the evolvement of resources. For the simplicity of the diagram, it would be helpful to combine the variables “Social harmony”, “Health”, and “freedom” into the general variable “Intangible aspects”. This variable would also leave room for other intangible aspects, which Zimmerman did not state in this example.

Changes to the initial causal relation diagram:

- The combination of the variables “Social harmony”, “Health” and “Freedom” into the variable “Intangible aspects”.

12.3 Safeguarding basic social assets

Dictionary definition asset: *“A useful or valuable quality, person, or thing, an advantage of resource”*(“Free Dictionary,” n.d.).

Dictionary definition safeguarding: *“To ensure the safety or protect”*(“Free Dictionary,” n.d.).

Definition Safeguarding basic social assets: The protection and preservation of the fundamental and valuable aspects of a human society.

Table 117 Safeguarding basic social assets

page	Variables influencing Safeguarding social basic assets	Variables influenced by Safeguarding social basic assets	Description
6	Communism		*Both socialism and communism are resource conscious. Both plan with a view to safeguarding and developing the basic social assets.*
6	Socialism		" "
6	Social responsibility		*A rather subtle influence is what may be called a growing sense of social responsibility. This too helps too helps to explain the increased awareness of the basic social assets.*

Comments:

- When looking at the statement "*Both socialism and communism are resource conscious. Both plan with a view to safeguarding and developing the basic social assets"* done by Zimmerman, it appears that the variables "Safeguarding basic social assets" and "Resource consciousness" possibly indicate the same thing, namely the alertness and protection of substances which may function as a resource for society. Zimmerman explains the resources conscious character of Socialism and Communism as the safeguarding of basic social assets.
- Even though, resources may be more that 'basic social assets', basic social assets may be resources. So, the safeguarding of basic social assets may be part of the resource consciousness. Therefore it seems valid to combine the variables "Resource consciousness" and "Safeguarding basic social assets" into the variable "Resource consciousness".

Changes to the initial causal relation diagram:

- The combination of the variables "Resource consciousness" and "Safeguarding social assets" into the variable "Resource consciousness".

12.4 Relationships between men

Dictionary definition relationship: *"A particular type of connection existing between people related to or having dealings with each other"* ("Free Dictionary," n.d.).

Definition Relationships between men: The existing connections between members of the human population.

Table 118 Relationships between men

page	Variables influencing Relationships between men	Variables influenced by Relationships between men	Description
7		Resource function	*Likewise unfortunate is the tendency to think of resources in terms of a single asset, e.g., coal rather than in terms of the whole complex of substances, forces, conditions, relationships, institutions, policies, etc., which alone help to explain the way coal functions as a resource at a given time and place.*
12	Culture		*Not only wants and abilities of the individual man and of groups of men are affected by culture but the relationships between men, social organizations, and societal institutes also come under its spell.*

Comments: -

Changes to the initial causal relation diagram:-

12.5 Social organization

Dictionary definition organization: *"Something made of up of elements with varied functions that contribute to the whole and to collective function"* ("Free Dictionary," n.d.).

Definition Social organization: A structured sum of elements which contribute to the human society.

Table 119 Relationships between men

page	Factors influencing Social organization	Variables influenced by Social organizations	Description
12	Culture		*Not only wants and abilities of the individual man and of groups of men are affected by culture but the relationships between men, social organizations, and societal institutes also come under its spell.*

Comments: -

Changes to the initial causal relation diagram:-

12.6 Increased human contact

Definition Increased human contact: An increase in the amount of human beings which are in contact with each other.

Table 120 Increased human contact

page	Variables influencing Increased human contact	Variables influenced by increased human contact	Description
12	Improvement Communication system		*Improved means of communication and transportation bring always wider strata of humanity into contact.*
12	Improvements transportation system		*Improved means of communication and transportation bring always wider strata of humanity into contact.*
123		Blended/alloyed cultures	*During the early stages of human existence, such cultural occurred in airtight compartments. As contacts increased and various group interrelations ensued-submission conquest, merging through intermarriage, etc. –cultures lost some of this pristine simplicity, and blended or alloyed cultures developed. These intergroup contacts tend to enrich cultures and help to accelerate their growth.*

Comments: -

Changes to the initial causal relation diagram:-

12.7 Complexity social order

Dictionary definition order: *"The established system of social organization."* ("Free Dictionary," n.d.)

Definition Complexity social order: The complexity of the system of social organization.

Table 121 complexity social order

page	Variables influencing Complexity social order	Variables influenced by Complexity social order	Description
14	Global interdependence		*Another source of trouble is the growing complexity of social order. As nations increase in size, as economies become more elaborate, and as global interdependence grows, the task of "living together well", of good neighborliness, of The Good Society, grows more difficult and the pitfalls become more numerous and deeper.*
14	Economy		" "
14	Population growth		" "

14		Difficulties "good society"	" "
14		Pitfalls	" "

Comments: -

Changes to the initial causal relation diagram:-

12.8 Living standards

Dictionary definition standards of living: *"A level of material comfort as measured by the goods, services and luxuries available to an individual, group, or nation"* ("Free Dictionary," n.d.).

Definition Living standards: The level of welfare and requirements of a human society.

Table 122 Living standards

page	Variables influencing Living standards	Variables influenced by Living standards	Description
21		Resource appraisal	*The people of the earth differ widely in living standards, and hence in their appraisal of a given environment.*
21	Individual wants/short term		*Individual wants, through established habit and social sanction, tend to crystallize into group standards of living.*

Comments: -

Changes to the initial causal relation diagram:-

12.9 Social conditions

Dictionary definition conditions: *"Existing circumstances"* ("Free Dictionary," n.d.).

Definition Social conditions: The circumstances in a human society.

Table 123 Social conditions

page	Variables influencing Social conditions	Variables influenced by Social conditions	Description
34		Inventions	The theory that inventions *are the results of social conditions is supported by the fact when the need for an invention is felt simultaneously in several places, similar inventions are the rule rather than the exception.*

Comments: -

Changes to the initial causal relation diagram:-

12.10 Social life

Dictionary definition life:

1. *"Living organisms considered as a group.*
2. *Human existence, relationships, or activity in general"* ("Free Dictionary," n.d.).

Definition Social life: The human relationships and activities of a human society.

Table 124 Social life

page	Variables influencing Organization society	Variables influenced by Organization society	Description
138	Space		*The pulse of economic and social life would beat quicker, and much effort, time, and wealth could be saved if short direct connections could replace the circuitous journeys necessary at present.*

Comments: -

Changes to the initial causal relation diagram:-

13. Methods/means/aims

13.1 Means

"Resources were defined as means of attaining given ends, i.e., individual wants and social objectives. Means take their meaning form the ends which they serve. As ends change, means must change also. Thus resources must reflect every change in the purpose of the appraiser."(p11)

Dictionary definition Means: *"A method, a course of action, or an instrument by which an act can be accomplished or an end achieved"* ("Free Dictionary," n.d.).

Definition Means: A method to attain (given) ends.

Table 125 Means

page	Variables influencing Means	Variables influenced by Means	Description
11	Ends		*Means take their meaning form the ends which they serve. As ends change, means must change also.*
17		Ends	*Table 1.1 may give a false impression of a one-way flow from top to bottom, from means to ends. As was pointed out, the process is not one-way. The current flows from ends to means with equal ease.*

Comments:

- From the definition, provided by Zimmerman, means to attain given ends are considered as resources. Therefore it could be considered to place the variable “Means” under the variable “Resources”. However, the variable means does not indicate resources; it indicates a method to attain given ends. If these ends are not present, there are no resources. Therefore, the variable “Means” alone does not imply the same as the variable resources and can therefore not be combined with the variable “Resources”.

Changes to the initial causal relation diagram:-

13.2 Methods

Dictionary definition Methods:

1. *“A means or manner of procedure, especially a regular and systematic way of accomplishing something*
2. *Orderly arrangement of parts or steps to accomplish an end”* (“Free Dictionary,” n.d.).

Definition Methods: A means to accomplish an end.

Table 126 Method

page	Variables influencing Methods	Variables influenced by Methods	Description
54		Resource appraisal	The resource appraisal of our environment depends on our own wants, aims, and methods.

Comments:

- When looking at the dictionary definition of the variable “Method” and the relation in which this variable is used, it seems valid to combine this variable with the variable “Means” into the variable “Methods/Means”.

Changes to the initial causal relation diagram:

- The combination of the variables “Means” and “Methods” into the variable “Methods/means”.

13.3 Aims

Dictionary definition Aims: *“A purpose or intention towards which one’s efforts are directed”* (“Free Dictionary,” n.d.).

Definition Aims: A purpose or goal to which is wanted to be achieved.

Table 127 Aims

page	Factors influencing Aims	Variables influenced by Aims	Description
54		Resource appraisal	*The resource appraisal of our environment depends on our own wants, aims, and methods.*

Comments:

- An aim can be seen as a goal or purpose, in other words, an objective. In the diagram a few variables concerning "Objectives" are already identified. These variables are "Man's objectives" (The goals of the human population) and "Social objectives" (Goals or ends desired by human societies). These two variables are together with the variable "Group wants/long term" (Social wants or objectives desired by the group of which people live in) combined into the variable "Group wants/long term".
- Considering the definitions of the variable "Aims" and the other variables which are combined into the variable "Group wants/long term", it appears that variable "Aims" may be also placed under the combined variable "group wants/long term", since both variables indicate goals and objectives wanted to be achieved.

Changes to the initial causal relation diagram:

- The combination of the variable "Aims" with the variable "Group wants/long term" into the variable "Group wants/long term".

13.4 Aims for resource utilization

Definition Aims for resource utilization: The purposes or goals for the usage of resources.

Table 128 Aims for resource utilization

page	Variables influencing Aims	Variables influenced by Aims	Description
120	Organization society		*Any change therefore, which goes on in the human mind, which affects the organization of society, which influences the aims of resource utilization, injects into the resource aspects of nature a human element which is inseparable from it.*

Comments:

- Since all the variables concerning objectives, aims, and wants, reason about objectives, aims and wants related to resources, it appears the variable "Aims for resources utilization" may also be placed under the variable "Aims". Since all wants and aims are related to resource utilization, this variable does not provide new or significant information. Therefore the variable "Aims for resource utilization" may be combined with the more general variable "Aims". Since, the variable "Aims" was placed under the variable "Group wants/ long term"; the variable "Aims for resources utilization" will also be placed under this variable.

Changes to the initial causal relation diagram:

- The placement of the variable "Aims for resource utilization" under the variable "Aims" which is already placed under the variable "Group wants/long term".

13.5 Ends

"Resources were defined as means of attaining given ends, i.e., individual wants and social objectives." (p11)

Dictionary definition Ends: *"Something toward which one strives, a goal."* ("Free Dictionary," n.d.)

Definition Ends: A goal, want or objective.

Table 129 Ends

page	Variables influencing Ends	Variables influenced by Ends	Description
11		Means	*Means take their meaning form the ends which they serve. As ends change, means must change also.*
11		Resources	*Resources were defined as means of attaining given ends, i.e., individual wants and social objectives. Means take their meaning form the ends which they serve. As ends change, means must change also.*
17	Means		*Table 1.1 may give a false impression of a one-way flow from top to bottom, from means to ends. As was pointed out, the process is not one-way. The current flows from ends to means with equal ease.*

Comments:

- Considering the definition of Ends, and the statement of Zimmerman, it may be concluded that the variable "Ends", can be considered as an objective, goal or want. Zimmerman states that examples of ends are individual wants and social objectives. Therefore this variable may be placed under the same variable under which the variable "Social objectives" is placed. This variable is "Group wants/long term".
- However, since this variable is also defined as individual wants, this variable and its content will also be placed under the variable "Individual wants". This will mean that both the variable "group want/long term" and "individual wants" will be of influence on the variable "Means".

Changes to the initial causal relation diagram:

- The placement of the variable “Ends” under the variable “Group wants/long term”
- The placement of the variable “Ends” under the variable “Individual wants”

13.6 Search for means to attain given ends

“Resources were defined as means of attaining given ends, i.e., individual wants and social objectives. Means take their meaning form the ends which they serve. As ends change, means must change also. Thus resources must reflect every change in the purpose of the appraiser.” (p11)

Definition Search for means to attain given ends: A search for methods to achieve certain goals, i.e. a search for resources.

Table 130 Search for means to attain given ends

page	Variables influencing Search for means to attain given ends	Variables influenced by Search for means to attain given ends	Description
8	Individual wants/short term		*The dictionary definitions show that resources result from an interaction between (1) man (a) searching for means to attain given ends (such as the satisfaction of individual wants and the attainment of group or social objectives) and (b) possessed of the capacity to take advantage of opportunities or to extricate himself from difficulties, and (2) something outside of man which for the time being will be called nature.*
8	Social objectives		" "
8	Group wants/long term		" "
8		Evolvement resources	*The dictionary definitions show that resources result from an interaction between (1) man (a) searching for means to attain given end.*

Comments: -

Changes to the initial causal relation diagram:-

14. External influences

14.1 Closing frontier

“Undoubtedly, one of the events which stirred the American people to resource consciousness and with it to a recognition of the fact business appeared to be neglectful of the basic social assets was the “closing of the frontier” in the sense of the completion of the settlement of the continent the end of free land. The story of Theodor Roosevelt’s eloquent appeal for a conservation policy is too well known to need

recounting. It led to a period of pausing in the mad rush, taking stock, and, in a way, locking the stable after the horse was gone…. With the twentieth century at the half way mark, this early realization of the exhaustibility of the reserves of the earth resources has matured into a cleared and more sober understanding of the facts and their meaning." (p5)

Definition Closing frontier: The discovery and recognition of the frontier and therewith the end of available free land in the American continent.

Table 131 Closing frontier

page	Variables influencing Closing frontier	Variables influenced by Closing frontier	Description
5		Resource consciousness	*Undoubtedly, one of the events which stirred the American people to resource consciousness and with it to a recognition of the fact business appeared to be neglectful of the basic social assets was the "closing of the frontier" in the sense of the completion of the settlement of the continent the end of free land. (p5) Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness.*

Comments:

- The closing of the frontier has had a significant impact on the American history. Therefore Zimmerman describes it in his theory. However, even though such important events/developments should be acknowledged to understand the history of a country, in this causal relation diagram the variable does not provide significant information, since the causal relation diagram is not developed to understand the American history but to understand the development and functionality of resources. This variable is very specific for the American history and could therefore not be used in a causal relation diagram which should be able increase the understanding of the development and functionality of resources in other countries as well. Therefore, the variable should be changed in a more general form. Thus, the variable "Closing of the frontier" will be placed under the more general variable "External influences". This variable will represent the important events in history which are of influence on the development and functionality of resources, though which could hardly be influenced by the government of one country.

Changes to the initial causal relation diagram:

- The placement of the variable "Closing frontier" under the new variable "External influences".

14.2 World wars

Dictionary definition war: *"A state of open, armed, often prolonged conflict carried between nations, states or parties"* ("Free Dictionary," n.d.).

Definition World wars: The armed conflict between several nations of the world.

Table 132 World wars

page	Variables influencing world wars	Variables influenced by Ends	Description
5		Resource consciousness	*A world that has not forgotten two World Wars and is worried over the possibility of a third is bound to be a resource-conscious world. (p3) The two World Wars contributed materially to resource consciousness in many parts of the world and through wide strata of its population. Modern total war calls for total mobilization of resources, and military potential differs from economic potential in little sense but objective. This awareness of the causal nexus between resources and victory continues (p5) Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness.*

Comments:

- A world war is a type of war. Therefore the variable "World wars" could also be placed under the more general variable "War". This variable would then represent all the types of war and is therefore a more general variable than the specific variable "World wars".

Changes to the initial causal relation diagram:

- Placement of the variable "World wars" under the more general variable "War".

14.3 Great depression

Wikipedia definition Great depression: *"The great depression was a sever worldwide economic depression in the decade preceding World war II* ("Wikipedia," n.d.).

Definition Great depression: The worldwide economic depression in the decade before World War II.

Table 133 Great depression

page	Variables influencing Great depression	Variables influenced by Great depression	Description
5		Resource consciousness	Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness.

Comments:

- The great depression is also an important historical 'event' which is of influence on the variable "Resource consciousness". However, the same comments stated for the variable "Closing frontier" are also applicable in this case. Even though this development was very important in the history of the U.S.A., in the causal relation diagram it will be considered as an "External influence" on resources in order to make the causal relation diagram more suitable for generalization purposes in other countries and other times. In the variable "external influences", other variables which may also be of influence in the diagram but which have not been literally stated by Zimmerman may be placed. So, the variable "External influences" will provide a general variable which represent important historical events which hardly be influenced by a single government.

Changes to the initial causal relation diagram:

- Placement of the variables "Great depression" under "External influences"

14.4 Barbarism/civil strife

Dictionary definition Barbarism: *"A brutal, coarse or ignorant act"* ("Free Dictionary," n.d.).

Dictionary definition Civil strife: *"A war between factions or regions of the same countries"* ("Free Dictionary," n.d.).

Definition Barbarism/civil strife: Brutal, coarse or ignorant actions and war between factions or regions.

Table 134 Barbarism/civil strife

page	Variables influencing Barbarism/civil strife	Variables influenced by Barbarism/civil strife	Description
16		Depletion/demolishment resources	*Since the resources at the disposal of man evolve out of the working combination of natural, human and cultural aspects- a combination which expands with every advance of human knowledge and wisdom and contracts with every relapse into the barbarism of war and civil strife.*

Comments:

- Barbarism is often part of wars. Moreover civil strife is a type of war. Therefore these variables could be placed under the more general variable "War". The variable "World wars" is also placed under this variable.

Changes to the initial causal relation diagram:

- The placement of the variable "Barbarism/civil strife" under the variable "War".

14.5 Continuation of peace

Dictionary definition continuation: *"The act or fact of continuing without interruptions; prolongation"*("Free Dictionary," n.d.).

Definition Continuation of peace: The prolongation of peace.

Table 135 Continuation of peace

page	Variables influencing Continuation of peace	Variables influenced by Continuation of peace	Description
57		Discovery ways of tapping new and inexhaustible fuels	*If, as seems possible, an increasing share of the vast energies now derived from exhaustible fuels is used to discover ways of tapping new and inexhaustible energies that confidence may well be justified. Much will depend on the continuation of peace.*

Comments:

- The continuation of peace implies that there is no war. Zimmerman states that the continuation of peace has a positive effect on the "discovery of ways of tapping new and inexhaustible fuels". This statement could also be done in a reversed way, that war has a negative influence on the "Discovery ways of tapping new and inexhaustible fuels".

- The replacement of the variable "Continuation of peace" by the variable "War" and the change of the sign of the relation between the variable "War" and the "Discovery ways of tapping new and inexhaustible fuels" makes sense, since the replacement of variable "Continuation of Peace" by the variable "War" would simplify the diagram and would still imply the same; that war has a negative influence on the discovery of ways and inventions of tapping new and inexhaustible fuels.

Changes to the initial causal relation diagram:

- The combination of the variable "Continuation of peace" with the variable "War" into the variable "War".
- Adding of the negative relation between "War" and the "Discovery ways of tapping new and inexhaustible fuels".

15. Space

15.1 Space

Dictionary definition Space:

1. *"An extent or expanse of a surface or three-dimensional area*
2. *A black or empty area*
3. *An area provided for a particular purpose"* ("Free Dictionary," n.d.).

Definition Space: An (empty) area which can be used for a specific purpose.

Table 136 Space

page	Variables influencing Space	Variables influenced by Space	Description
138		Vision	*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways.*
138		Freedom of motion	*" "*
138		Economic life	*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways. But there is no gainsaying that an excess of space is one of the greatest luxuries, one of the most expensive possessions which a country may boost.* But the distances are also costly and when looking of the example Australia he says *The pulse of economic and social life would beat quicker, and much effort,*

			time, and wealth could be saved if short direct connections could replace the circuitous journeys necessary at present.
138		Widening horizon	*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways.*
138		Social life	*The pulse of economic and social life would beat quicker, and much effort, time, and wealth could be saved if short direct connections could replace the circuitous journeys necessary at present.*
138		Transportation costs	*" "*
138		space handicap	*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways. But there is no gainsaying that an excess of space is one of the greatest luxuries, one of the most expensive possessions which a country may boost.*
138		Transportation time	*The pulse of economic and social life would beat quicker, and much effort, time, and wealth could be saved if short direct connections could replace the circuitous journeys necessary at present.*
138		Vision	*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways.*

Comments: -

Changes to the initial causal relation diagram:-

15.2 Space handicap

Dictionary definition Handicap: *"To cause to be at a disadvantage; impede"* ("Free Dictionary," n.d.).

Definition Space handicap: The disadvantages caused by (the abundance of) space.

Table 137 Space handicap

page	Variables influencing Space handicap	Variables influenced by Space handicap	Description
111-112, 139	Improvement Communication system		*Every improvement in technique- and one might add in the management- of transportation and communication reduces the space handicap. (p111-112) Since excessive space is one great handicap under which north America labors, and since that handicap can be neutralized through improved transportation and communication. (p139)*
111-112, 139	improvements transportation system		*" "*
138	Pipelines/railroads /highways/automobiles		*Railroads, and highways, automobiles and pipelines, telephones and power transmission lines are the means of overcoming the space handicap and of creating prosperity in spite of excessive space.*
138	Space		*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways. But there is no gainsaying that an excess of space is one of the greatest luxuries, one of the most expensive possessions which a country may boost.*
138	Transportation system		With their transport system they overcome their handicap of the excess of space.
139	Optimal population density= man land ratio		*Excessive population density necessitates heavy transportation expenditure at least as much as does excessive sparsity, though for different reasons. It is not maximum density but optimum density which can solve the problem.*

Comments: -

Changes to the initial causal relation diagram:-

16. Communication

16.1 Communication

Dictionary definition Communication: *"The exchange of thoughts, messages, or information, as by speech, signals, writing or behavior"* ("Free Dictionary," n.d.).

Definition Communication: The activity of exchanging information by signs, gestures, written and printed messages.

Table 138 Communication

page	Variables influencing Communication	Variables influenced by Communication	Description
122		Development Psychosocial environment	*Thus communication becomes a vital factor in the development of the psychosocial environment.*
122		Crystallized human thought	*Thus communication becomes a vital factor in the development of the psychosocial environment. As communication advances from the halting and unsatisfactory level of gestures and sign language to the higher level of written, including printed, language, when books and libraries come into vogue, cultural adaption comes progressively more under the influence of established crystalized human thought and seeks adjustments not to nature directly, but to a growing accumulation of previous human reactions to experiences in life.*

Comments: -

Changes to the initial causal relation diagram:-

16.2 Improved communication system

Definition Improved communication system: The advancement of the communication system by means of alterations and improvements.

Table 139 Improved Communication system

page	Variables influencing Improved communication system	Variables influenced by Improved communication system	Description
12		Increased human contact	*Improved means of communication and transportation bring always wider strata of humanity into contact.*
111-112		Weight of overhead burden	*Every improvement in technique- and one might add in the management- of transportation and communication reduces the space handicap, lowers the weight of the overhead burden, and thus brings us closer to the optimum.*
111-112,139		Space handicap	*Every improvement in technique- and one might add in the management- of transportation and communication reduces the space handicap, lowers the weight of the overhead burden, and thus brings us closer to the optimum. (111-112) Since excessive space is one great handicap under which north America labors, and since that handicap can be neutralized through improved transportation and communication, it follows that every improvement of the arts. , every invention and every discovery which make transportation and communication more efficient and therefore cheaper, mean most to that country which is most dependent on efficient transportation. (139)*

Comments: -

Changes to the initial causal relation diagram:-

16.3 Efficient communication system

Dictionary definition efficient: *"Functioning or producing effectively and with the least waste of effort; competent"* ("Free Dictionary," n.d.).

Definition Efficient communication system: A communication system which functions effectively with a low waste of effort.

Table 140 Efficient communication system

Page	Variables influencing Efficient communication system	Variables influenced by Efficient communication system	Description
139	Improvement of arts		*Since excessive space is one great handicap under which north America labors, and since that handicap can be neutralized through improved transportation and communication, it follows that every improvement of the arts , every invention and every discovery which make transportation and communication more efficient and therefore cheaper, mean most to that country which is most dependent on efficient transportation.*
139	Inventions and discoveries		*" "*
139		Transportation costs	*" "*

Comments:

- The relation and definition described above leads to two comments; the fact that an efficient system can be, and often is, the result of an improved communication system and that the variable "Efficient communication system" in this situation is extremely necessary for the United States because of the space handicap which the country has to deal with. Therefore the situation described by Zimmerman is a situation specific for the United States.
- The first comment leads to possibility to combine the variable "Efficient Communication system" with the variable "Improved communication system" into the variable "Improved communication system".
- However, the second comment leads to possibility to exclude the variable "Efficient communication system" from the diagram, since it illustrates the relations of the variable "Efficient communication system" specific for the U.S.A. Though, since an efficient communication system is important for every country in the world in the current times, it is decided to keep the variable "Efficient communication system" However, the variable will not present in its original form but in the combined form under the variable "Improved communication system" since an efficient communication system is often the result from an improved communication system. The system was in most cases not efficient from the start.

Changes to the initial causal relation diagram:

- The combination of the variable "Efficient communication system" with the variable "Improved communication system" into the variable "Improved communication system".

17. Population

17.1 Population growth

Dictionary definition Population: *"The total number of inhabitants constituting a particular race, class or group in specified area"* ("Free Dictionary," n.d.).

Definition Population growth: The increase in the total number of inhabitants of a specific race, group or the increase in the number of inhabitants of a certain area.

Table 141 population growth

page	Variables influencing Population growth	Variables influenced by Population growth	Description
12,116	Culture		Also the size of the human population is affected by cultural change. First an increase is noticed by the expanding and improved culture. Later a decrease is noticed by the planned parenthood and birth control. (p12) *Culture even affects the most intimate of human mores, those governing reproduction. When culture reaches higher levels, unrestrained breeding against the means of sustenance yield to birth control and planned parenthood (p119).*
14		Complexity social order	*Another source of trouble is the growing complexity of social order. As nations increase in size, as economies become more elaborate, and as global interdependence grows, the task of "living together well", of good neighborliness, of The Good Society, grows more difficult and the pitfalls become more numerous and deeper.*

Comments: -

Changes to the initial causal relation diagram:-

17.2 Population density

Dictionary definition density: *"The number of individuals, such as inhabitants or housing units, per unit of area"* ("Free Dictionary," n.d.).

Definition Population density: The number of inhabitants or their houses, per unit of area.

Table 142 Population density

page	Variables influencing Population density	Variables influenced by Population density	Description
76		Resistances	*Higher population density of geographical distribution affects the energy requirements of transportation.*

Comments:

- In the chapter "Resistances" it was already mentioned that the variable "Population density" poses an example of a resistance. Next to this example, other examples such as "Topography" were mentioned. Since these are all examples of resistances, and do not have any relations with other variables in the causal relation diagram, it is decided to leave these examples out of the diagram.

Changes to the initial causal relation diagram:

- Removal of the variable "Population density".

17.3 Optimal population density = man land ratio

"The man-land ratio is a highly complex concept of a qualitative relationship. The man-land ratio takes into account all the human qualities bearing on productivity and all the environmental aspects, both natural and cultural, affecting the availability of resources. A high population density figure may indicate overpopulation; but even a region with a low population density may be overpopulated. Only the qualitative and critical human wants and abilities and of the availability of resources can furnish conclusive evidence as to the true state of affairs." (p92).

"Perhaps the simplest definition of the term optimal population is that it is the ideal man-land ratio. Overpopulation may be defined as the man land ratio at which, because of excessive numbers of people, the social economy brings lower returns in terms of the values the economy strives to achieve. Under population is defined in the same way except that excessive numbers is replaced by insufficient numbers. The social economy may be considered subject to the law of diminishing returns. Returns may diminish because of an excess or deficiency or any one factor- nature, culture or man. But the triune interrelation of the factors must never be lost sight of. Because of this, the optimal point of each factor depends on the proportionality of all three factors." (p111-112)

Dictionary definition optimal: *"Most favorable or desirable, optimum"* ("Free Dictionary," n.d.)

Definition Optimal population density=man land ratio: That population density for which the factors nature, culture and man are in perfect balance and the returns of the social economy are maximized.

Table 143 Optimal population density= man land ratio

page	Variables influencing Optimal population density=man land ratio	Variables influenced by Optimal population density=man land ratio	Description
111-112	Foreign energy/animate energy		*The population density at which the optimum is attained depends primarily on the amount of foreign energy, particular inanimate energy.*
111-112	Capital equipment		*The population density at which the optimum is attained depends largely on the amount of capital equipment available.*
111-112	Nature		*Returns may diminish because of an excess or deficiency or any one factor-nature, culture or man. But the triune interrelation of the factors must never be lost sight of.*
111-112	Culture		*Returns may diminish because of an excess or deficiency or any one factor-nature, culture or man. But the triune interrelation of the factors must never be lost sight of. Too sanguine hopes should not be based on this statement, for one must not lose sight of the fact that population growth is itself a dynamic factor in the process of cultural development. Therefore, what at a given moment may appear as an ideal man-land ratio, viewed as a stage of an unfolding process, may fall short of then an ideal,*
111-112	Mobility of population		*Because of this, the optimal point of each factor depends on the proportionality of all three factors.*
139		Space handicap	*Excessive population density necessitates heavy transportation expenditure at least as much as does excessive sparsity, though for different reasons. It is not maximum density but optimum density which can solve the problem.*

Comments: -

Changes to the initial causal relation diagram:-

17.4 Excessive population density

Dictionary definition excessive: *"Exceeding a normal, usual, reasonable, or proper limit "* ("Free Dictionary," n.d.).

Definition Excessive population density: A population density in which the number of inhabitants or housing per area is exceeding the normal or reasonable amount.

Table 144 Excessive population density

page	Variables influencing Excessive population density	Variables influenced by Excessive population density	Description
139		Transportation costs	*Excessive population density necessitates heavy transportation expenditure at least as much as does excessive sparsity, though for different reasons.*

Comments:

- It may be considered to remove this variable, since the content of the relation between "Excessive population density" and the variable "Transportation costs" could also be expressed by the variable "Optimal population density=man land ratio" and the variable "Transportation costs". The variable "Optimal population density= man land ratio" would provide positive influence on the variable "Transportation costs". This because when the optimal population density is reached, less heavy transportation expenditure is necessary. This implies that the optimal population has the most beneficial effect on transportation costs. This is true, since to less population would require more transport and therefore more transport costs, which is stated by Zimmerman by the sentence "*Excessive population density necessitates heavy transportation expenditure at least as much as does excessive sparsity".*
- So, the relation between the variable "Excessive population density" and "Transportation costs" will be changed into the relation between the "optimal population density-man land ratio" which has a positive effect on the transport costs.

Changes to the initial causal relation diagram:

- The placement of the variable "Excessive population density" under the variable "Optimal population density=man land ratio".
- The negative relation between "Excessive population density" and "Transport costs" will then be changed into a positive relation between ""Optimal population density=man land ratio" and "Transport costs".

17.5 Population

Dictionary definition Population: *"The total number of inhabitants constituting a particular race, class or group in specified area."* ("Free Dictionary," n.d.)

Definition population: The total amount of people living in certain area or being part of a race of class.

Table 145 Population

page	Variables influencing Excessive population density	Variables influenced by Excessive population density	Description
116		Culture	*Culture varies in origin, form, and function according to the character of the natural environment and the relationship between the natural opportunities and the population.*

Comments: -

Changes to the initial causal relation diagram:-

18. Remaining variables

18.1 Health

Dictionary definition Health: *"A condition of optimal well-being"* ("Free Dictionary," n.d.).

Definition Health: The well-being of an organism.

Table 146 Health

page	Variables influencing Health	Variables influenced by Health	Description
6		Evolvement resources	*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects- such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors.*

Comments:

- As stated in the section on the variable "Social harmony", Zimmerman names a list of examples of intangible aspects which are related to the Evolvements of resources. The variable "Health" forms on of these examples. Since it is aimed to create a clear and a simple diagram, these examples will not be named explicitly in the diagram, but will be grouped under the variable “Intangible aspects”.

Changes to the initial causal relation diagram:

- The placement of the variable “Health” under the variable “Intangible aspects”.

18.2 Freedom

Dictionary definition Freedom: *“The condition of being free of restraints”* (“Free Dictionary,” n.d.).

Definition Freedom: The condition in which an organism is not subject to restraints.

Table 147 Freedom

page	Variables influencing Freedom	Variables influenced by Freedom	Description
6		Evolvement resources	*To be sure, substances can function as resources, and indeed they play a tremendous part as resources. One has but to think of coal, iron, petroleum, copper etc. to realize that. They are obvious , easily recognized, and considered important, whereas less patent invisible and intangible aspects- such as health, social harmony, wise policies, knowledge, freedom – are ignored, even though possible these latter are more important than all the coal, iron, gold and silver in the world put together. In fact, resources evolve out of the dynamic interaction of all of these factors.*

Comments:

- See comment under Health.

Changes to the initial causal relation diagram:

- The placement of the variable “Freedom” under the variable “Intangible aspects”.

18.3 Sense of historical perspective

Dictionary definition sense:

1. *“An intuitive or acquired perception or ability to estimate*
2. *A capacity to appreciate of understand*
3. *Recognition or perception either through the senses of through the intellect; consciousness ”* (“Free Dictionary,” n.d.).

Definition Sense of historical perspective: The capacity to understand, recognize and appreciate history.

Table 148 Sense of historical perspective

page	Variables influencing Sense of history	Variables influenced by Sense of history	Description
6		Social responsibility	*A rather subtle influence is what may be called a growing sense of social responsibility. This too helps too helps to explain the increased awareness of the basic social assets. This sense of responsibility is probably best explained in terms of a keener sense of historical perspective and a fuller understanding of social processes and phenomena.*

Comments: -

Changes to the initial causal relation diagram:-

18.4 Understanding social processes and phenomena

Dictionary definition social:

1.
   a. *"Living together in communities*
   b. *Of or relating to communal living*
   c. *Of or relating to human society and its modes of organization.*
2. *Living together in organized groups or similar close aggregates*
3. *Involving all members of a confederacy*
4.
   a. *Inclined to seek out or enjoy the company of other; sociable*
   b. *Spent in or market by friendly relations or companionship*
   c. *Intended for convivial activities*
5. *Of, relating to, or occupied with matter affecting human welfare"* ("Free Dictionary," n.d.).

Definition Understanding social processes and phenomena: The understanding of the processes and phenomena relating to the human society.

Table 149 Understanding social processes and phenomena

page	Variables influencing Understanding social processes and phenomena	Variables influenced by Understanding social processes and phenomena	Description
6		Social responsibility	*A rather subtle influence is what may be called a growing sense of social responsibility. This too helps too helps to explain the increased awareness of the basic social assets. This sense of responsibility is probably best explained in terms of a keener sense of historical perspective and a fuller understanding of social processes and phenomena.*

Comments: -

Changes to the initial causal relation diagram:-

18.5 Conditions

Dictionary definition conditions: *"Existing circumstances"* ("Free Dictionary," n.d.).

Definition Conditions: The circumstances at present.

Table 150 Conditions

page	Variables influencing Conditions	Variables influenced by Conditions	Description
7		Resource function	*Likewise unfortunate is the tendency to think of resources in terms of a single asset, e.g., coal rather than in terms of the whole complex of substances, forces, conditions, relationships, institutions, policies, etc., which alone help to explain the way coal functions as a resource at a given time and place.*

Comments: -

Changes to the initial causal relation diagram:-

18.6 Substances

Dictionary definition substances:

1. *"That which has mass and occupies space; matter.*
2. *The tangible matter of which a thing consists."* ("Free Dictionary," n.d.)

Definition Substances: The tangible matter of which something is made up.

Table 151 Substances

page	Variables influencing Substances	Variables influenced by Substances	Description
7		Resource function	*Likewise unfortunate is the tendency to think of resources in terms of a single asset, e.g., coal rather than in terms of the whole complex of substances, forces, conditions, relationships, institutions, policies, etc., which alone help to explain the way coal functions as a resource at a given time and place.*

Comments: -

Changes to the initial causal relation diagram:-

18.7 Forces

Dictionary definition forces: *"The capacity to do work or cause physical change; energy; strength or active power"* ("Free Dictionary," n.d.).

Definition Forces: An influence which can create physical change or do work.

Table 152 Forces

page	Variables influencing Forces	Variables influenced by Forces	Description
7		Resource function	*Likewise unfortunate is the tendency to think of resources in terms of a single asset, e.g., coal rather than in terms of the whole complex of substances, forces, conditions, relationships, institutions, policies, etc., which alone help to explain the way coal functions as a resource at a given time and place.*

Comments: -

Changes to the initial causal relation diagram:-

18.8 Global interdependence

Dictionary definition interdependence: *"Dependence between two or more people, groups, or things"* ("Free Dictionary," n.d.).

Definition Global interdependence: The dependence between countries and people spread over the world.

Table 153 Global interdependence

page	Variables influencing Global interdependence	Variables influenced by Global interdependence	Description
14		Complexity social order	*Another source of trouble is the growing complexity of social order. As nations increase in size, as economies become more elaborate, and as global interdependence grows, the task of "living together well", of good neighborliness, of The Good Society, grows more difficult and the pitfalls become more numerous and deeper.*

Comments: -

Changes to the initial causal relation diagram:-

18.9 Pitfalls

Dictionary definition pitfalls: *"An unsuspected difficulty or danger"* ("Free Dictionary," n.d.).

Definition Pitfalls: Difficulties, trouble or danger which are not obvious or apparent.

Table 154 Pitfalls

page	Variables influencing Pitfalls	Variables influenced by Pitfalls	Description
14		Complexity social order	*Another source of trouble is the growing complexity of social order. As nations increase in size, as economies become more elaborate, and as global interdependence grows, the task of "living together well", of good neighborliness, of The Good Society, grows more difficult and the pitfalls become more numerous and deeper.*

Comments: -

Changes to the initial causal relation diagram:-

18.10 Difficulties "Good society"

Definition Difficulties Good society: The problems and difficulties concerned with living together and being a good neighbor which appear due to the increasing complexity of social order.

Table 155 Difficulties good society

page	Variables influencing Difficulties Good society	Variables influenced by Difficulties Good society	Description
14		Complexity social order	*Another source of trouble is the growing complexity of social order. As nations increase in size, as economies become more elaborate, and as global interdependence grows, the task of "living together well", of good neighborliness, of The Good Society, grows more difficult and the pitfalls become more numerous and deeper.*

Comments:

- When the assumption is made that the problems and difficulties presented under the variable "Difficulties Good society", also concern problems which were not obvious from the beginning, the variable "Pitfalls", which represents those difficulties which were not obvious from the beginning, could be combined with the variable "Difficulties good society".
- In order to simplify the diagram it is assumed that the variable "Difficulties Good society" indeed also relates to the problems which are unapparent or not obvious on forehand. With this assumption made the variables "Difficulties 'Good society' and "Pitfalls" can be combined into one variable. This combined variable will present the problems and difficulties for countries to be a good neighbor for other countries, both obvious and unapparent.

Changes to the initial causal relation diagram:

- Placement of the variable "Pitfalls" under the variable "Difficulties 'Good society''.

18.11 Demands

Dictionary definition Demand:

"The desire to possess a commodity or make use of a service, combined with the availability of use.

The amount of a commodity or service that people are ready to buy for a given price" ("Free Dictionary," n.d.).

Definition Demand: The sum of desire of a population for a certain resource.

Table 156 Demands

page	Variables influencing Demands	Variables influenced by Demands	Description
15		Resource ship	*Resource ship stems from the purposeful interaction of natural, cultural and human aspects primed and kept going by demand based on availability for use.*

Comments: -

Changes to the initial causal relation diagram:-

18.12 Determination technical feasibility

Dictionary definition Determination: *"The act of making or arriving at a decision"*("Free Dictionary," n.d.).

Dictionary definition feasible: *"Capable of being accomplished or brought about; possible; a feasible plan"* ("Free Dictionary," n.d.).

Definition Determination technical feasibility: The process of arriving at the decision on the capability of achievements on the technical area.

Table 157 Determination technical feasibility

page	Variables influencing Determination technical feasibility	Variables influenced by Determination technical feasibility	Description
17		Resource appraisal	*The appraisal of resources proceeds from:* *1. The knowledge of facts of nature and culture to* *2. The determination of technical feasibility to* *3. The determination of profitability* *4. The formulation of the grand strategy along socio-economic lines.*

Comments: -

Changes to the initial causal relation diagram:-

18.13 Attitudes toward material progress

Definition Attitudes towards material progress: The position of human beings concerning the material development.

Table 158 Attitudes toward material progress

page	Variables influencing Attitudes toward material progress	Variables influenced by Attitudes toward material progress	Description
33		Development arts	*Peculiar nature of a given environment and of specific needs therefore determines the general lines along which the arts develop. Besides differences in environment and needs, differences in attitudes toward material progress and the crystallization of such attitudes in patent laws and similar institutions must be taken into consideration.*

Comments:

- As stated in the table, the attitudes toward material progress crystallize into patent laws and similar institutions. Since the variable "Patent laws/institutions" is placed under the variable "Institutions", the attitudes toward material progress will now be crystalized in institutions.
- Since crystallization could be seen as the more definite form of attitudes toward material progress, in which the attitudes are transformed into more concrete elements of institutions, it could be stated that "Attitudes toward material progress" could be considered abundant. This because the more crystalized or concrete form of these attitudes is already present in the form of institutions, and is therefore already present under the variable "Institutions". The variable "Attitude towards Material progress" therefore does not add new information.
- Consequently the variable "Attitudes toward material progress" may be removed.

Changes to the initial causal relation diagram:

- Removal of the variable "Attitudes toward material progress".

18.14 Necessity

Dictionary definition Necessity: *"Pressing or urgent need"* ("Free Dictionary," n.d.).

Definition Necessity: Something which is deeply needed.

Table 159 Necessity

page	Variables influencing Necessity	Variables influenced by Necessity	Description
35		Inventions	*For countless ages men improved his arts reluctantly, only under dire pressure. "Necessity is the mother of invention" became a commonly accepted truth.*

Comments: -

Changes to the initial causal relation diagram:-

18.15 (Exhaustion) fuel use

Dictionary definition Exhaustion: *"The condition of being used up; consumption"* ("Free Dictionary," n.d.).

Definition Exhaustion fuel use: The extreme usage of fuels in such a way in that they could become depleted.

Table 160 Exhausting fuel use

page	Variables influencing Exhaustion fuel use	Variables influenced by Exhaustion fuel use	Description
57		Discovery ways of tapping new and inexhaustible fuels	*So great is the confidence of modern industrial man in his own capacity to create resources to discover ways and means of tapping new sources of energy, or finding treasure chests buried more deeply than that containing the fossil fuels that he insists on keeping up the exhausting pace of fuel use. If, as seems possible, an increasing share of the vast energies now derived from exhaustible fuels is used to discover ways of tapping new and inexhaustible energies that confidence may well be justified. Much will depend on the continuation of peace.*
57	Confidence man in finding new energy sources		" "

Comments:

- Zimmerman does not state the direct relation between the variable "Exhausting fuel use" and the "Depletion/demolishment of resources". Though it is obvious that the exhausting fuel use of man will lead to a decreased amount of resources available, i.e. the depletion of resources. Therefore, the relation between the variables "Exhausting fuel use" and "Depletion/demolishment of resources" will be added to the causal relation diagram.

Changes to the initial causal relation diagram:

- Adding of the (positive) relation between the variable "Exhausting fuel use" and the variable "Depletion/demolishment resources".

18.16 Energy basis

Definition Energy basis: The distribution of energy sources used in country for the supply of energy.

Table 161 Energy basis

page	Variables influencing Energy basis	Variables influenced by Energy basis	Description
72		Technical arts	*As a result, foreign trade and the export of capital assume increasing importance and thus broaden the resource basis of mobilized economy. We see, therefore, that the energy basis is truly the foundation of a civilization. It determines the choice of materials which can be utilized, it sets a definite limit to the size of performance, it governs the degree of mobility and, in general, controls the arts societal and technical, and through them shapes the institutions, material and non-material.*
72		Societal arts	" "
72		Choice of materials	" "
72		Size performance	" "
72		Mobility population	" "

Comments: -

Changes to the initial causal relation diagram:-

18.17 Size performance

Definition Size performance: The magnitude of the production (capacity) and accomplishments of a country.

Table 162 Size performance

page	Variables influencing Size performance	Variables influenced by Size performance	Description
72	Energy basis		*As a result, foreign trade and the export of capital assume increasing importance and thus broaden the resource basis of mobilized economy. We see, therefore, that the energy basis is truly the foundation of a civilization. It determines the choice of materials which can be utilized, it sets a definite limit to the size of performance, it governs the degree of mobility and, in general, controls the arts societal and technical, and through them shapes the institutions, material and non-material.*

Comments: -

Changes to the initial causal relation diagram:-

18.18 Choice of materials

Definition Choice of materials: The choice of materials which may be utilized in a country.

Table 163 Choice of materials

page	Variables influencing Choice materials	Variables influenced by Choice materials	Description
72	Energy basis		*As a result, foreign trade and the export of capital assume increasing importance and thus broaden the resource basis of mobilized economy. We see, therefore, that the energy basis is truly the foundation of a civilization. It determines the choice of materials which can be utilized, it sets a definite limit to the size of performance, it governs the degree of mobility and, in general, controls the arts societal and technical, and through them shapes the institutions, material and non-material.*

Comments: -

Changes to the initial causal relation diagram:-

18.19 Energy expenditure

Dictionary definition Expending: *"To use up, consumption"* ("Free Dictionary," n.d.).

Definition Energy expenditure: The amount of energy consumed.

Table 164 Energy expenditure

page	Variables influencing Energy expenditure	Variables influenced by Energy expenditure	Description
78		Well-being	*But for it should be equally clear that there is no greater force promoting well-being than energy expenditure.*

Comments: -

Changes to the initial causal relation diagram:-

18.20 Ignorance

Dictionary definition Ignorance: *"lack of knowledge, information or education; the state of being ignorant"* ("Free Dictionary," n.d.).

Definition Ignorance: The state of man in which he lacks knowledge, information or education.

Table 165 Ignorance

page	Variables influencing Ignorance	Variables influenced by ignorance	Description
81		Depletion/demolishment of resources	*Nature's contributions are also subject to contraction, by usage, becoming useless by obsolescence or damage by man beyond repair, mainly because of ignorance, especially of the laws of ecology.*

Comments: -

Changes to the initial causal relation diagram:-

18.21 Human folly and cussedness

Dictionary definition Folly:

1. *"A lack of good sense, understanding or foresight,*
2. *An act or instance of foolishness"* ("Free Dictionary," n.d.).

Dictionary definition Cussedness*: "Perverse; stubborn"* ("Free Dictionary," n.d.).

Definition Human folly and cussedness: The act of foolishness, which presents a lack of understanding or foresight and the stubbornness of man.

Table 166 Human folly and cussedness

page	Variables influencing Human folly and cussedness	Variables influenced by Human folly and cussedness	Description
14		Depletion/demolishment of resources	*But a far greater destruction is wrought by man not in the orderly process of rational resource use, but because of human folly and cussedness. As was mentioned the individual tends to take a short-sighted view of things.* The consequences are often ignored, especially when these count for other which may not even be born. *The proper use and care of complex natural processes that are governed by the laws of ecology presuppose a high degree of scientific knowledge which has been reached only very recently, after centuries of blind groping and foolish blundering.*

Comments:

- The variables "Ignorance" and "Human folly and cussedness" both indicate the negative effect of a lack of understanding and capacity to oversee the consequences of an act on nature and its resources. Both variables are having a positive influence on the variable "Depletion/demolishment resources", which indicates that both variables have a negative influence on the amount of resources available.
- Due to the definitions of these variables and the issues they indicate, it seems valid to combine these two variables into one. This variable will be named "Human Ignorance, folly and cussedness".

Changes to the initial causal relation diagram:

- The combination of the variables **"**Ignorance" and "Human folly and cussedness" into the variable "Human ignorance, folly and cussedness"

18.22 Destruction fauna and flora

Dictionary definition fauna and flora: *"All the animal life of a given place or time"* ("Free Dictionary," n.d.).

Dictionary definition flora: *"All the plant life of a given place of time"* ("Free Dictionary," n.d.).

Definition Destruction fauna and flora: The demolishment of the plant and animal life at a certain place or time.

Table 167 Destruction fauna and flora

page	Variables influencing Destruction fauna and flora	Variables influenced by Destruction fauna and flora	Description
13	Depletion/ demolishment of resources		*The proper use and care of complex natural processes that are governed by the laws of ecology presuppose a high degree of scientific knowledge which has been reached only very recently, after centuries of blind groping and foolish blundering. Soil erosion caused by faulty methods of farming, of overgrazing, or unscientific cutting of timber comes readily to mind. The destruction of fauna and flora which interferes with nature's creative work through natural selection and the variation of species limits or even blocks the progress of the plant and animal breeder.*

Comments: -

Changes to the initial causal relation diagram:-

18.23 Technology

Dictionary definition Technology:

1. *"The application of science, especially to industrial or commercial objectives.*
2. *The scientific methods and material used to achieve a commercial or industrial objective.*
3. *Electronic or digital products and systems considered as a group.*
4. *The body of knowledge available to society that is of use in fashioning implements, practicing manual arts and skills, an extracting or collecting materials."* ("Free Dictionary," n.d.)

Definition Technology: The sum of scientific methods and materials used to achieve objectives, electronic or digital products and systems and the body of knowledge concerning technique.

Table 168 Technology

page	Variables influencing Technology	Variables influenced by Technology	Description
15		Evolvement resources	*Resources are not, they become: they are not static but expand and contract in response to human wants and human actions. In these examples, two forms of human actions were prominent: technics and business enterprise.*
15		Depletion/ demolishment of resources	*Not only do modern science and technology backed by wants and needs create resources; they also destroy them and reconvert them into "neutral stuff"* (p15) *All of these examples prove the same basic fact: resource are not, they become: they are not static but expand and contract in response to human wants and human actions. In these examples, two forms of human actions were prominent: technics and business enterprise.*

Comments: -

Changes to the initial causal relation diagram:-

18.24 Mobility population

Dictionary definition mobility: *"The ability to move physically"* ("Free Dictionary," n.d.).

Definition Mobility population: The capacity of a population concerning physical movements.

Table 169 Mobility population

page	Variables influencing Mobility population	Variables influenced by Mobility population	Description
72	Energy basis		*As a result, foreign trade and the export of capital assume increasing importance and thus broaden the resource basis of mobilized economy. We see, therefore, that the energy basis is truly the foundation of a civilization. It determines the choice of materials which can be utilized, it sets a definite limit to the size of performance, it governs the degree of mobility and, in general, controls the arts societal and technical, and through them shapes the institutions, material and non-material.*
111-112		Optimal population density = man land ratio	*The population density at which the optimum is attained depends on the relative mobility of the population.*

Comments: -

Changes to the initial causal relation diagram:-

18.25 Foreign energy/inanimate energy

"Inanimate energy: those derived from nonliving matter, especially the fossil fuels, coal, oil and gas and from falling water." (p41)

1. *The population density at which the optimum is attained depends primarily on the amount of foreign energy, particular inanimate energy.*
    a. *Since foreign energy can be made available only by means of capital equipment, the same principle could expressed as follows:*
2. *The population density at which the optimum is attained depends largely on the amount of capital equipment available.*
    a. *Furthermore, since a low density is compatible with a high civilization only if the sparse population is very mobile, we can express the same idea in a third way." (p111-112)*

Definition Foreign energy/inanimate energy: Energy which is derived from non-living substances by the means of capital equipment.

Table 170 Foreign energy/inanimate energy

page	Variables influencing Foreign energy/inanimate energy	Variables influenced by Foreign energy/inanimate energy	Description
111-112		Optimal population density = man land ratio	*The population density at which the optimum is attained depends primarily on the amount of foreign energy, particular inanimate energy.*

Comments: -

Changes to the initial causal relation diagram:-

18.25 Capital equipment

Dictionary definition Capital equipment: *"Equipment that you use to manufacture a product, provide a service or use to sell, store and deliver merchandise"* ("Entrepreneur.com," n.d.).

Definition Capital equipment: The equipment which is used to manufacture a product or to be able to deliver a service.

Table 171 Capital equipment

page	Variables influencing Capital equipment	Variables influenced by Capital equipment	Description
111-112		Optimal population density = man land ratio	*The population density at which the optimum is attained depends largely on the amount of capital equipment available.*

Comments:

- The definition of "Capital equipment" indicates the equipment used for the production or the delivery of a service. The content of this variable is quite similar to the variable "Required machines resources". The variable "Required machine resources" indicates the amount of machine resources necessary and is considered to be part of the overhead.
- Considering the dictionary definition of overhead: *"The operating expenses of a business, including the costs of rent, utilities, interior decoration, and taxes, exclusive of labor and materials"* it seems that capital equipment would also be part of the overhead. However, in this case the variable "Capital equipment" indicates the influence of capital equipment on the optimal population density. When the variable "Capital equipment" would be placed under the variable "weight overhead burden" such as the variable "Required machine resources", the influence of capital equipment on the optimal population density would not be clear. Therefore the variable "capital equipment" will not be placed under the variable "Weight overhead burden" because the meaning of its relation with the variable "Optimal population density=man land ratio" would be lost.

Changes to the initial causal relation diagram:-

18.26 Indirectness=gap between first impression and first reaction

Definition Indirectness = gap between first impression and first reaction: The increased amount of time and activities which appear between the first impression of something and the first reaction to this impression.

Table 172 Indirectness = gap between first impression and first reaction

page	Variables influencing Indirectness = gap between first impression and first reaction	Variables influenced by Indirectness=gap between first impression and first reaction	Description
122		Miraculous achievements	*This increased indirectness, this widening of the gap between first impression and final reaction, logically leads, on the top level of derivative control and institutions, to the miraculous achievements of an Einstein on the one hand, and to the confusion of the human mind so characteristic for the modern age.*
122		Confusion human mind	" "
122		Indirect adaptions to nature	*As communication advances from the halting and unsatisfactory level of gestures and sign language to the higher level of written, including printed, language, when books and libraries come into vogue, cultural adaption comes progressively more under the influence of established crystalized human thought and seeks adjustments not to nature directly, but to a growing accumulation of previous human reactions to experiences in life. This increased indirectness, this widening of the gap between first impression and final reaction, logically leads, on the top level of derivative control and institutions, to the miraculous achievements of an Einstein on the one hand, and to the confusion of the human mind so characteristic for the modern age.*

Comments: -

Changes to the initial causal relation diagram:-

18.27 Widening horizon

Definition Widening horizon: The increase of available space and options.

Table 173 Widening horizon

page	Variables influencing Widening horizon	Variables influenced by Widening horizon	Description
138	Space		*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways.*

Comments: -

Changes to the initial causal relation diagram:-

18.28 Vision

Dictionary definition Vision: *"The faculty of sight, eyesight"* ("Free Dictionary," n.d.).

Definition Vision: The capacity to see.

Table 174 Vision

page	Variables influencing Vision	Variables influenced by Vision	Description
138	Space		*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways.*

Comments: -

Changes to the initial causal relation diagram:-

18.29 Freedom of motion

Definition Freedom of motion: The freedom to move.

Table 175 Freedom of motion

page	Variables influencing Freedom of motion	Variables influenced by Freedom of motion	Description
138	Space		*Space – abundance of space- has its glorious advantages. It develops vision, widens the horizon, allows freedom of motion, and helps in many other ways.*

Comments:

- The variables “Widens horizon”, “Vision” and “Freedom of motion” are all examples of assets which may be brought by the abundance of space. However, these examples are not important in the understanding of the theory of Zimmerman on resources. They are an illustration of what space can create. Since, these variables are only an illustration they are not important enough to keep in the causal relation diagram and will be removed in order to simplify causal relation diagram.

Changes to the initial causal relation diagram:

- Removal of the variables: “ Widens horizon” , “Vision” and “Freedom of motion”

18.30 Confusion human mind

Definition Confusion human mind: A disorder in the human consciousness developed in the brain which shows itself in thoughts, perceptions and actions.

Table 176 Confusion human mind

page	Variables influencing Confusion human mind	Variables influenced by Confusion human mind	Description
122	Indirectness = gap between first impression and first reaction		*This increased indirectness, this widening of the gap between first impression and final reaction, logically leads, on the top level of derivative control and institutions, to the miraculous achievements of an Einstein on the one hand, and to the confusion of the human mind so characteristic for the modern age.*

Comments: -

Changes to the initial causal relation diagram:-

18.31 Usage of substances

Definition Usage of substances: The usage of materials.

Table 177 Usage of substances

page	Variables influencing Usage of substances	Variables influenced by Usage of substances	Description
13		Depletion/demolishment of resources	*Man, the great culture-builder, is not only a creator of resources, he is also a destroyer. Man cannot help that coal and oil are dissipated in use. He cannot use such minerals without using them up.*

Comments: -

Changes to the initial causal relation diagram:-

18.32 Historical forces

Definition Historical forces: Effects which result from history which are of influence on the present

Table 178 Historical forces

page	Variables influencing Historical forces	Variables influenced by Historical forces	Description
25		National character	*The extent to which the state should interfere in private business s most debatable with regard to such activities affecting vital group assets. The power industry is another case in point. Nations differ widely with regard to their attitude towards this middle zone. Some nations practically absorb it into the province of free individual enterprise, leaving social control only a narrow fringe of public functions. Other nations take the very opposite attitude. Such attitudes are explained partly by historical forces which have molded national character, partly by differences in the actual situation which these nations are facing at a given time.*

Comments: -

Changes to the initial causal relation diagram:-

18.33 National character

Definition National character: The sum of properties which are characteristic for a nation.

Table 179 National character

page	Variables influencing National character	Variables influenced by National character	Description
25		Economic life	*The extent to which the state should interfere in private business s most debatable with regard to such activities affecting vital group assets. The power industry is another case in point. Nations differ widely with regard to their attitude towards this middle zone. Some nations practically absorb it into the province of free individual enterprise, leaving social control only a narrow fringe of public functions. Other nations take the very opposite attitude. Such attitudes are explained partly by historical forces which have molded national character, partly by differences in the actual situation which these nations are facing at a given time.*
25	Historical perspective		

Comments: -

Changes to the initial causal relation diagram:-

18.34 Actual situation nation

Definition Actual situation nation: The current sum of conditions which shape the situation in a country.

Table 180 Actual situation nation

page	Variables influencing Actual situation nation	Variables influenced by Actual situation nation	Description
25	Economy		*The extent to which the state should interfere in private business s most debatable with regard to such activities affecting vital group assets. The power industry is another case in point. Nations differ widely with regard to their attitude towards this middle zone. Some nations practically absorb it into the province of free individual enterprise, leaving social control only a narrow fringe of public functions. Other nations take the very opposite attitude. Such attitudes are explained partly by historical forces which have molded national character, partly by differences in the actual situation which these nations are facing at a given time such minerals without using them up.*

Comments: -

Changes to the initial causal relation diagram:-

18.35 National wealth

Dictionary definition:

1. *"The state if being rich; affluence.*
2. *All goods and resource having value in terms of exchange or use"* ("Free Dictionary," n.d.).

Definition National wealth: The sum of national goods and resources which have value in use or in exchange.

Table 181 National wealth

page	Variables influencing National wealth	Variables influenced by National wealth	Description
25	Nature		*National wealth depends, in the first place, on the natural environment itself, on the availability-or utility- of the untransformed aspects of nature. It depends, in the second place, on the arts and institutions to which that environment, in view of the racial and cultural characteristics of that human element, gives rise. Among these, the institutions surrounding population increase are of special importance, for the largess of nature may result either in an ever growing number of people at or near a point of minimum sustenance or in a rising living standard for a restricted number.*
25	Arts		" "
25	Institutions		" "

Comments: -

Changes to the initial causal relation diagram:-

18.36 Size and complexity modern nations

Definition Size and complexity modern nations: The size and complexity of modern nations.

Table 182 Size and complexity modern nations

page	Variables influencing Size and complexity modern nations	Variables influenced by Size and complexity modern nations	Description
5		Resource consciousness	*Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness. They are by no means the only forces responsible for this new awareness. A number of quiet, slowly moving trends have contributed materially to the change in attitude. The growing size and complexity of modern nations is one of them. It points, with perhaps inevitable logic, toward a strengthening of the power of the central government. In so far as this growing complexity is due to a merging of once local or regional activities and interest into national concerns, the increased need for central – in the United States, federal- controls is evident. Another vital trend is marked by the decline of competition and by its corollary, the concentration of economic power.*

Comments: -

Changes to the initial causal relation diagram:-

18.37 Decline of competition

Definition Decline of competition: A decrease in competition.

Table 183 Decline of competition

page	Variables influencing Decline of competition	Variables influenced by Decline of competition	Description
5		Resource consciousness	*Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness. They are by no means the only forces responsible for this new awareness. A number of quiet, slowly moving trends have contributed materially to the change in attitude. The growing size and complexity of modern nations is one of them. It points, with perhaps inevitable logic, toward a strengthening of the power of the central government. In so far as this growing complexity is due to a merging of once local or regional activities and interest into national concerns, the increased need for central – in the United States, federal- controls is evident. Another vital trend is marked by the decline of competition and by its corollary, the concentration of economic power.*

Comments: -

Changes to the initial causal relation diagram:-

18.38 Concentration economic power

Definition Concentration economic power: The bundling of economic capacities in one place.

Table 184 Concentration economic power

page	Variables influencing Concentration economic power	Variables influenced by Concentration economic power	Description
5		Resource consciousness	*Up to this point attention has been focused on spectacular events such as the closing of the frontier, the great depression, and the world wars as sources of growing resource consciousness. They are by no means the only forces responsible for this new awareness. A number of quiet, slowly moving trends have contributed materially to the change in attitude. The growing size and complexity of modern nations is one of them. It points, with perhaps inevitable logic, toward a strengthening of the power of the central government. In so far as this growing complexity is due to a merging of once local or regional activities and interest into national concerns, the increased need for central – in the United States, federal- controls is evident. Another vital trend is marked by the decline of competition and by its corollary, the concentration of economic power.*

Comments: -

Changes to the initial causal relation diagram:-

19. Conclusion

19.1 Definitions

Resources

1. **Definition Resource ship**: The state or condition when tangible or intangible aspects can function as a resource, which evolves out of the interaction of natural, human and cultural aspects.
2. **Definition Resource function**: The action or purpose of a substance which makes it suitable for the fulfillment of the role as a resource.
3. **Definition Resource**: Resources are things or substances which function or perform as means to attain specific ends, given by individual wants and social objectives.

4. **Definition Resource appraisal**: The human judgment on the want satisfying capacity of the environment.
5. **Definition Human appraisal**: The human judgment on the want satisfying capacity of the environment.
6. **Definition Evolvement resources**: The development or achievement of resources in response to (changing) ends accomplished by the dynamic interaction of multiple (tangible and intangible) factors.
7. **Definition Depletion/demolishment resources**: The use of resources in a way that these resources will not be able to be used again.
8. **Definition Man's resources**: That part of natural resources which are made usable for the desired ends by men due to human ingenuity, experience and knowledge.
9. **Definition Natural resources**: Those aspects of nature, which can be utilized without efforts or improvements, in order to satisfy man's creature wants.
10. **Definition Gross resources**: Possible resources for which obstacles and resistances still need to be overcome, before these can be used for the well-being of men.
11. **Definition Net resources**: Aspects of nature for which obstacles and resistances have been overcome and which are available are for the usage of men for their well-being.
12. **Definition Natural-cultural resources**: Those aspects of nature which are made available for utilization by man achieved by the improvements done by men.
13. **Definition Resource consciousness**: The acknowledgement and alertness on the importance of resources.
14. **Definition Tempo resource development**: The speed for which resources are developed and prepared for usage.

Resistances

15. **Definition Resistances**: Things or forces which have the capacity to resist.
16. **Definition Natural-cultural resistances**: Natural resistances which are the result from the human interference or the human impact with nature.
17. **Definition Natural-cultural resistances**: Natural resistances which are the result from the human interference or the human impact with nature.

Wants

18. **Definition Wants**: A desire or human need for something.
19. **Definition Basic wants**: The needs of human beings which need to be fulfilled for the continuation of their existence.
20. **Definition Individual wants**: The expression of individual desires and objectives.
21. **Definition Man's objectives**: The goals of the human population.
22. **Definition Group wants/long term**: Social wants or objectives desired by the groups of human beings.
23. **Definition Social objectives:** Goals or ends desired of people living in human societies.
24. **Definition Changing wants**: Changing desires.
25. **Definition Conflict between group and individual interests**: A state of disharmony between group and individual interests.

26. **Definition Conflict**: A state of disharmony.
27. **Definition Specific needs**: Specific required or wanted aspects.
28. **Definition Satisfaction of wants**: The fulfillment of desires.
29. **Definition Well-being:** A condition in which people are healthy and enjoying welfare.

Nature

30. **Definition The nature of the environment:** The physical environment offered by nature.
31. **Definition Nature given environment:** Physical environment offered by nature.
32. **Definition Physical environment**: The physical environment viewed as the changing relationships of trends and forces.
33. **Definition Nature**: The physical environment which offers limits and opportunities for its population.
34. **Definition Natural aspects:** Elements or facets of nature.
35. **Definition Natural assets**: Valuable aspects of nature.
36. **Definition Nature's opportunities:** Chances or favorable circumstances brought by nature.
37. **Definition Nature's limits**: The restricting forces of nature which pose boundaries for the opportunities.
38. **Definition Direct adaption to nature**: The direct adjustments done by man to get adapted to his environment.

Culture

39. **Definition Culture**: The total sum of human products stemming from the human capacity to invent arts and artifacts in order to meet man's objectives.
40. **Definition Cultural assets**: Valuable aspects of culture.
41. **Definition Cultural aspects**: Elements or facets of culture.
42. **Definition Enriched culture**: A culture which has increased in fullness and richness.
43. **Definition Blended/alloyed cultures**: The combination or mixture of elements of several cultures.
44. **Definition Problems (with cultural values which move**): The problems which appear when parts of culture are blended into other cultures due to the loss of the coherence of the cultural aspects and their logic.
45. **Definition Psychosocial environment**: A cultural environment in which the human mind has entered as a modifying factor.
46. **Definition Cultural adaption:** The indirect adjustments done by man to get adapted to his environment.

Arts

47. **Definition Arts**: The skills and efforts of human to alter nature.
48. **Definition Development arts**: The expansion and growth of the skills and efforts of humans to alter nature.
49. **Definition Improvement of arts**: An increase in the quality of skills and efforts of humans to alter nature.
50. **Definition State of the arts**: The sum of human capacities.
51. **Definition Societal arts**: The sum of human capacities relating to the structure, organization or functioning of society in order to regulate and improve human relations.

52. **Definition Technical arts**: The sum of human capacities relating to material of technical abilities to utilize substances and energies.

Man

53. **Definition Man:** Mankind
54. **Definition Human assets:** The valuable features of mankind.
55. **Definition Human aspects**: The notable features of mankind.
56. **Definition Science**: Activities of investigation and explanation of phenomena in order to gain knowledge.
57. **Definition Knowledge/wisdom:** The understanding and awareness of information which has been discovered experienced or learned through the ages.
58. **Definition Knowledge of facts of nature and culture**: The understanding and awareness of information on nature and culture.
59. **Definition Human capacity**: The human ability or capability.
60. **Definition Man's capacity to take advantage of opportunities**: The human ability or capability to take advantage of opportunities.
61. **Definition General capacity to take advantage of opportunities**: The general human ability or capability to take advantage of opportunities.
62. **Definition Man's abilities**: The qualities, skills, or talents of man which make him accomplish certain goals.
63. **Definition Mental abilities**: The qualities, skills or talents to accomplish something by use of or related to the mind.
64. **Definition Physical abilities**: The qualities, skills or talents to accomplish something by use of or related to the body.
65. **Definition Human mind**: The human consciousness developed in the brain which presents itself in thoughts, perceptions and actions.
66. **Definition Human effort**: The physical or mental energy put into a subject by man.
67. **Definition Human behavior and effort**: The energy put into a subject and the related actions or reactions of man.
68. **Definition Human productive effort**: The effectiveness of human energy and actions devoted to a specific subject.
69. **Definition Human actions**: The things done by humans.
70. **Definition Crystallized human thought**: Precise and definite thoughts of mankind established by advanced communication.
71. **Definition Human ingenuity**: The human cleverness and skills which enables inventions.
72. **Definition Experience:** The knowledge of skills derived after the participation or live through of certain events as a group or as an individual.
73. **Definition Accumulation human reactions to experience**: The sum of human reactions on experiences.
74. **Definition Reactions/adaption diverse environments**: The adjustments and reactions of men to adapt to diverse environments.

75. **Definition Confidence man in finding new energy resources**: Man's trust in finding new energy resources.
76. **Definition Human impact or interference**: The effect or hinder of human beings on nature.

Inventions

77. **Definition Invention and discoveries:** Something new discovered and/or developed from study and experimentation which serves a certain goal.
78. **Definition Earlier inventions**: Something which was previously new developed from study and experimentation which serves a certain goal and upon which other inventions may be built.
79. **Definition Discovery ways of tapping new and inexhaustible fuels**: The discovery of possibilities in order to exploit new and inexhaustible fuels.
80. **Definition Miraculous achievements**: An astounding or phenomenal accomplishment.

Transport

81. **Definition Improved transportation system**: Improvements done in the group of the interacting elements which carry or convey things from one place to another.
82. **Definition Transportation system**: The interacting elements to carry or convey things from one place to another.
83. **Definition Pipelines/railroads/highways/automobiles**: Pipelines/railroads/highways/automobiles
84. **Definition Efficient transportation system:** The interacting elements to carry or convey things effectively from one place to another
85. **Definition Transportation costs**: Costs involved with the transportation of substances.
86. **Definition Transportation time**: The amount of time needed to transport substances from one location to another.

Economy

87. **Definition Economy**: System of human activities considering the production, distribution and consumption of commodities and services.
88. **Definition Business enterprise**: A business organization which is accounted with activity directed to profit.
89. **Definition Determination profitability**: The process of arriving at a decision about the profit yield of a substance or process.
90. **Definition Formulation of grand strategy along social-economic lines**: The formulation of the overarching strategy in the social economic area.
91. **Definition Economic process**: The process which involves the human activities concerned with production, distribution and consumption of commodities and services.
92. **Definition Division of labor**: The segmentation of different kinds of labor.
93. **Definition Rise of capitalism**: The development of an economic system in which the producing, distributing and exchanging elements are in private or companies' possession which are allowed to manage these properties in order to achieve the highest profit.
94. **Definition Importance of money**: The significance and influence of the presence of money on the world.

95. **Definition Productive efficiency**: The proportion of effective output compared to the ineffective output in production.
96. **Definition Profit motive**: The reason to act derived from the desire to attain profit.
97. **Definition Returns social economy**: The yield achieved by means of the social economy.
98. **Definition Weight overhead burden**: The weight of the operating expenses.
99. **Definition Required amount of energy**: The amount of energy required.
100. **Definition Required machine resources**: The necessary amount machine resources.
101. **Definition Growth**: The development to a more complex, bigger, more valuable or stronger substance.
102. **Definition Economic life**: The sum of human activities related to the production, distribution, and consumption of commodities and services.

Policy and institutions

103. **Definition Communism**: A governmental system in which the state is in control and where all goods are equally distributed over the people.
104. **Definition Socialism**: A system of social organization in which the producing and distributing agencies are possessed by the government which also designs and controls the economy.
105. **Definition Wise policy**: A smart and informed course of action of a government in order to influence, to be able to make decisions and to take action,
106. **Definition Governmental policy**: A course of action of a government in order to influence, to be able to make decisions and to take action.
107. **Definition Institutions:** The customs, practices, relationships and behavior patterns which are important for a country or organization and specific for that country or organization.
108. **Definition Patents laws/institutions**: **Definition Patents laws/institutions**: The laws governing patents and the customs, practices, relationships and behavior patterns which are important to a country and which are specific for a country.
109. **Definition Organization society**: The formation of a group of human beings, grouped by mutual interests, relationships, institutions and culture.

Social

110. **Definition Social responsibility**: The accountability and liability for actions which are of influence on the human society.
111. **Definition Social harmony:** A state of being wherein the people who live in a society live together in a state of agreement in feeling and opinion.
112. **Definition Safeguarding social basic assets**: The protection and preservation of the fundamental, and valuable aspects of a human society.
113. **Definition Relationships between men**: The existing connections between members of the human population.
114. **Definition Social organization**: A structured sum of elements which contribute to the human society.
115. **Definition Increased human contact:** An increase in the amount of human beings which are in contact with each other.
116. **Definition Complexity social order**: The complexity of the system of social organization.

117. **Definition Living standards**: The level of welfare and requirements of a human society.
118. **Definition Social conditions**: The circumstances in a human society.
119. **Definition Social life**: The human relationships and activities of a human society.

Methods/means/aims

120. **Definition Means**: A method to attain (given) ends.
121. **Definition methods**: A means to accomplish an end.
122. **Definition Aims**: A purpose or goal to which is wanted to be achieved.
123. **Definition Aims for resource utilization**: The purposes or goals for the usage of resources.
124. **Definition Ends**: A goal, want or objective.
125. **Definition Search for means to attain given ends**: A search for methods to achieve certain goals, i.e. a search for resources.

External influences

126. **Definition Closing frontier**: The stop of the movement of the frontier line.
127. **Definition World wars**: The armed conflict between several nations of the world.
128. **Definition Great depression**: The worldwide economic in depression in the decade before World War II.
129. **Definition Barbarism/civil strife:** Brutal, coarse or ignorant actions and war between factions or regions.
130. **Definition Continuation of peace**: The prolongation of peace.

Space

131. **Definition Space**: An (empty) area which can be used for a specific purpose.
132. **Definition Space handicap**: The disadvantages caused by (the abundance of) space.

Communication

133. **Definition Communication**: The activity of exchanging information by signs, gestures, written and printed messages.
134. **Definition Improved communication system**: The advancement of the communication system by means of alterations and improvements.
135. **Definition Efficient communication system:** A communication system which functions effectively with a low waste of effort.

Population

136. **Definition Population growth**: The increase in the total number of inhabitants of a specific race, group or the increase in the number of inhabitants of a certain area
137. **Definition Population density**: The number of inhabitants or their houses, per unit of area.
138. **Definition Optimal population density=man land ratio**: That population density for which the factors nature, culture and man are in perfect balance and the returns of the social economy are maximized.
139. **Definition Excessive population density**: A population density in which the number of inhabitants or housing per area is exceeding the normal or reasonable amount.

140. **Definition population**: The total amount of people living in certain area or being part of a race of class.

Remaining variables

141. **Definition Health**: The well-being of an organism.
142. **Definition Freedom**: The conditions in which an organism is not subject to restraints.
143. **Definition Sense of historical perspective**: The capacity to understand, recognize and appreciate history.
144. **Definition Understanding social processes and phenomena:** The understanding of the processes and phenomena relating to the human society.
145. **Definition Conditions**: The circumstances at present.
146. **Definition Substances**: The tangible matter of which something is made up.
147. **Definition Forces:** An influence which can create physical change or do work.
148. **Definition Global interdependence**: The dependence between countries and people spread over the world.
149. **Definition Pitfalls**: Difficulties, trouble or danger which are not obvious or apparent.
150. **Definition Difficulties Good society**: The problems and difficulties concerned with living together and being a good neighbor which appear due to the increasing complexity of social order.
151. **Definition Demand**: The sum of desire of a population for a certain resource.
152. **Definition Determination technical feasibility**: The process of arriving at the decision on the capability of achievements on the technical area.
153. **Definition Attitudes towards material progress**: The position of human beings concerning the material development.
154. **Definition Necessity**: Something which is deeply needed.
155. **Definition Exhaustion fuel use:** The extreme usage of fuels in such a way in that they could become depleted.
156. **Definition Energy basis**: The distribution of energy sources which are used in country for the supply of energy.
157. **Definition Size performance**: The magnitude of the production (capacity) and accomplishments of a country.
158. **Definition Choice of materials**: The choice of materials which may be utilized in a country.
159. **Definition Energy expenditure**: The amount of energy consumed.
160. **Definition Ignorance**: The state of man in which he lacks knowledge, information or education.
161. **Definition Human folly and cussedness**: The act of foolishness, which presents a lack of understanding or foresight and the stubbornness of man.
162. **Definition Destruction fauna and flora**: The demolishment of the plant and animal life at a certain place or time.
163. **Definition Technology**: The sum of scientific methods and materials used to achieve objectives, electronic or digital products and systems and the body of knowledge concerning technique.
164. **Definition Mobility population**: The capacity of a population concerning physical movements.
165. **Definition Foreign energy/inanimate energy:** Energy which is derived from non-living substances by the means of capital equipment.

166. **Definition Capital equipment**: The equipment which is used to manufacture a product or to be able to deliver a service.
167. **Definition Indirectness = gap between first impression and first reaction**: The increased amount of time and activities which appear between the first impression of something and the first reaction to this impression.
168. **Definition widening horizon**: The increase of available space and options.
169. **Definition Vision**: The capacity to see.
170. **Definition Freedom of motion**: The freedom to move.
171. **Definition Confusion human mind**: A disorder in the human consciousness developed in the brain which shows itself in thoughts, perceptions and actions.
172. **Definition Usage of substances**: The usage of materials.
173. **Definition Historical forces**: Effects which result from history which are of influence on the present
174. **Definition National character**: The sum of properties which are characteristic for a nation.
175. **Definition Actual situation nation**: The current sum of conditions which shape the situation in a country.
176. **Definition National wealth**: The sum of national goods and resources which have value in use or in exchange.
177. **Definition Size and complexity modern nations**: The size and complexity of modern nations.
178. **Definition Decline of competition**: A decrease in competition
179. **Definition Concentration economic power**: The bundling of economic capacities in one place.

19.2 Alterations to the diagram

Resources

- The variables “Resource ship”, “Resource function” and “Resources” may be combined into the variable” Resources”.
- Adding of a positive relation between “Evolvement Resources” and “Resources”.
- Adding of negative relation between the variable “Depletion/demolishment resources” and the variable “Resources”.
- The variables “Military potential” and” Victory” will be combined into the variable “Military potential”.
- The variables “Human appraisal” and “Resource appraisal” will be combined into the variable “Human appraisal of resources”
- Combination of the variables “Man’s resources”, “Net resources” and “Natural-cultural resources” into the variable “Natural-cultural resources”.

Resistances

- Removal of the different examples of resistances from the diagram in order to clarify the diagram. These removed examples are:
  - “Shape of territory”
  - “Ratio effective territory”
  - “Population density”
  - “Topography”

- "Age composition"
- "Population density "
- "Outlook upon security"
- "Spirit of civilization"

Wants

- Combination of the variables "Social objectives", "Group wants/long term" and "Man's objectives into the variable "Group wants/long term".
- The combination of the variable "Changing wants" and "Wants" into the variable "Wants"
- Adding of the relation between the variable "Individual wants/short term" and the variable "Conflict between group and individual interest".
- Adding of the relation between the variable "Social objectives" and the variable "Conflict between group and individual interest".
- The combination of the variables "Conflict" and "Conflict between group and individual interest" into the variable "Conflict between group and individual interest".
- The combination of the variables "Specific needs" and "Wants" into the variable "Wants"
- The combination of the variables "Well-being" and "Want satisfaction" into the variable "Want satisfaction".

Nature

- The combination of the variables "Adaption natural advantages/disadvantages", "Nature given environment", "Physical environment" , "Nature" and the "Nature of the environment" into the variable "Nature".
- The combination of the variable "Natural aspects" and "Natural assets" into the variable "Natural aspects".

Culture

- The combination of the variables "Cultural aspects" and "Cultural assets" into the variable "Cultural aspects".
- The combination of "Blended/alloyed cultures" and "Enriched cultures" into the variable "Enriched cultures".

Arts

- Adding of the relation between "Arts" and "Human productive effort".
- Adding of the relation from the "Development of arts" to "Arts".
- The combination of the variables "State of arts" and "Arts".
- The placement of "Societal Arts" and "Technical arts "under the general term "Arts"

Man

- The combination of the variables "Human aspects " and "Human assets" into the variable "Human aspects"
- Placement of the variable "Knowledge of facts of nature and culture" under the variable "Knowledge /wisdom"

- The combination of the variables “Mental abilities”, “Physical abilities” and “Man’s abilities” into the variable “Man’s abilities”.
- The combination of the variable “Human capacity”, “Man’s capacity to take advantage of opportunities”, “General capacity to take advantage of opportunities”, Man’s abilities” into the variable “Human capacity”.
- Combination of the variables “Human effort” ,**“**Human behavior and effort” and “Human productive effort” into the variable ” Human behavior and effort”
- The combination of the variable “Reactions/adaptions diverse environment” and “Direct Adaption to nature” into the variable “Direct adaption to nature”

Inventions

- The combination of the variables “Inventions and discoveries” , “Earlier Inventions” and “Miraculous achievements” into the variable “Inventions and discoveries”

Transport

- Adding of the relation between the variable “Improvements of arts” towards the variable “Improved transportation system”.
- Adding of the relation between the variable “Improved transportation system” towards the variable “Mobility of population”.
- The placement of the variable “Pipelines/railroads/highways/automobiles” under the variable “Transportation system”.
- Combination of the variable “Efficient transportation system” with the variable “Improved transportation system” into the variable “Improved transportation system”

Economy

- Removal of the variable “Division of labor”.
- Removal of the variable “Rise of capitalism”.
- Removal of the variable “Importance of money”.
- Removal of the variable “Productive efficiency”.
- The placement of the variable “Required amount of energy” under the variable “Weight overhead burden”.
- Placement of the variable “Required machine resources” under the variable “Weight overhead burden”.
- Combination of the variables “Economic life”, “Economic processes” and “Economy” in the variable “Economy”.

Policies and institutions

- The combination of the variable “Wise policy” and “Governmental policies” into the variable “Governmental policies”.
- The combination of the variable “Patent laws/institutions” and “Institutions” into the variable “Institutions”.

Social

- The combination of the variables “Social harmony”, “Health” and “Freedom” into the variable “Intangible aspects”.
- The combination of the variables “Resource consciousness” and “Safeguarding social assets” into the variable “Resource consciousness”.

Methods/means/aims

- The combination of the variables “Means” and “Methods” into the variable ” Methods/means”
- The combination of the variable “Aims” with the variable “Group wants/long term” into the variable “Group wants/long term”.
- The placement of the variable “Aims for resource utilization” under the variable “Aims” which is already placed under the variable “Group wants/long term”.
- The placement of the variable “Ends” under the variable “Group wants/long term”.
- The placement of the variable “Ends” under the variable “Individual wants”

External influences

- Placement of the variables “Great depression” and “Closing frontier” under “External influences”.
- The combination of the variable “Barbarism/civil strife” and the variable “World wars” into the variable “War”.
- The combination of the variable “Continuation of peace” with the variable “War” into the variable “War”.
- Adding of the negative relation between “War” and the “Discovery ways of tapping new and inexhaustible fuels”.

Space: -

Communication:

- The combination of the variable “Efficient communication system” with the variable “Improved communication system” into the variable “Improved communication system”.

Population

- Removal of the variable “Population density”.
- The placement of the variable “Excessive population density” under the variable “Optimal population density=man land ratio”.
- The positive relation between “Excessive population density” and ”Transport costs” will then be changed into a negative relation between ““Optimal population density=man land ratio” and “Transport costs”.

Remaining variables

- The placement of the variable “Health” under the variable “Intangible aspects”.
- The placement of the variable “Freedom” under the variable “Intangible aspects”.
- Placement of the variable “Pitfalls” under the variable “Difficulties Good society’’.
- Removal of the variable “Attitudes toward material progress”.

- Adding of the (positive) relation between the variable “Exhausting fuel use” and the variable “Depletion/demolishment resources”.
- The combination of the variables **“**Ignorance” and “Human folly and cussedness” into the variable “Human ignorance, folly and cussedness”
- Removal of the variables: “Widening horizon”, “Vision” and “Freedom of motion”.

19.3 Definitions new variables:

1. **Definition Resources**: The state or condition in which substances are able to function in such a way the given ends may be achieved and wants are satisfied.

Table 185 New variable Resources

Name	Variables included in the variable
Resources	Resource ship
	Resource function
	Resources

2. **Definition Military potential**: The military potential of a country

Table 186 New variable Military potential

Name	Variables included in the variable
Military potential	Military potential
	Victory

3. **Definition Human appraisal of resources**: The human judgment on the want satisfying capacity of their environment.

Table 187 New variable Human appraisal of resources

Name	Variables included in the variable
Human appraisal resources	Resource appraisal
	Human appraisal

4. **Definition Natural cultural resources**: Substances which may perform or function to attain given ends and satisfy wants, since the obstacles and resistances concerning these aspects have been overcome.

Table 188 New variable Natural cultural resources

Name	Variables included in the variable
Natural cultural resources	Man’s resources
	Net resources
	Natural cultural resources

5. **Definition Group wants/long term**: The wants and objectives of a human population.

Table 189 New variable Group wants/long term

Name	Variables included in the variable
Group wants/long term	Social objectives
	Man's objectives
	Aims
	Aims for resources utilization
	Ends

6. **Definition Conflict between group and individual interest**: A state of disharmony between group and individual wants and objectives.

Table 190 New variable Conflict between group and individual interest

Name	Variables included in the variable
Conflict between group and individual interest	Conflict
	Conflict between group and individual interest

7. **Definition Wants**: Mans required or wanted aspects.

Table 191 New variable Wants

Name	Variables included in the variable
Wants	Wants
	Changing wants
	Specific needs

8. **Definition Want satisfaction:** The fulfillment of desires which brings people in a condition in which they are healthy and enjoying welfare.

Table 192 New variable Want satisfaction

Name	Variables included in the variable
Want satisfaction	Well-being
	Want satisfaction

9. **Definition Nature**: The physical and dynamic environment offered by nature which brings both limits and opportunities.

Table 193 New variable Nature

Name	Variables included in the variable
Nature	Nature
	The nature of the environment
	Nature given environment
	Physical environment
	Adaption natural advantages/disadvantages

10. **Definition Natural aspects:** Elements or facets of nature.

Table 194 New variable Natural aspects

Name	Variables included in the variable
Natural aspects	Natural aspects
	Natural assets

11. **Definition Cultural aspects**: Elements or facets of culture.

Table 195 New variable Cultural aspects

Name	Variables included in the variable
Cultural aspects	Cultural aspects
	Cultural assets

12. **Definition Enriched culture:** A fuller and more meaningful culture due to the influence of other cultures.

Table 196 New variable Enriched cultures

Name	Variables included in the variable
Enriched cultures	Enriched cultures
	Blended/alloyed cultures

13. **Definition Arts:** The sum of human capacities, skills and effort to alter nature, both on the societal and technical area.

Table 197 New variable Arts

Name	Variables included in the variable
Arts	Arts
	State of the arts
	Societal arts
	Technical arts

14. **Definition Human aspects**: The notable features of mankind.

Table 198 New variable Human aspects

Name	Variables included in the variable
Human aspects	Human aspects
	Human assets

15. **Definition Knowledge/wisdom**: The understanding and awareness of information which has been discovered experienced or learned through the ages.

Name	Variables included in the variable
Knowledge/wisdom	Knowledge/wisdom
	Knowledge of facts of nature and culture

16. **Definition Human capacity**: The human abilities or capabilities which make human beings attain their objectives.

Table 199 New variable Human capacity

Name	Variables included in the variable
Human capacity	Human capacity
	Man's capacity to take advantage of opportunities
	general capacity to make use of the environment
	Man's abilities
	Mental abilities
	Physical abilities

17. **Definition Human effort and behavior**: The physical or mental energy and the related actions or reactions put into a subject by man.

Table 200 New variable Human effort and behavior

Name	Variables included in the variable
Human effort and behavior	Human effort and behavior
	Human effort
	Human productive effort

18. **Definition Direct adaption to nature**: The direct adjustment and reactions of men to get adapted to their environment.

Table 201 New variable Direct adaption to nature

Name	Variables included in the variable
Direct Adaptations to nature	Direct adaption to nature
	Reactions/adaptions diverse environments

19. **Definition inventions and discoveries:** Something discovered and/or developed from study and experimentation which serves a certain goal and provides a new machine, method or process both today or in earlier days.

Table 202 New variable Inventions and discoveries

Name	Variables included in the variable
Inventions and discoveries	Inventions and discoveries
	Earlier inventions
	Miraculous achievements

20. **Definition transportation system**: The interacting elements to carry things from one place to another.

Table 203 New variable Transportation system

Name	Variables included in the variable
Transportation system	Transportation system
	Pipelines/railroads/highways/automobiles

21. **Definition improved transportation system**: Improvements done in the group of the interacting elements of transport to carry things from one place to another.

Table 204 New variable Improved transportation system

Name	Variables included in the variable
Improved transportation system	Improved transportation system
	Efficient transportation system

22. **Definition Weight overhead burden**: The weight of the operating expenses.

Table 205 New variable Weight overhead burden

Name	Variables included in the variable
Weight overhead burden	Weight overhead burden
	Required amount of energy
	Required machine resources

23. **Definition Economy**: The sum, processes or system of human activities related to the production, distribution, and consumption of commodities and services.

Table 206 New variable Economy

Name	Variables included in the variable
Economy	Economy
	Economic processes
	Economic life

24. **Definition Governmental policy**: A course of action of a government in order to influence and be able to make decisions and to take action.

Table 207 New variable Governmental policy

Name	Variables included in the variable
Governmental policy	Governmental policy
	Wise policy

25. **Definition Institutions:** The laws and the customs, practices, relationships and behavior patterns important for a country or organization and specific for that country or organization.

Table 208 New variable institutions

Name	Variables included in the variable
Institutions	Institutions
	Patent laws/institutions

26. **Definition Intangible aspects:** Aspects which are material or physical such as health, social harmony, policy, freedom and knowledge.

Table 209 New variable Intangible aspects

Name	Variables included in the variable
Intangible aspects	Health
	Freedom
	Social harmony

27. **Definition Resource consciousness:** The acknowledgement and alertness on the importance of resources and the protection and preservations of these valuable aspects of human society.

Table 210 New variable Resource consciousness

Name	Variables included in the variable
Resource consciousness	Resource consciousness
	Safeguarding basic social assets

28. **Definition Methods/means:** A means or method to attain given ends.

Table 211 New variable Methods/means

Name	Variables included in the variable
Methods/means	Means
	Methods

29. **Definition External influences:** Historical events which are of big influence and which were hard to influence by individual governments.

Table 212 New variable External influences

Name	Variables included in the variable
External influences	Closing frontier
	Great depression
	Continuation of peace

30. **Definition war:** Armed conflict between nations.

Table 213 New variable War

Name	Variables included in the variable
War	barbarism civil strife
	World wars
	Continuation of peace

31. **Definition improved communication system**: The advancement the communication system by alterations and improvements.

Table 214 New variable Improved communication system

Name	Variables included in the variable
Improved communication system	Improved communication system
	Efficient communication system

32. **Definition Optimal population density=man land ratio**: That population density for which the factors nature, culture and man are in perfect balance and the returns of the social economy are maximized.

Table 215 New variable Optimal population density=man land ratio

Name	Variables included in the variable
optimal population density = man land ratio	Optimal population density = man land ratio
	Excessive population density

33. **Definition Difficulties Good society**: The problems and difficulties concerned with living together and being a good neighbor due to the increasing complexity of social order.

Table 216 New variable Difficulties good society

Name	Variables included in the variable
Difficulties Good society	Difficulties Good society
	Pitfalls

34. **Definition Human ignorance, folly and cussedness:** The state of man in which he lacks knowledge, information or education and lacks the understanding capacity to oversee the consequences of an act on nature and its resources.

Table 217 New variable Human ignorance, fully and cussedness

Name	Variables included in the variable
Human ignorance, fully and cussedness	Ignorance
	Human folly and cussedness

19.4 Simplified causal relation diagram

The suggested alterations in paragraph 19.2 lead to the following causal relation diagram. Again, this diagram can also be found in a more readable version in appendix VI.

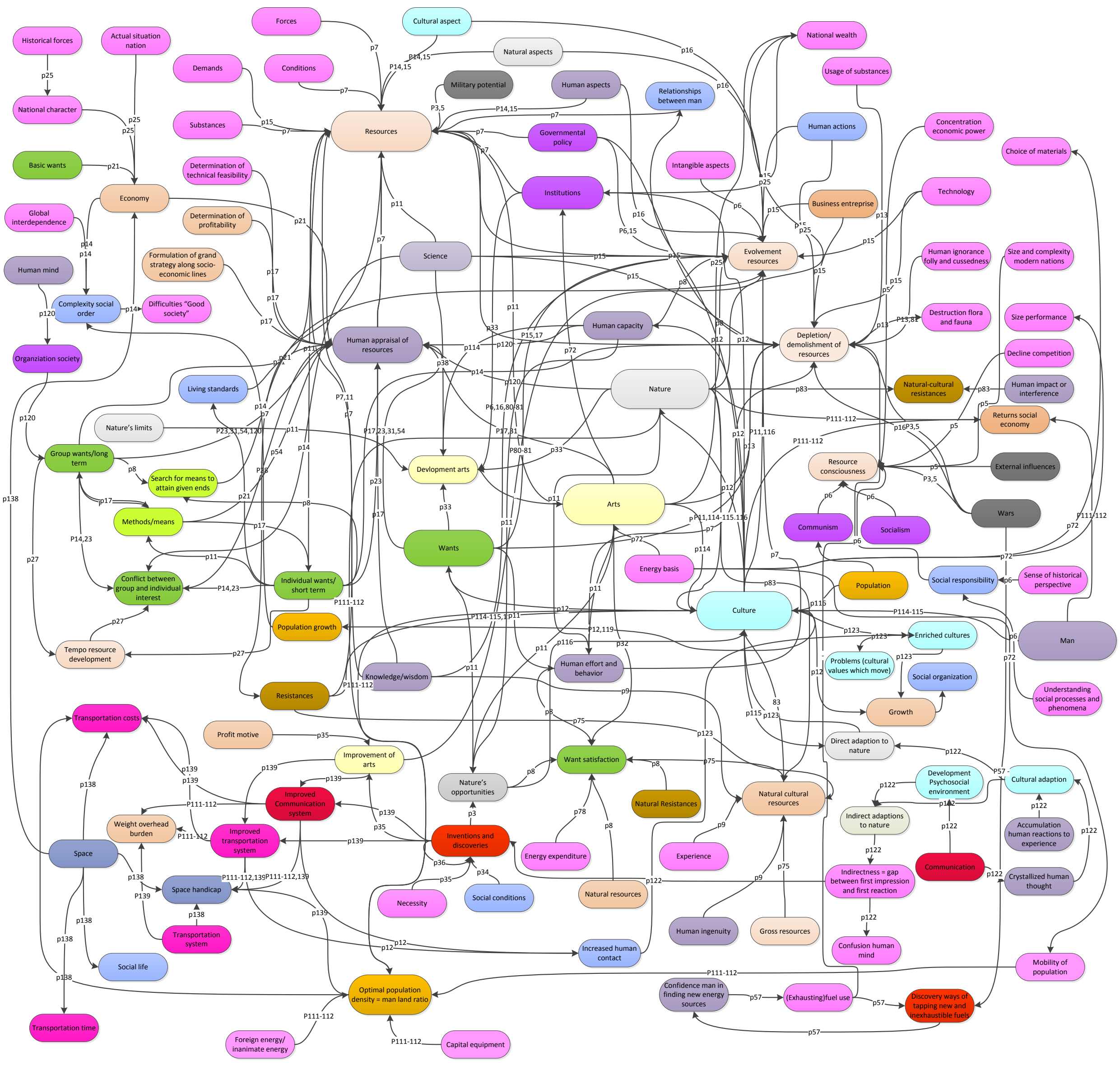


Figure 36 Simplified causal relation diagram

Appendix II Development Zimmerman framework

In this appendix the steps towards the development of the ‘Zimmerman framework’, already briefly stated in chapter three, are more thoroughly explained.

Usage of the causal relation diagram

The initial causal relation diagram was used to provide an overview of Zimmerman’s theory .The development of this causal relation diagram was necessary, since Zimmerman’s theory is quite extended, complex and unstructured which may make it hard for the reader to extract the essential parts of Zimmerman’s theory. The development of this initial causal relation diagram is the first step to extract and summarize the core of Zimmerman’s theory.

This initial causal relation diagram was then altered and simplified into the simplified causal relation diagram. The alterations done to the initial causal relation diagram are presented in paragraph 19.2. The simplified and improved causal relation diagram forms the input for the framework. Since this diagram is still quite complex and unstructured, it is challenging to convert this diagram directly into a framework. Therefore another step is taken in between. In this step the variables which are most significant in the analysis of Zimmerman have to be identified. In order to identify these variables, first the variables which contained the most relations with other variables were identified. The reason for this approach can found in the expectation that the variables which have the most relations with other variables, will also present the largest share of the theory. However, since the theory of Zimmerman is rather complex and unstructured, the amount of relations is not the only criterion. The identified variables will also be judged on their validity, by the usage of the complete theory if Zimmerman and common sense. Variables which have many relations, but which are obviously not representing one of the most important elements of theory will not be included in the framework.

The variables which contained three or more relations are taken into consideration and are circled in the figure below. Though, one exception has been made. This exception is the variable “Man”. This variable only has two direct relations. Though, since it is one of the resource creating factors according to Zimmerman, this variable is also circled and taken to the next step of the development of the framework.

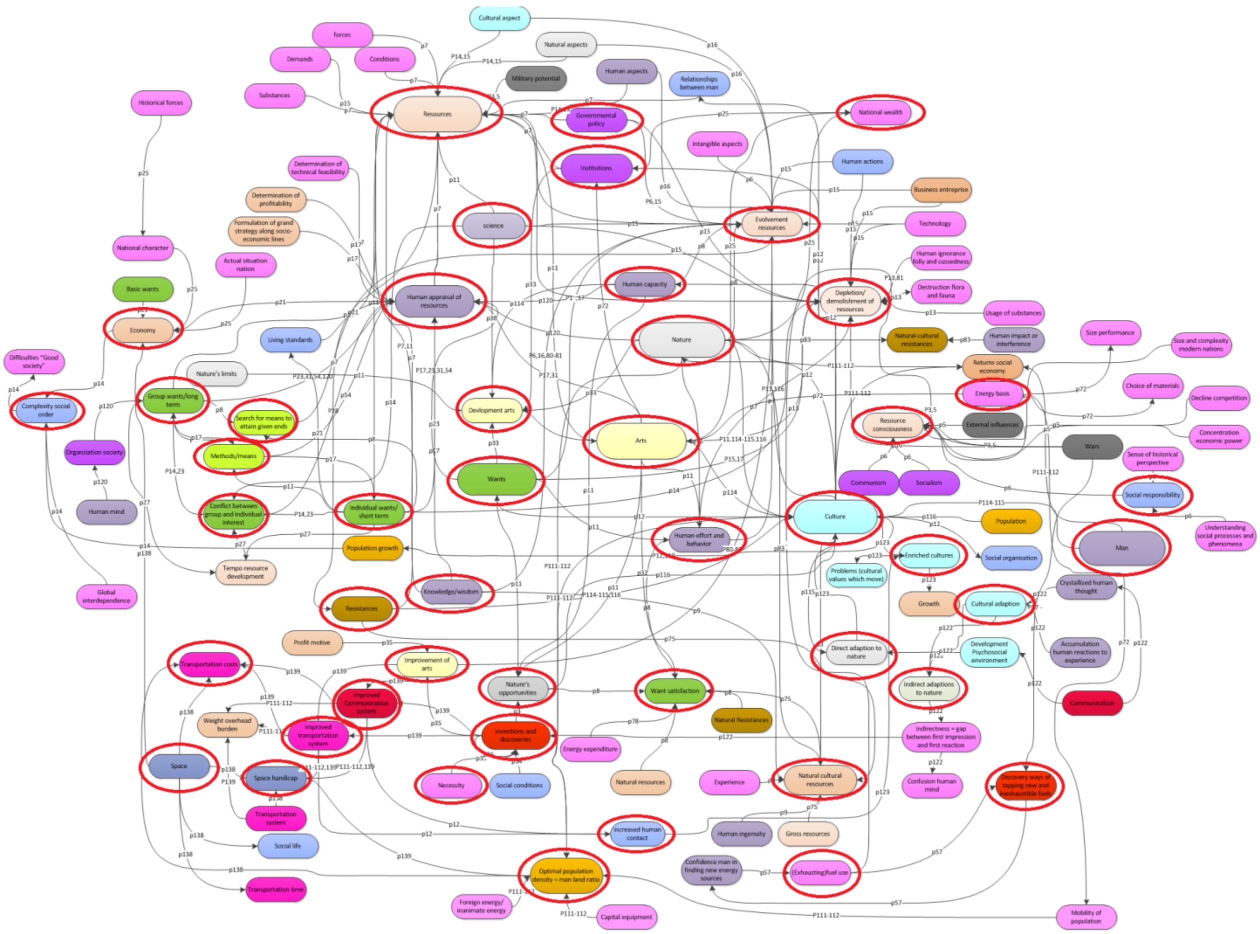


Figure 37 Simplified causal relation diagram with circled variables

The variables which are marked by a circle are also presented in the table below. The number behind the variable presents the number of relations with other variables in the causal relation diagram. This number is only presented for variable placed in the columns which have multiple options for the amount of relations.

Table 218 Variables and their relations

Variables with 8 or more relations	**Variables with 6-7 relations**	**Variables with 5 relations**	**Variables with 4 relations**	**Variables with 3 relations**
Resources (20)	Nature's opportunities (6)	Improvement arts	Group wants/long term	National wealth
Human appraisal of resources (15)	Improved communication system (6)	Improved transportation system	Enriched cultures	Governmental policy
Nature (10)	Human effort and behavior (6)	Human capacity	Cultural adaption	Search for means to attain given ends
Evolvement Resources (16)	Economy (6)	Space handicap	Energy basis	Weight overhead burden
Depletion/demolishment resources (14)	Optimal population density (7)	Science	Transportation costs	Increased human contact
Culture (18)	Want satisfaction (7)	Space	Resistances	Direct adaption to nature
	Development arts (7)	Conflict between group and individual interest	Knowledge/ wisdom	Indirect adaptions to nature
Arts (10)	Resource consciousness (7)	Institutions	Group wants/long term	Necessity
Wants (8)			Complexity social order	Discovery ways of tapping new and inexhaustible fuels
Individual wants/short term (8)			Methods/means	Social responsibility
Inventions and discoveries (8)				War
Natural cultural resources (8)				Returns social economy

* Man is not included in this table since this variable only contains two relations

With the variables and their number of interrelations identified, this information is used to identify the primary factors which will form the core of the 'Zimmerman framework'. Second, the factors which can be categorized under these primary factors are identified. From the first category, with eight or more relations, the variables Resources, Nature, Culture, Arts and Wants are obvious primary factors. First, these variables fulfill an important share in the theory of Zimmerman concerning the functionality and development of resources. Second, because of the presence of these variables in the diagrams provided by Zimmerman in his book *World resources and industries* (figure 5 and 11). Third, the variables contain a significant amount of interrelations with other variables.

After the identification of these first primary factors, the remaining factors are considered in order to find the remaining primary factors. These factors are primary factors if they contain many relations and cannot be represented by another (primary) factor. This leads to the identification of the primary factor

Economy. This factor has six relations with other variables and cannot be represented by another variable. Hereafter, the variable Human capacity is identified as a primary factor. This variable was also already introduced in the theory of Zimmerman as a strong influence on Arts, contains five relations and cannot be represented by other variables. The last primary factor which can be identified from the table is the variable 'Resistances'. As stated by Zimmerman resources cannot be without resistances, so this variable could not be missing from the framework. Furthermore it contains four relations and cannot be represented by other primary factors. Finally, the variable Man will form a primary factor, even though the variable is not present in the table. The reason for this can be found in the fact that the variable fulfills an important function as one of the original resource creating factors. Substances could never become a substance if Man does not pose Wants or develops Arts.

From this analysis, table 219 is developed. This table presents which variables are identified as primary factors and which variables can be placed under these primary factors. These primary factors may therefore be also considered categories under which the rest of the factors will be located. The remaining factors will be placed either in the second or the third ring of the framework. The factors placed in the second ring consider further specified factors than the primary factors and which can be categorized under the primary factor. These factors may add information to the understanding of the primary factor. Human effort and behavior is, for example a more specified variant of the primary factor human capacity. In the third ring, the effects or products of the primary factors and the influences on the primary factors are located.

The second and third ring are placed around the ring of primary factors in the 'Zimmerman framework'. The ring of primary factors is placed around the center of the framework, which is formed by the factor Resources. The reason that the factor resources is presented as the center of the framework is because the framework is developed to understand the factors which are of influence on the development and functionality of resources and all the surrounding primary factors are of influence on this factor.

In addition, there are two types of factors which will not be placed in any of the rings. These are the external factors and the factors which can be considered as the result of the development and functionality of resources.

The variable "External influences" represents the factors which have an effect on the development and functionality of resources, but which cannot always be influenced by individual governments. The variables which are located under the variable "External influences" were all examples of external influences stated by Zimmerman, and were of influence on the variable "Resource consciousness". However the variable "External influences" in the framework is a more general variable which may also contain external influences which are not only of influence on the "Resource consciousness" Next, the variable "Wars" is also integrated as an external factor on the development and functionality of resources. This variable contained three relations with other variables, though it has an important role in the depletion and demolishment of resources. Therefore, this factor is also added as an external factor, which is of influence on the development and functionality of resources.

The factors which are considered the result of the development and functionality of resources, and which will be presented as outgoing arrows, are “Want satisfaction”, “Depletion/demolishment resources”, “Evolvement resources”, “Resource consciousness” and “Energy basis”.

Table 219 Primary, secondary, tertiary factors

Primary factors	Factors in the second ring	Factors in the third ring
Arts	Development arts	Inventions and discoveries
	Improvement arts	Improved communication system
		Improved transportation system
		Discovery ways of new and inexhaustible fuels
		Technology
		Science
		Methods/means
		Search for means to attain given ends
Culture	Cultural adaption	Enriched cultures
	Indirect adaption to nature	Knowledge/wisdom
	Direct adaption to nature	
Human appraisal of resources	-	Knowledge/wisdom
Economy		Weight overhead burden
		Returns social economy
		National wealth
		Transportation costs
Human capacity	Human effort and behavior	Human folly and cussedness
	Human actions	
Man		Population
		Population growth
		Man-land ratio
		Increased human contact
Resistances		Space handicap
Nature	Natural resources	Nature’s opportunities
	Natural-cultural resources	
		Space
Institutions		Governmental policy
		Social responsibility
		Complexity social order
Wants	Group wants/long term	Necessity
	Individual wants/short term	Conflict between group and individual interest
Resources		

With the factor(s) in the center, the first ring, the second ring and the third ring, the external influences and the result of the development and functionality of resources identified, the initial 'Zimmerman framework' can now be created. This initial Zimmerman framework is presented below. A better readable version of this framework can be found in appendix VI.

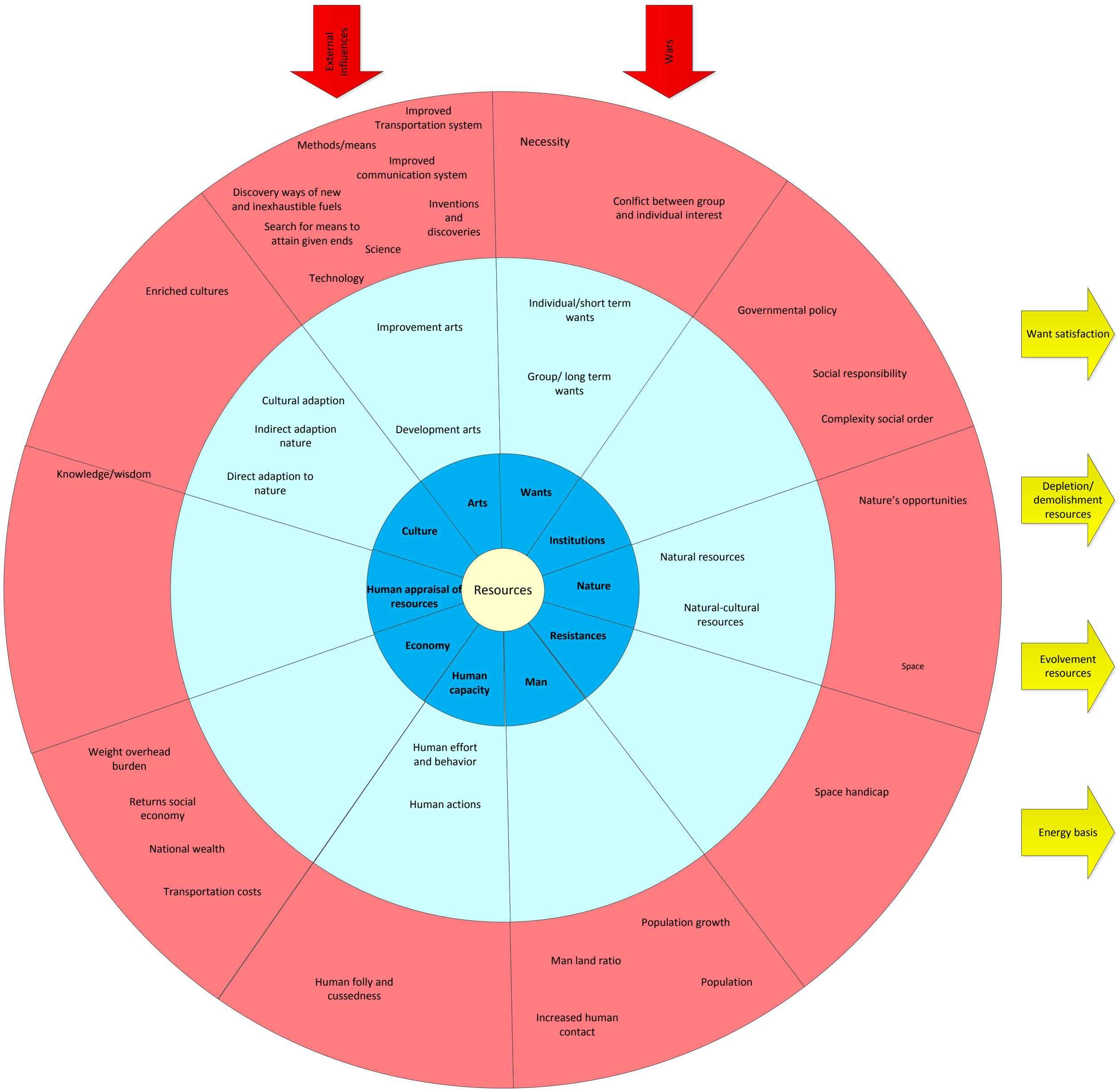


Figure 38 The iinitial Zimmerman framework

Adding of the Zimmerman categories

After the development of this initial Zimmerman framework, based on the simplified causal relation diagram, this diagram is further completed with the theory of Zimmerman. This completion will consider the addition of sub-categories for some of the primary factors, as described by Zimmerman, and the addition of secondary factors for the primary factor "Human appraisal of resources" since the factors which explain the factor "Human appraisal of resources" only contain one relation in the causal relation diagram and were therefore not integrated in the framework in the previous step.

The complete framework, according to Zimmerman, will then be operationalized and tested in the next appendix. During this operationalization, it will be determined which factors are indeed important, which are abundant and which may still be missing for the description of the development and functionality of a resource according to Zimmerman.

Sub categories according to Zimmerman

In paragraph 3.1 distinctions and categories for the primary factors Arts, Wants, Resistances, Economy and Culture according to Zimmerman are presented. These distinctions and categories may be considered sub categories of the primary factors and will therefore be placed in the second ring of the framework. The following sub categories of the primary variables will be added to the second ring of the framework:

Arts:

- Material technical arts
- Societal/institutional arts
- Arts which render more effective man's productive effort
- Arts which render the environment more amenable

Wants

- Cultural wants
- Basic wants

Resistances

- Direct Primary human resistances (ignorance and cussedness)
- Direct secondary human resistances (results from complexity)
- Secondary direct cultural resistances (bad capital, obsolete equipment)
- Primary indirect natural resistances (distance, distribution raw materials)
- Primary indirect human resistances (population density, age composition)
- Secondary indirect natural resistances (primary aspects influences by culture)
- Secondary indirect cultural resistances (dead hand from the past, Abortive policies)
- Secondary indirect human resistances (conflict)

Economy

- Activities left to individual and private initiative
- Activities left to public and social control
- Activities of the third economy (activities left both individual initiatives and public control)

Culture

- Cultural modification of the non-man environment
- Cultural changes affecting human attitudes and human relations
- Tangible changes of the natural environment which may be called capital equipment
- Intangible changes such as technique, knowledge acquired skills

Furthermore, Zimmerman differentiates in factors which produce and which condition resources (see figure 10). Since, there are no second ring and third rings for the factors resources, these sub factors are divided over the categories Nature, Man and Culture. The factors are divided over these three categories since the factors consider Natural aspects, Human aspects (man) and Cultural aspects. Also, these sub-factors will be included in the framework.

For the primary factors Nature and Man, based on the categories under resources, the following sub categories are added:

Nature

- Nature's primary conditioning factors
- Nature's secondary conditioning factors

Man

- Primary human factors of resource production (native abilities and drive)
- Secondary human factors of production (human capacities through training, experience)
- Primary human conditioning factors (social attitudes favorable to "living together)
- Secondary human conditioning factors (Constructive labor, attitudes, management)

Zimmerman also provides the variables "Secondary cultural factors of resource production" and the variable "Secondary cultural conditioning factors". Though, these variables will not be included in the framework since these variables imply the same as the sub-categories already provided under culture. For example, the variable "Secondary cultural resource producing factors" may for instance relate to capital equipment. Though, capital equipment is also considered as a tangible change of the environment, for which a variable is already present in the framework. Thus, the variable "Secondary cultural resource producing factors" could represent the same as the variable "Tangible changes of the environment". Therefore, the variable only one variable will be integrated in the framework. This variable is "Tangible changes of the natural environment". Next is the second abundant category, the "Secondary cultural conditioning factors". Examples of the "Secondary cultural conditioning factors" are institutions and accumulated knowledge. These examples may also fall under the subcategories cultural changes which affect human attitudes and relations or the subcategory intangible changes such as technique and knowledge. This implies that the variable "Secondary cultural conditioning factors" does not add a new and distinctive sub category. Therefore, the variables "Secondary cultural factors of resource production" and the variable "Secondary cultural conditioning factors" are not integrated in the framework, since it would create factors for which the same information could be attained.

Human appraisal of resources

The final alteration to the framework, based on the theory of Zimmerman, considers the primary factor "Human appraisal of resources". For this primary factor, there are no secondary or tertiary factors present in the framework which can help explain this primary factor. This because the factors which explain the variable human appraisal, only contained one relation in the causal relation diagram, the one with human appraisal. Therefore, these variables were not circled in the causal relation diagram and taken to the next step of this analysis. However, in order to understand the building blocks of the variable human appraisal these variables have to be added to the framework. For this reason, in the test framework the factors which are of influence on the human appraisal in the theory of Zimmerman are added. These are

- The determination of technical feasibility
- The determination of profitability
- Formulation of grand strategy along socio-economic lines

The factors "Knowledge and wisdom", "State of arts" and "State of Wants" are also of influence on the human appraisal, however these factors are already included in the framework. Therefore, these factors are not added in the secondary or third ring under the primary factor "Human appraisal".

The addition of these sub categories provides the following test framework. This framework is also provided in more readable version in appendix VI. This framework will now operationalized in appendix III, by means of Zimmerman's own theory on coal, to identify if the framework indeed does represent those variables which are considered important to describe the development and functionality of a resource, according to Zimmerman.

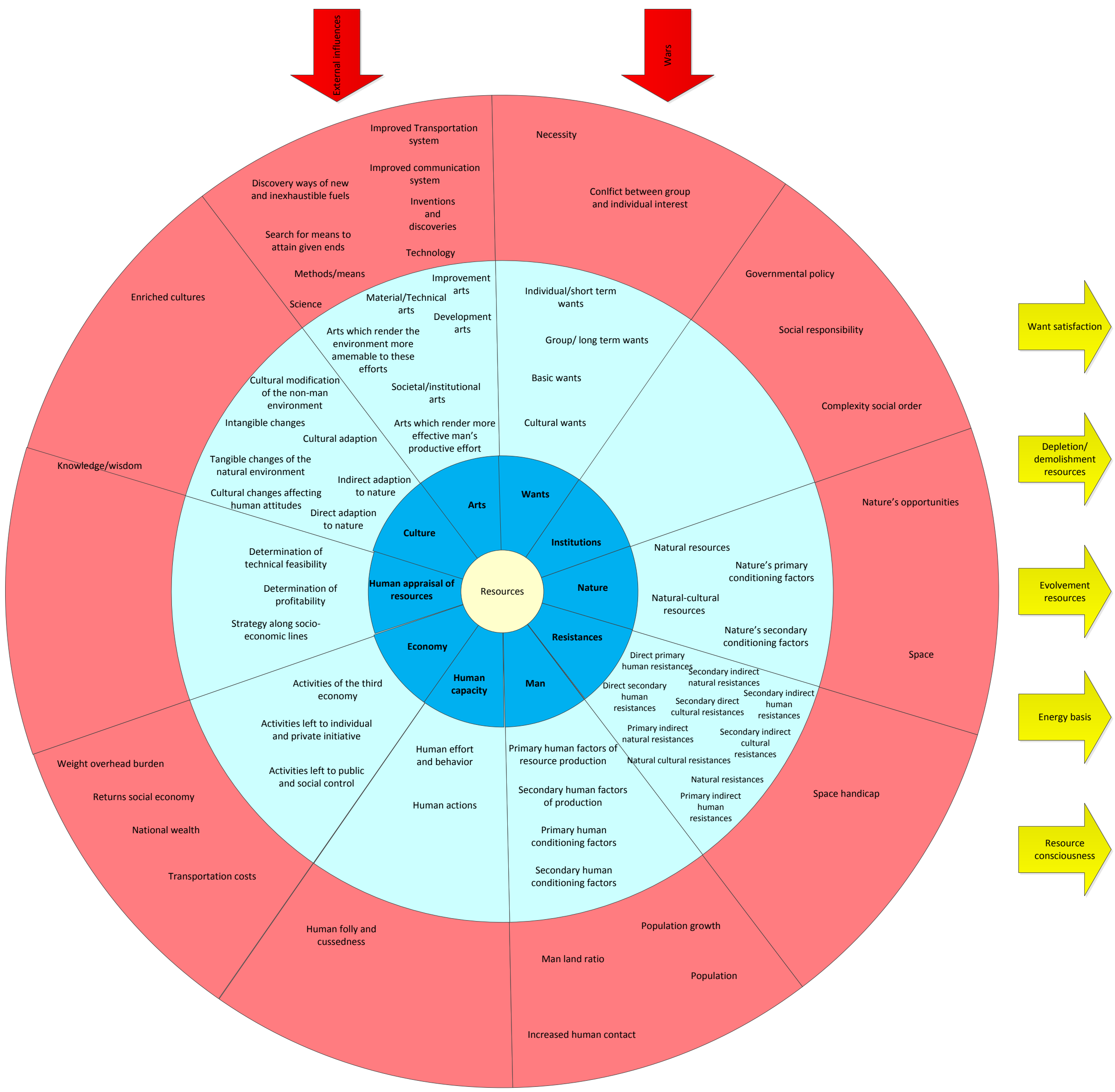


Figure 39 Test framework

Appendix III

In this appendix the test framework, develop in appendix II, is operationalized with the theory on the evolution and functionality of coal. This theory is provided by Zimmerman and can be found in the chapters 24,25, 26, 27, 28 and 29 of his book *World resources and industries*. The reason for this operationalization is to confirm if the framework contains all the variables necessary to describe the development and functionality of a resource. Since Zimmerman provides quite an extended description on the development and functionality of coal, this substance is chosen for the operationalization of the framework.

During this operationalization, the theory on coal is analyzed and the statements found in the theory which underline the presence of a factor in the framework are presented in tables. For every primary factor a table is developed. In this table the statements from E.W. Zimmerman on the development and functionality of coal, for this primary factor, are placed. The statements are categorized under the second or tertiary factors of the primary factors. Hence, these statements are able to validate the presence of these secondary and tertiary factors, and there with the presence of the primary factors. If necessary, the part of the statement which is relevant is made bold.

It may happen that even though statements will underline the importance of a factor, the factors may still be removed if the same information can be located under multiple factors. Otherwise, the factors would not provide additional information but a duplication of the information, when describing the development and functionality of a resource. So, in that situation only one of the factors under which this type of information can be categorized will be maintained and the other factors will be considered abundant. Furthermore it may occur that no statement is found which underlines the presence of a factor according to E.W. Zimmerman. However, this does not directly lead to an elimination of the factor. When the factor is still considered important for the analysis of the development and functionality of a resource according to the writer, the factor may still be maintained.

The filled out tables and the comments following from these tables are presented below. Just as in appendix I, the text stated in italic considers statements which are literally retrieved from *World resources and industries* from E.W. Zimmerman. The number of the page on which this statement can be found, are in these tables presented after the statement. The quotes again represent that statement on the relation of the previous variable, also is applicable for this variable. In second paragraph of this appendix, the necessary changes resulting from the operationalization phase are presented. Finally, in paragraph three of this appendix the conclusion of this operationalization is presented.

1. Validation Zimmerman framework

In this paragraph, the tables for the primary factors Arts, Wants, Nature, Culture, Institutions, Resistances, Man, Human capacity, Economy and Human appraisal of resources are presented. In these tables the statements of E.W. Zimmerman which underline the presence of the secondary or tertiary factor associated with the primary factors are placed. The comments provided in the table may clarify the statements of Zimmerman and therewith why the secondary or tertiary factor is important in the development or functionality of coal. The underlining of these secondary and tertiary factors also validates the presence of the primary factors. If no statements are found which may categorized under a factor, the row of the specific factor is kept blank.

Arts

Table 220 Operationalization Primary factor Arts

Type of arts	Information from Zimmerman	Comments
Material/technical arts	*It is also the source of valuable materials such as gases, oils, tar and pitch, from which in turn an infinite array of chemical products can be extracted. (455)*	Technical arts are able to create other products of coal, which create new functions for the substance coal as a resource.
	Carbon derived mainly from coke, a refined state of coal, is an indispensable ingredient of steel, the sinew of machine industry and of mechanized warfare. (p455)	Technical arts are able to make steel from the substance coal, and therefore add a function for the substance coal as a resource.
	The fact that coal has lost some its importance during recent decades is in part due to discoveries of new sources of heat and energy and to new developments affecting the use of fuels, and in part due to the fact that coal is less suitable for certain purposes than other fuels. (p456)	Coal has lost some of its functions to other substances due to the development of technical/ material arts. Also, due to material/technical arts, other substances which are more suitable for specific functions are discovered.
	One should not overlook the fact that while the output of coal has no more than held its own, the energy obtained from this fuel has increased rapidly. For like other fuels, coal today yields far more actual heat and energy than it did thirty years ago. In the second place, as was mentioned before, not all fuels are solely for the generation of energy. Most anthracite, bituminous and a considerable amount of fuel oil and natural gas are used for space heating. Moreover, considerable and increasing amounts of the mineral fuels are used for purposes other than conversion into heat	An increase in energy which can be derived from this substance is achieved by improvement in the Technical/material arts. Therefore the 'resource' coal increases due improvement in the technical/material arts. The type and amount of functions of coal increased due technical and material arts.

	and energy. (Coal to coke etc.) (p485)	
	The declining role of coal in the energy economy of the united states is the result of the triumph of negative forces of decline over positive forces of growth. Pertinent factors of expansion and contraction are as follows: *1) Expansion* *a. Growth of population* *b. Expansion of industrial output* *c. Increased coal requirements of particular industries which have been growing* ***d. New uses of coal*** ***e. New techniques of coal*** *2) Contraction* *a. The depressed status of such important coal-consuming industries as railway and steamship transport.* *b. The displacement of coal as a fuel by fuel oil, natural gas, and water power.* ***c. Its displacement as a raw material by the shift to a process whereby more steel is obtained through*** *the remelting of scrap than through the remelting of iron ore* ***d. Higher fuel efficiency in the coal consuming industries, particularly iron and steel manufacture, electricity supply, railway and steamship transport. The forces of contraction, which as we have said, proved stronger than the expansion forces, fall into two distinct categories:*** *1) Those stemming from outside the coal economy, especially competition from other fuels and of water power, and, indirectly, the greater reliance on scrap as a source of steel* ***2) Those connected with the more efficient utilization of coal itself.*** *(p486)*	Technical/materials arts both provide new possibilities and new technologies to use coal. Due to technical/material arts less coal is necessary for the making of steel, due to the remelting of scrap and the higher fuel efficiency.
	Coal has been used for many centuries for household purposes and by individual craftsmen, such as smiths, brewers, and others. (p455)	Coal has functioned as resource for many kinds of technical and material arts.

	Needless to say, the suitability of coal is purely relative. For example, the substitution of the modern by product coke oven for the old-fashioned beehive oven has revised the definition of good coking coal. Changes in furnaces and boilers similarly affect the suitability of coals, the increasing use of powdered coal being especially noticeable. (p461)	Changes in technical/materials arts bring changes in the suitability of the substance coal to function as a resource.
	One conclusion should be crystal clear from this estimate of the coal reserves of the united states; unless truly fantastic improvements in the state of the arts are achieved, our descendants will have to pay far more for coal than the prices paid both in the past and at present. Large portions of the coal reserves listed by Campbell are of such poor quality, are located in such out-of-the-way corners, are so unfavorable as to thickness of vein, depth, etc. that only unheard-of-ingenuity or desperate need will render them available for use. In other words, they are not commercial reserves now, and they may never be. (p462)	Some ‘resources’ are not yet resources. Though these substance could become resources if it would be possible to improve the technical/material arts.
	It is indeed difficult to imagine a more ideal distribution of specific types of coal than that found in Britain. Unfortunately much of this advantage of location is offset by unfavorable working conditions which account for high pit prices and which have been aggravated by prolonged exploitation. In the united states the argument is occasionally heard that the British fell behind in the technical proficiency of coal mining, especially behind the united states and Germany. Since the government has taken over the coal mines, however some efforts to raise the efficiency of Britain’s coal mines have	Due to a lack of material/technical arts the benefits of the optimal natural conditions in Britain may be lower than they could be.

	been made. (p468)	
	The Ruhr district possesses an unusual combination of favorable circumstances. It has the greatest coal reserves in Europe, the seams being, relatively both thick and numerous. Its coal field is the best located on the continent. The deep and regular Rhine river provides a magnificent navigable waterway through the western part of the field, and adjoining canals lead through the district. A dense network or railroads connects the Ruhr with other parts of Germany and Europe. The high state of German technical development found expression in efficient mining and extensive use of coal products. A powerful national organization of production and sales stabilized exploitation. (p469)	The material/technical arts led to efficient mining and extensive use of coal products in Germany. This has led to an advantage for Germany.
	Different methods to mine coal are used in the US and in Europe. In the US they use the "room and pillar system" which leaves pillars of coal behind. In Europe the "long wall system" is used which removes all the coal and replaces it with other material. From this it may be concluded that the U.S. is long on coal and short and labor while in Europe it is the other way around. (p481)	Due to the different long and short factors present in the Europe and the U.S. the material/technical arts have developed differently in these areas.
	Coal used to be the least efficiently used fuel and it had the most gain from technological improvements, but certain limitations inherent in the nature of coal make it likely to the underdog in the interfuel fight- at least in the near future (p486)	The technical arts had a positive influence on the usage and exploitation of coal, though natural limitations concerning the usage of coal are still present.
	It is true that, in response to the higher wages demanded by strongly organized union labor, remarkable progress in	Due to the wants for higher wages, improvements of arts were required. This maintained

	mechanization has been made. Thus while, in 1896 less than 12 percent of all bituminous coal was cut by machine, the figure for 1946 was over 90 percent. (487)	the profitability of the substance coal.
Societal institutional arts	-	
Arts which render more effective man's productive effort	-	
Arts which render the environment more amenable	*Thus coal is the backbone of America's land transportation system, as it was, throughout critical decades, of the water transportation system upon which rests the British empire. Coal has been "the key to the carrying trade" when that trade grew from its formative stage to its world-conquering manhood. (456)*	Material/technical arts resulted in improved transport possibilities, which have made the transport of coal and other energy sources easier.
Inventions and discovery	*As a major factor world history, coal dates only from the eighteenth century. Its "coming of age" is accounted for by many factors, among which the following are the most important:* *1) The depletion of forests and the threatening of scarcity of fuel-wood and charcoal- and of building material, especially for the shipbuilding industry à Born from need* ***2) The epoch making discovery in 1708 of the practical application of coal to the smelting and manufacturing of iron.*** *3) The perfection of the steam engine by James Watt in 1782. (p455)*	The invention to use coal to make iron provided a new function for the substance coal.
	As a major factor world history, coal dates only from the eighteenth century. Its "coming of age" is accounted for by many factors, among which the following are the most important: *1) The depletion of forests and the*	The development and invention of the steam engine provided an additional function for coal; the generation of electric energy.

	threatening of scarcity of fuel-wood and charcoal- and of building material, especially for the shipbuilding industry à Born from need *2) The epoch making discovery in 1708 of the practical application of coal to the smelting and manufacturing of iron.* *3**) The perfection of the steam engine by James Watt in 1782**. (p455)*	
	The fact that coal has lost some its importance during recent decades is in part due to discoveries of new sources of heat and energy and to new developments affecting the use of fuels, and in part due to the fact that coal is less suitable for certain purposes than other fuels. (p457)	Due to new inventions and discoveries other substances have become suitable for the same function as coal while providing other benefits. Therefore coal has lost some of its functions.
	1) Expansion *a. Growth of population* *b. Expansion of industrial output* *c. Increased coal requirements of particular industries which have been growing* ***d. New uses of coal*** ***e. New techniques of coal*** *2) Contraction* *a. The depressed status of such important coal-consuming industries as railway and steamship transport.* ***b. The displacement of coal as a fuel by fuel oil, natural gas, and water power.*** ***c. Its displacement as a raw material by the shift to a process whereby more steel is obtained through the remelting of scrap than through the remelting of iron ore*** ***d. Higher fuel efficiency in the coal consuming industries, particularly iron and steel manufacture, electricity supply, railway and steamship transport.***	New inventions created new functions and techniques of coal. Inventions and discoveries have made other substances more suitable for some of the functions of coal. Moreover, inventions were done which lowered the demand for coal, due to an increase in efficiency.

	The forces of contraction, which as we have said, proved stronger than the expansion forces, fall into two distinct categories: *1) Those stemming from outside the coal economy, especially competition from other fuels and of water power, and, indirectly, the greater reliance on scrap as a source of steel* *2) Those connected with the more efficient utilization of coal itself.*	
	The history of the united states is railroad history. The iron and steel rails, the locomotives, are unthinkable without the coal of Pennsylvania and Ohio; and to this day, though hard pressed by diesel oil, coal is premier source of energy which keeps the wheels of the railroads moving; not only that, but coal also furnishes the railroads with their largest single item of revenue freight. (p456)	The invention of the locomotive and the railroad were important inventions for the role as a resource for coal.
	One conclusion should be crystal clear from this estimate of the coal reserves of the united states; unless truly fantastic improvements in the state of the arts are achieved, our descendants will have to pay far more for coal than the prices paid both in the past and at present. Large portions of the coal reserves listed by Campbell are of such poor quality, are located in such out-of-the-way corners, are so unfavorable as to thickness of vein, depth, etc. that only unheard-of-ingenuity or desperate need will render them available for use. In other words, they are not commercial reserves now, and they may never be. (p462)	In order to make these resources <u>commercially</u> available, inventions and discoveries which will improve the arts are necessary.
Development arts	*As a major factor world history, coal dates only from the eighteenth century. Its "coming of age" is accounted for by*	Due to the development of the technical arts to make iron out of the substance coal, coal attained

	many factors, among which the following are the most important: *1) The depletion of forests and the threatening of scarcity of fuel-wood and charcoal- and of building material, especially for the shipbuilding industry à Born from need* ***2) The epoch making discovery in 1708 of the practical application of coal to the smelting and manufacturing of iron.*** *3) The perfection of the steam engine by James Watt in 1782. (p455)*	a new function as a source for iron.
	The fact that coal has lost some of its importance during recent decades is in part due to discoveries of new sources of heat and energy and to new developments affecting the use of fuels, and in part due to the fact that coal is less suitable for certain purposes than other fuels. (p456)	Due to the development of arts, more fuels became suitable to fulfill the same functions as coal. Therefore coal has lost some of its functions.
Improvement arts	*As a major factor world history, coal dates only from the eighteenth century. Its "coming of age" is accounted for by many factors, among which the following are the most important:* *1) The depletion of forests and the threatening of scarcity of fuel-wood and charcoal- and of building material, especially for the shipbuilding industry à Born from need* *2) The epoch making discovery in 1708 of the practical application of coal to the smelting and manufacturing of iron.* ***3) The perfection of the steam engine by James Watt in 1782. (p455)***	Due to the improvement of technical arts, the steam engine was improved. This engine provided a major function for the substance coal, namely the generation of energy.
	One should not forget the fact that while the output of coal has no more than held its own, the energy obtained from this fuel has increased rapidly. For like other fuels, coal today yields far more actual	Due to the improvement of arts, more energy can be obtained from the same amount of coal.

	heat and energy than it did thirty years ago (p485) In the second place, as was mentioned before, not all fuels are solely for the generation of energy. Most anthracite, bituminous and a considerable amount of fuel oil and natural gas are used for space heating. Moreover, considerable and increasing amounts of the mineral fuels are used for purposes other than conversion into heat and energy. (Coal to coke etc.) (p485)	
	1) Expansion *a. Growth of population* *b. Expansion of industrial output* *c. Increased coal requirements of particular industries which have been growing* *d. New uses of coal* *e. New techniques of coal* *2) Contraction* *a. The depressed status of such important coal-consuming industries as railway and steamship transport.* *b. The displacement of coal as a fuel by fuel oil, natural gas, and water power.* *c. Its displacement as a raw material by the shift to a process whereby more steel is obtained through the remelting of scrap than through the remelting of iron ore* ***d. Higher fuel efficiency in the coal consuming industries, particularly iron and steel manufacture, electricity supply, railway and steamship transport.*** *The forces of contraction, which as we have said, proved stronger than the expansion forces, fall into two distinct categories:* *1) Those stemming from outside the coal economy, especially competition from other fuels and of water power, and,*	Due to the improvement of arts, higher fuel efficiency is achieved.

	indirectly, the greater reliance on scrap as a source of steel **2) Those connected with the more efficient utilization of coal itself.** *(486)*	
	Needless to say, the suitability of coal is purely relative. For example, the substitution of the modern by product coke oven for the old-fashioned beehive oven has revised the definition of good coking coal. Changes in furnaces and boilers similarly affect the suitability of coals, the increasing use of powdered coal being especially noticeable. (461)	Improved arts affect the suitability of coal for certain functions.
	One conclusion should be crystal clear from this estimate of the coal reserves of the united states; unless truly fantastic improvements in the state of the arts are achieved, our descendants, will have to pay far more for coal than the prices paid both in the past and at present. Large portions of the coal reserves listed by Campbell are of such poor quality, are located in such out-of-the-way corners, are so unfavorable as to thickness of vein, depth, etc. that only unheard-of-ingenuity or desperate need will render them available for use. In other words, they are not commercial reserves now, and they may never be. (p462)	Improvements in arts are necessary to make these resources commercially available.
	The enormous overcapacity in 1923 was due to mainly two facts: 1) *During World War I and immediately afterward, coal prices rose to great heights, almost quadrupling by 1920 and bring wartime prosperity to a starving industry. This led to an enormous expansion of capacity.* 2) *No one at that time foresaw the*	Due to improved arts, it was possible to use coal in a more economical way. However, this led to overcapacity in the supply of coal.

	drastic downward trend in the demand for bituminous coal resulting from the incredible rise of oil, natural gas, and water power and spectacular advances made in using coal economically. (p473-475)	
Technology	-	
Science	-	
Improved communication system	-	
Improved transportation system	*The world output of coal is man's most colossal performance in material handling and mass moving. It constitutes by far the railroads' most important payload and has played a vital role in the growth of the world's seaborne trade. (p455).*	The usage of coal as a substance was an important factor in the growth of the transportation system.
	The effect of the steam engine is too complex to be appraised accurately in a few sentences. However its importance can be traced along two major lines. In the first place, it made possible the expansion of mining operations, for it solved the problem of water control and ventilation in coal mines and thus permitted deeper shafts and more economical exploration. The steam engine also aided in underground hauling, in hoisting, and in the land transportation of mineral products. (p455-456) *In the second place, the steam engine brought about a phenomenal increase in the demand for mineral products. By cheapening coal it cheapened energy and, consequently anything made with the aid of mechanical energy.* ***Furthermore, it revolutionized transportation by land and sea and, in so doing, incredibly enhanced the usefulness of coal and***	Due to invention of the steam engine, the substance coal attained a function in the transport system. The invention of the steam engine led to an improvement in the transportation system.

	immeasurable extended its market. Made of iron or steel, the steam engine itself depends on coal for both its manufacture and operation. (p456)	
	The history of the united states is a railroad history. The iron and steel rails, the locomotives, are unthinkable without the coal of Pennsylvania and Ohio; and to this day, though hard pressed by diesel oil, coal is premier source of energy which keeps the wheels of the railroads moving; not only that, but coal also furnishes the railroads with their largest single item of revenue freight. (p456)	Coal has enabled an improved transportation system and also is one of the reasons why this system is developed and operates as it does.
	Thus coal is the backbone of America's land transportation system, as it was, throughout critical decades, of the water transportation system upon which rests the British empire. Coal has been "the key to the carrying trade" when that trade grew from its formative stage to its world-conquering manhood. (456)	Coal has offered the possibilities for an improved transportation system. This system also provides the demand for the substance coal.
	A glance at figure 26.2 shows that the Bristol channel cuts way into this region, making such ports as Cardiff and Newport easily accessible to the merchant fleets of the world, to say nothing of the British navy (p467). The coal of Durham shire, on the other hand, is an excellent gas coal which could be readily sold not only to English and Scottish gas works but also to those on the continent. It moved via Hamburg to Berlin, via le Havre to Paris, up to the Rhine to cologne and all the way to Mannheim. Just to the north of this lies another field of excellent steam coal made famous by the expression "carrying coals to Newcastle". In the black country or the midlands region, coal suitable for conversion into metallurgical	A strong transportation system enables the feasibility of coal as a resource.

	coke was found in close proximity to iron ore and limestone. (p468)	
	The Ruhr district possesses an unusual combination of favorable circumstances. It has the greatest coal reserves in Europe, the seams being, relatively both thick and numerous. Its coal field is the best located on the continent. The deep and regular Rhine river provides a magnificent navigable waterway through the western part of the field, and adjoining canals lead through the district. A dense network of railroads connects the Ruhr with other parts of Germany and Europe. The high state of German technical development found expression in efficient mining and extensive use of coal products. A powerful national organization of production and sales stabilized exploitation. (p469)	A strong transportation system is of influence on the feasibility of the coal products.
Discovery ways of tapping new and inexhaustible fuels	-	-
Means/methods	-	
Search for means and methods	-	

Comments:

- The categories "Material/technical arts", "the developments of arts", "the improvement of arts" and "inventions and discoveries" generate the same information. This makes sense since both the development and improvements of arts and the inventions and discoveries create technical/material arts or societal arts. Furthermore, inventions and discoveries and often lead to the development and improvement of arts. However, the variable "Inventions and discoveries" is maintained, even though it overlaps with the variables "Development of arts" and "improvement of arts". The reason can be found in the fact that both the development and improvements of arts are may lead to inventions and discoveries, though this is not necessarily the case. It may happen that improvements and developments of arts will lead to an improvement in arts, though not to a new inventions or a discovery. The improvement of development may also involve an iterative improvement which may not be considered as a new invention or discovery. Therefore the variable is "Innovations and discoveries'' may still add new information and will be maintained.

- For this example no statements were found which underlines the importance of the factor "Societal/Institutional arts". However, it is perceived that this factor may be valuable in the analysis of the development and functionality of another substance. Therefor this factor is not excluded from the framework.
- During this operationalization no information could be found for the category of "Arts which render more effective man's productive effort". However, this factor will not be excluded since it may be possible that for other examples this type of arts may be important.
- No information on the substance coal to underline the presence of the factor "Technology" could be identified. This because this information is already placed under the factor "Material/technical arts". This makes the factor "Technology" abundant. Therefore this factor should be removed from the framework.
- No information on the substance coal could be found which underlined the presence of the factor "Science". However, the writer does not want to exclude the possibility that this factor could be important for the development and functionality of another resource. Therefore this factor is not excluded.
- The factor "Improved communication" does not pose a category for which statements could be found to underline the importance of this factor. However, this factor may be more important in a time in which communication is more important. Since the framework will (also) be used for the analysis of resources of the current times, the possibility exists that this factor could be valuable for the analysis of a current resource. Therefore this factor is not excluded.
- No information is found which could be located under the factor "Discovery ways of tapping new and inexhaustible fuels". Furthermore, it may be considered that the "Discovery of ways for new and inexhaustible fuels" may fall in the categories "Development of arts", "Improvement of arts" or "Inventions and discoveries". So, for these reasons the variable "Discovery of ways for new and inexhaustible fuels" will be removed from the framework.
- For the factor "Methods/means" and "Search for methods and means" no statements were found which underline the relevance of these factors. Furthermore, when considering the definitions of a mean (a method to attain (given) ends) and a method (means to accomplish an end) the possibility already appeared that method and means could also be seen as Arts used to attain given ends. Moreover, Zimmerman sees resources as means to attain given ends. Since resources are already present in the framework, the variable "Methods/means" and its search for it appear abundant. Due to these three reasons it is decided to remove the factors "Methods/means' and "search for means/methods" from the framework.

Changes to the framework:

- Removal of the factor "Technology"
- Removal of the factor "Discovery ways of new and inexhaustible fuels"
- Removal of the factor "Methods/means".

- Removal of the factor “Search for means/methods”.

Wants

Table 221 Operationalization Primary factor Wants

Type of wants	**Information from Zimmerman**	**Comments**
Cultural wants	*It is also the source of valuable materials such as gases, oils, tar and pitch, from which in turn an infinite array of chemical products can be extracted. (455)*	The substance coal is wanted due to cultural wants for other products.
	As the products of the blast furnace and steelworks are sent over the earth, they carry with them the demand for coal necessary for their operation and use- a demand which may be satisfied by tapping local supplies or by importing coal (p456)	As long as the cultural wants for the blast furnace and steel works are present, the cultural want for coal will be maintained.
	Coal fields are opened up and exploited with machine equipment, both below and above ground; the coal , in turn is needed to make the iron and steel and other metals which into that machinery. Coal hoists and moves coal; steel helps to make more steel. Thus the supplies of mineral fuels and machine materials must be viewed not as a dead mass of inert materials, but as parts belonging to a living organism that possessed dynamic powers of its own, even though they are subject to man’s will and control (432).	The cultural want for coal also depends on the cultural want of the products made from it. Furthermore, the transport system enabled by the substance coal transports and increases the demand for coal. Therefore the cultural wants for coal and its products are considered dynamic.
	As a major factor world history, coal dates only from the eighteenth century. Its “coming of age” is accounted for by many factors, among which the following are the most important: ***1) The depletion of forests and the threatening of scarcity of fuel-wood***	The wants to sail the sea can be considered a cultural want. The substance coal is used to fulfill this cultural want.

	and charcoal- and of building material, especially for the shipbuilding industry *2) The epoch making discovery in 1708 of the practical application of coal to the smelting and manufacturing of iron. à born by?* *3) The perfection of the steam engine by James Watt in 1782. à born by? (p455)*	
	As a major factor world history, coal dates only from the eighteenth century. Its "coming of age" is accounted for by many factors, among which the following are the most important: *1) The depletion of forests and the threatening of scarcity of fuel-wood and charcoal- and of building material, especially for the shipbuilding industry* ***2) The epoch making discovery in 1708 of the practical application of coal to the smelting and manufacturing of iron.*** *3) The perfection of the steam engine by James Watt in 1782. (p455)*	The want for products of steel is not a basic wants. One could survive without this product. However, this product has become important in our current society. Therefore the usage of coal to make iron stems from a cultural want.
	Without iron there can be no modern machinery, no steel rails; and without them no modern industry and transportation can hardly exist. (456)	The cultural want for iron, leads to the cultural want for coal.
	The history of the united states is railroad history. The iron and steel rails, the locomotives, are unthinkable without the coal of Pennsylvania and ohio; and to this day, though hard presses by diesel oil, coal is premier source of energy which keeps the wheels of the railroads moving; not only that, but coal also furnishes the railroads with their largest single item	The want for a transportation system is a cultural want. This because the transportation system is not necessary to survive.

	of revenue freight. (p456)	
	The declining role of coal in the energy economy of the united states is the result of the triumph of negative forces of decline over positive forces of growth. Pertinent factors of expansion and contraction are as follows: 1*) Expansion* *a. Growth of population* *b. Expansion of industrial output* ***c. Increased coal requirements of particular industries which have been growing*** *d. New uses of coal* *e. New techniques of coal* *2) Contraction* *a. The depressed status of such important coal-consuming industries as railway and steamship transport.* *b. The displacement of coal as a fuel by fuel oil, natural gas, and water power.* *c. Its displacement as a raw material by the shift to a process whereby more steel is obtained through the remelting of scrap than through the remelting of iron ore* *d. Higher fuel efficiency in the coal consuming industries, particularly iron and steel manufacture, electricity supply, railway and steamship transport.* *The forces of contraction, which as we have said, proved stronger than the expansion forces, fall into two distinct categories:* *1) Those stemming from outside the coal economy, especially competition from other fuels and of water power, and, indirectly, the greater reliance on scrap as a source of steel*	If the wants which are satisfied by the industries for which coal functions as a resource are considered cultural wants, the substance coal satisfies cultural wants. However, some of these industries may provide products which satisfy basic wants. In that case the substance coal would serve to satisfy basic wants.

	2) Those connected with the more efficient utilization of coal itself. (486)	
	The declining role of coal in the energy economy of the united states is the result of the triumph of negative forces of decline over positive forces of growth. Pertinent factors of expansion and contraction are as follows: *1) Expansion* *a. Growth of population* ***b. Expansion of industrial output*** *c. Increased coal requirements of particular industries which have been growing* *d. New uses of coal* *e. New techniques of coal* *2) Contraction* *a.* ***The depressed status of such important coal-consuming industries as railway and steamship transport.*** *b. The displacement of coal as a fuel by fuel oil, natural gas, and water power.* *c. Its displacement as a raw material by the shift to a process whereby more steel is obtained through the remelting of scrap than through the remelting of iron ore* *d. Higher fuel efficiency in the coal consuming industries, particulary iron and steel manufacture, electricity supply, railway and steamship transport.* *The forces of contraction, which as we have said, proved stronger than the expansion forces, fall into two distinct categories: (486)* *1) Those stemming from outside the coal economy, especially competition from other fuels and of water power, and, indirectly, the greater reliance on*	The expansion of the industrial output is influenced by the wants for certain product. These wants may be considered cultural wants. This expansion due to (cultural wants) leads to an increase in (cultural) wants for coal. A depressed status of an industry on the other hand leads to a decrease in wants for a resource.

	scrap as a source of steel *2) Those connected with the more efficient utilization of coal itself. (486)*	
	Thus coal is the backbone of America's land transportation system, as it was, throughout critical decades, of the water transportation system upon which rests the British empire. Coal has been "the key to the carrying trade" when that trade grew from its formative stage to its world-conquering manhood. (456)	The want for a (water) transportation system, is considered a cultural want. The transportation system is often not necessary to survive. People could also move, when nature is not able to satisfy their wants. So the transportation system is born out of the cultural want to stay in the same location, while having the (basic and cultural) wants satisfied with substances which cannot be found in the direct environment.
	The value of coal deposits depends on its availability for use. A region which possesses coals unsuitable to its needs may not be much better off than one which lacks coal. (p467)	The availability of use of a substance is of influence on the satisfaction of the (cultural) wants of a region.
	British coal mining industry up to world war I is partly explained by the almost miraculous manner in which the various types of coal happened to fit the specific requirements of the markets they could most readily serve. Thus the major portion of the famous South wales coal field consists of coal admirably suited for bunker purposes (p467).	The success of a coal mining industry in a specific location depends on the cultural wants present at that location.
	Realizing the connection between industrial progress, economic well-being, and political power, many other nations have likewise made strenuous efforts to develop their coal resources. (examples of Japan, India, China, Brazil etc.) (p456)	The relation between industrial progress, economic well- being, and political power caused by the presence of coal which is able to satisfy the wants in these fields, further increases the want for coal.
	The enormous overcapacity in 1923	Because of the war the cultural

	was due to mainly two facts *1) During world war 1 and immediately afterward, coal prices rose to great heights, almost quadrupling by 1920 and bring wartime prosperity to a starving industry. This led to an enourmous expansion of capacity.* *2) No one at that time foresaw the drastic downward trend in the demand for bitominous coal resulting from the incredible rise of oil, natural gas, and water power and spectacular advances made in using coal economically. (p473-475)*	wants for coal increased which led to an increase in capacity to satisfy these wants. However, these wants decreased tremendously in after the wars, which led to an overcapacity.
	The demand of coal was seasonal and often war dependent. The demand of gas is less seasonal since it can easier be shipped and also less war dependent. (p482).	The cultural want for coal is seasonal and often war dependent. In winter and war time the demand is higher than in summer and in times of peace.
	The peak of capacity reached in 1923- four years after the armistice- with roughly 900 million tons. Against this capacity, the actual output of 500.3 million tons for the average year 2921-1930 does not look so impressive. By 1933 the capacity gas dropped roughly 30 percent, but the average annual production during 1931-1940 was only 384.6 million tons. After that it to move slowly upward again, full capacity being reached during world war II. Evidently it takes a war, or preparation for and recovery from one, to put this country most basic industry into the black (487-488).	The two world wars had a very significant effect on the want for coal.
	But anthracite's formidable position was attacked by that deadly enemy,	Due to changing cultural wants, oil and natural gas were able to take

	commodity competition. Fuel oil and natural gas sapped the market and forced the industry to retreat from its peak output of almost 100 million tons during world war I to somewhere between half and two-thirds that amount after 1930, a retreat that brought painful adjustments in its train. (473)	over a part of the function and therefore the want for coal.
	Thus the Koppers Company, one of the largest owns of captive mines, is perhaps the largest seller of coal in the commercial market. The reason is simple. The mining properties which yield the types and grades of coal the company needs for its by-products coke ovens and chemical plants also yield other types and grades for which it has no use but which can be marketed elsewhere. (p480).	Due to the fact that types and grades of coal which are mined also deliver other types and grades of coal, which can be sold, the company also earns money from other type of (cultural) wants for coal.
	In general the demand for coal is erratic. Its demand for household and commercial space-heating purposes is seasonal. Storage is costly and, in the case of lower-grade coals, not without danger. The demand for industrial coal as well as for railroad fuel follows the business cycle. This means that from half to two-thirds of the coal industry is afflicted with cyclical disturbances. Coal also plays a major role in war, the output and capacity tending to expand rapidly without assurance that peacetime requirements will support the expansion. (482)	The demand or cultural and basic wants for coal are not static and depends on several factors.
	Coal is an excellent but not ideal fuel. For the household, bituminous coal cannot compare in cleanliness and convenience with natural gas or fuel oil. Coal is a solid, and solids are much	Due to changing wants of what is desired of a fuel, coal lost much of its market share to the substances natural gas and oil.

	harder to move than liquids and gas. Although the latter require special equipment and facilities, once these are installed, oil and gas can be moved and handled far more cheaply than coal. Moreover, both oil and natural gas have higher heat values per unit for weight and volume, e.g. per pound and cubic foot than coal does. As a result of this difference in heat value-especially available heat value-per unit of weight and volume, coal has been replaced by petroleum and natural gas for many purposes, especially in the field of transportation. (486)	
	The fact that coal is still used as widely as it is, is due to a number of reasons. In the first place, there is no substitute for metallurgical coke in extracting iron from ore. In the second place, industries have been built over or around coal fields; this means that, in many industrial areas, coal has the advantage of being on the spot or nearby, whereas other fuels must be brought in over considerable distances. Also, some industries tend to cluster around the iron and steel industry, which in turn is dependent on coal. Above all, coal near the mine is a cheap fuel; it's low price is its strongest point. Premium fuels tend to sell at premium prices. Only as high transportation charges are added to a low mine price does coal lose its advantage of cheapness and therefore have to yield to more mobile and otherwise more desirable fuels. (487)	In order to satisfy the cultural want for iron, coal is necessary. Therefore as long as iron is wanted, coal will satisfy a cultural want.
Basic wants	*But the fact remains that coal is man's major source of heat and energy. (455)*	Coal is capable of satisfying basic wants.

	As a major factor world history, coal dates only from the eighteenth century. Its "coming of age" is accounted for by many factors, among which the following are the most important: ***1) The depletion of forests and the threatening of scarcity of fuel-wood and charcoal- and of building material, especially for the shipbuilding industry*** *2) The epoch making discovery in 1708 of the practical application of coal to the smelting and manufacturing of iron. À born by?* *3) The perfection of the steam engine by James Watt in 1782. (p455)*	Due to need for satisfaction of basic wants with fuel wood and charcoal, the depletion of forests happened. This delivered the context for a substance coal to fulfill this function, without depletion the forest. This substance was coal
	One conclusion should be crystal clear from this estimate of the coal reserves of the united states; unless truly fantastic improvements in the state of the arts are achieved, our descendants, will have to pay far more for coal than the prices paid both in the past and at present. Large portions of the coal reserves listed by Campbell are of such poor quality, are located in such out-of-the-way corners, are so unfavorable as to thickness of vein, depth, etc. that only unheard-of-ingenuity or desperate need will render them available for use. In other words, they are not commercial reserves now, and they may never be. (p462)	When the cultural wants turn into basic wants, these resources of coal which are now unavailable may become the possible to be explored. This because the prices, driven upwards by needs, will make the exploration feasible.
Group term/long term wants	*Realizing the connection between industrial progress, economic well-being, and political power, many other nations have likewise made strenuous efforts to develop their coal resources.*	Social objectives such as industrial progress, economic well-being and political power, may be achieved by the usage of the substance coal.

	(Examples of Japan, India, China, Brazil etc.) (p456)	
Individual/short term wants	-	
Conflict between group and individual interest	-	
Necessity	*As a major factor world history, coal dates only from the eighteenth century. Its "coming of age" is accounted for by many factors, among which the following are the most important:* *1) **The depletion of forests and the threatening of scarcity of fuel-wood and charcoal- and of building material, especially for the shipbuilding industry*** *2) The epoch making discovery in 1708 of the practical application of coal to the smelting and manufacturing of iron.* *3) The perfection of the steam engine by James Watt in 1782. (p455)*	When other resources are depleted it is necessary to find new resources. So, with the scarcity of wood, the necessity for another source, which could satisfy the same wants, appeared. This led to development of coal as a resource.

Comments:

- There were not statements found which underlined that there is a difference between individual wants and group wants. This was easier for cultural and basic wants. However, the two types of these wants should be included in the framework, since they may be important in the analysis of another resource. It may be helpful to understand if wants are social objectives or individual wants to understand how the problems and opportunities around a resource evolve.
- No information has been found which could be placed into the variable "Conflict between group and individual interest. However it suspected that this could be the case for other resources. Therefore, the factor is maintained.
- The factor "Necessity" has in this case attracted the same information as the factor "Basic wants". Furthermore, it was stated that basic wants could considered necessities, since basic wants need be satisfied in order for the human beings to survive. So, since the factor necessity attract the same information and since the basic wants are also considered a necessity, the factor "Necessity" will be removed from the framework.

Changes to the framework:

- Removal of the factor "Necessity".

Nature

Table 222 Operationalization Primary factor Nature

Type of Nature	Information from Zimmerman	Comments
Natural resources	-	
Natural-cultural resources	*It is also the source of valuable materials such as gases, oils, tar and pitch, from which in turn an infinite array of chemical products can be extracted. (455)*	Coal is a resource for which man had to make improvements, such as mining, before he could achieve it. Therefore the substance coal is a natural-cultural resource.
	Each region of the earth makes use of whatever energy resources are available from local production or import .(455)	Local production and import are forms of improvements which create natural-cultural resources. The resources could not be picked up from the ground without any effort, so improvements in production and/or the transport system to attain the resource from another region had to be achieved.
	In general, the world dominance of the nation's bordering the North Atlantic can hardly be explained without reference to the striking concentration of useful materials within their borders, especially of major coal deposits and workable combinations of iron and coking coal. (p455).	The natural-cultural resources of a country bring wealth and a strong (economic) position.
	Not only do coal deposits differ widely in the nature of the coals they contain, they differ also as to the conditions under which these coals are found. *These factors go far to determine the mining methods which can be applied and the costs of production (p457).*	The conditions of the natural-cultural resources are of influence on the necessary improvements to obtain the substance and have the substance function as a resource and therefore on the costs of these improvements.

	The mechanical proficiency of considerable portions of our coal mining industry is high. Favorable natural conditions, however, are probably the underlying cause of our low costs. Coal output by miner is in this eastern bituminous coal province is very high*. But the methods of recovery used are more wasteful than those employed in typical European countries. In the United States roughly one ton of coal is lost for every two tons mined. European recovery rates are much higher. It will not do, therefore to count on the 3.2 trillion tons of coal that are supposed to be in the ground as available for use. Actually, if our current wasteful methods of recovery are continued, little over 2 trillion tons will be available. (p462)*	The natural aspects of coal have a significant influence on the costs of improvements necessary to attain the substance.
	It is indeed difficult to imagine a more ideal distribution of specific types of coal than that found in Britain. Unfortunately much of this advantage of location is offset by unfavorable working conditions which account for high pit prices and which have been aggravated by prolonged exploitation. In the united states the argument is occasionally heard that the British fell behind in the technical proficiency of coal mining, especially behind the United states and Germany. Since the government has taken over the coal mines, however some efforts to raise the efficiency of Britain's coal mines have been made. (p468)	A beneficial location of natural-cultural resources can be influence on the effectiveness of the improvements made to attain the resource.
	The Ruhr district possesses an unusual combination of favorable	The Ruhr district governs significant natural-cultural reserves. Also, the

	circumstances. It has the greatest coal reserves in Europe, the seams being, relatively both thick and numerous. Its coal field is the best located on the continent. The deep and regular Rhine river provides a magnificent navigable waterway through the western part of the field, and adjoining canals lead through the district. A dense network or railroads connects the Ruhr with other parts of Germany and Europe. The high state of German technical development found expression in efficient mining and extensive use of coal products. A powerful national organization of production and sales stabilized exploitation. (p469)	reserve is located in the best place of the continent.
Nature's opportunities	*Each region of the earth makes use of whatever energy resources are available from local production or import (455).*	
Nature's primary conditioning factors	*The connection between coal, iron and industrialization is very close. Because coal, the Aaron, is inarticulate without iron, its Moses, coal mining reaches its full development only where iron is found accessible to coal (p456).*	It depends on the conditioning factors of nature if coal and iron may be found close together. These conditioning factors have a strong influence on the development of coal mining.
	Probably the greatest handicap to future low-cost exploitation derives from the geographical distribution of the coal deposits. (p464)	The conditioning factors of nature are of influence on the costs, and are therefore of influence on the feasibility of coal as a resource.
	If the equivalent of the Pittsburg coal bed were within hailing distance of the Itabara iron deposits of Minas Gerais, Brazil might today, perhaps in partnership with other sections of South America, occupy an economic	The distribution of substances, and therefore the conditioning factors of nature, determine to great extent the possibility for substances to function as a resource.

	and political place similar to that held by the united states (442)	
	A glance at figure 26.2 shows that the Bristol channel cuts way into this region, making such ports as Cardiff and Newport easily accessible to the merchant fleets of the world, to say nothing of the British navy (p467). The coal of Durham shire, on the other hand, is an excellent gas coal which could be readily sold not only to English and Scottish gas works but also to those on the continent. It moved via Hamburg to Berlin, via le Havre to Paris, up to the Rhine to cologne and all the way to Mannheim. Just to the north of this lies another field of excellent steam coal made famous by the expression "carrying coals to Newcastle". In the black country or the midlands region, coal suitable for conversion into metallurgical coke was found in close proximity to iron ore and limestone. (p468)	The proximity of iron ore delivers an advantage for the usage of coal as a resource. So, the natural conditioning factors are of influence on suitability of substances as a resource.
	The Ruhr district possesses an unusual combination of favorable circumstances. It has the greatest coal reserves in Europe, the seams being, relatively both thick and numerous. Its coal field is the best located on the continent. The deep and regular Rhine river provides a magnificent navigable waterway through the western part of the field, and adjoining canals lead through the district. A dense network or railroads connects the Ruhr with other parts of Germany and Europe. The high state of German technical development found expression in efficient mining and extensive use of	The Ruhr reserve is located in the best place of the continent. This location is determined by nature's primary conditioning factors.

	coal products. A powerful national organization of production and sales stabilized exploitation. (p469)	
	In general, the world dominance of the nation's bordering the North Atlantic can hardly be explained without reference to the striking concentration of useful materials within their borders, especially of major coal deposits and workable combinations of iron and coking coal. (p455).	The primary natural conditions of a country have a significant influence on the wealth and economic position of a country
	The structure of the bituminous coal industry reflects: ***1) The heterogeneous nature of coal as it occurs in the crust of the earth and the resulting diversity of coal operations, and*** *2) The ideologies and institutions of the US. (p479)*	The way the coal is distributed over the states, is reflected in the structure of the industry. So the primary natural conditions are of influence on the structure of an industry.
Nature's secondary conditioning factors	-	
Space	-	

Comments:

- The factor "Nature's opportunities" may be considered abundant in the framework, since the natural and natural-cultural resources and the nature's primary and secondary conditioning factors provide these opportunities. Therefore, it is suggested to remove the variable "Nature's opportunities" from the framework.
- The factor "Nature's secondary conditioning factors" has not led to information in this example. However it is expected that this factor may important for the analysis of another resource. Therefore this variable is maintained in the framework.
- The importance of factor space could not be explained by means of the theory of the evolution of coal. Space may be seen as a natural resource. Furthermore it may be questioned if space will explain more in the functionality of resources. For renewable energy sources such as wind energy, space may be very important in their functionality, they cannot provide wind energy in a densely populated area. So, with the eye on the generalization possibilities of the framework, the factor space is kept for possible renewable resources or fossil fuels which could require space for its functionality.

Changes to the framework:

- Removal factor “Nature’s opportunities”.

Culture

Table 223 Operationalization Primary factor Culture

Type of culture	**Information from Zimmerman**	**Comments**
Cultural modification of non-man environments	-	
Cultural changes affecting human attitudes and human relation	-	
Intangible cultural changes such as technique, knowledge, acquired skills	-	
Tangible change of natural environment (which may be called capital equipment)	***The effect of the steam engine*** *is too complex to be appraised accurately in a few sentences. However its importance can be traced along to major lines. In the first place, it made possible the expansion of mining operations, for its solved the problem of water control and ventilation in coal mines and thus permitted deeper shafts and more economical exploration. The steam engine also aided in underground hauling, in hoisting, and in the land transportation of mineral products. (p455-456)* *In the second place, the steam engine brought about a phenomenal increase in the demand for mineral products. By cheapening coal it cheapened energy and, consequently anything made with the aid of mechanical energy. Furthermore, it revolutionized*	The steam engine is a tangible change of the natural environment. It can be considered as capital equipment.

	transportation by land and sea and, in so doing, incredibly enhanced the usefulness of coal and immeasurable extended its market. Made of iron or steel, the steam engine itself depends on coal for both its manufacture and operation. (p456)	
	Industrial conditions have generally adapted themselves to suitability of coals. (457)	The industrial conditions have been adjusted in such a way that they can process coal and deliver the necessary products. These are tangible changes, often present in the form of capital equipment.
Enriched cultures (effect of)	-	
Cultural adaption	-	
Indirect adaption to nature	*Industrial conditions have generally adapted themselves to suitability of coals. (461)*	The industrial processes have been adjusted to the characteristics of the substances processed and the objectives which the final products have to satisfy.
Direct adaption to nature	-	
Knowledge/wisdom	-	
Secondary conditioning factors culture	-	

Comments:

- For this example no information was found which verified the importance of the factor "Cultural modification of non-man environments". Though, since it seems valid that in the analysis of other resources this variable will be useful, this variable will not be removed.
- Furthermore in this example, no information was found which could be placed under the factor "Cultural changes affecting human attitudes and relation". However, since this variable may be of importance during the analysis of other variables this variable will be maintained in the framework.
- Also, no statements could be found which underlined the importance of the factor "Intangible cultural changes" to explain the development and functionality of the substance coal. Anyhow,

this factor will not be removed, since it seems plausible that this variable may be important to understand the development and functionality of other resources.

- The factor "Tangible changes of the natural environment" indicates aspects such as capital equipment. Therefore, the factor "Capital equipment" could also be placed under this factor and is therefore abundant in this framework. For this reason the factor "Capital equipment" will be removed from the framework.
- For this example, the factor, "Enriched culture" did not contribute to an improved understanding on the development and functionality of the resource coal. However, since it is possible that this factor may increase the understanding on the development and functionality of other resources, this variable will be maintained in the framework.
- Even though the factor "Cultural adaption" does not bring an increased understanding on the development and functionality of coal the variable will not be removed from the framework. This because of the possible contribution of this factor in the understanding of the development and functionality of other resources.
- For this example, there were no "Direct adaptions to nature". However it seems possible that "Direct adaptions to nature" have been present for other resources. Therefore this variable is maintained in the framework.
- Even though Zimmerman does not use the factor "Knowledge/wisdom" explicitly to describe the development and functionality of coal, it seems to be an important element in the development and functionality of a substance as a resource. Therefore this variable is maintained in the framework.
- Finally, the factor "Secondary/conditioning factors" is in this example not used to describe the development and functionality of coal. However, the factor may still be important for the analysis of other resources, and is therefore maintained in the framework.

Change to the framework:-

Institutions

Table 224 Operationalization Primary factor Institutions

Type of Institutions	Information from Zimmerman	Comments
Governmental policy	*It is indeed difficult to imagine a more ideal distribution of specific types of coal than that found in Britain. Unfortunately much of this advantage of location is offset by unfavorable working conditions which account for high pit prices and which have been aggravated by prolonged exploitation. In the united states the argument is occasionally heard that the British fell behind in the technical proficiency of coal mining, especially behind the United States and Germany. Since the government has taken over the coal mines, however some efforts to raise the efficiency of Britain's coal mines have been made. (p468)*	Governmental policy may have an important influence on the feasibility and profitability and therefore on the functionality of a substance as a resource.
Complexity social order	*Thus coal is the backbone of America's land transportation system, as it was, throughout critical decades, of the water transportation system upon which rests the British empire. Coal has been "the key to the carrying trade" when that trade grew from its formative stage to its world-conquering manhood. (456)*	The increase of complexity of the social order may bring functions for substances such as transport. In this case coal has been seen as the key for trade to grow from local to world markets.
Social responsibility	-	-

Comments:

- The factor "Social responsibility" is not stated by Zimmerman in relation to coal. However, since "Social responsibility" is an issue which lives among many people today, the writer beliefs that this factor can be used to explain the development and functionality of today's resources. Therefore this factor will be preserved.

Changes to the diagram:-

Resistances

Table 225 Operationalization Primary factor Resistances

Type of resistances	Information from Zimmerman	Comments
Natural resistances	-	
Natural-cultural resistances	-	
Direct Primary human resistances (ignorance and cussedness)	*The mechanical proficiency of considerable portions of our coal mining industry is high. Favorable natural conditions, however, are probably the underlying cause of our low costs. Coal output by miner is in this eastern bituminous coal province is very high. But the methods of recovery used are more wasteful than those employed in typical European countries. In the United States roughly one ton of coal is lost for every two tons mined. European recovery rates are much higher. It will not do, therefore to count on the 3.2 trillion tons of coal that are supposed to be in the ground as available for use. Actually, if our current wasteful methods of recovery are continued, little over 2 trillion tons will be available. (p462)*	With wasteful attitudes, there will be less of the 'resource' coal available than with attitudes to economize the resources. When people use the substances wisely, more of the substance can be used as a 'resource' and less of the substances will be wasted.
Direct secondary human resistances (results from complexity)	-	
Secondary direct cultural resistances (bad capital, obsolete equipment)	-	
Primary indirect	*Coal used to be the least efficiently*	Due to the limitations of nature, coal

natural resistances (distance, distribution raw materials)	*used fuel and it had the most gain from technological improvements, but certain limitations inherent in the nature of coal make it likely to the underdog in the interfuel fight- at least in the near future. (p486)*	has some disadvantages concerning efficient usage, when compared to other fuels.
	Not only is vertical or geological distribution, in the sense of distribution in depth, of great significance for the practical meaning of date on the minerals in the earth's crust, but horizontal or geographical distribution is equally important. If the Pittsburgh coal bed were located in the Antarctic it would still be untouched by human hands instead of having helped to shape the economic destiny of North America. (p442)	The location of a substance determines the resistances which present to achieve a substance. These substances may become resources when the resistances have been overcome by means of arts.
Primary indirect human resistances (population density, age composition)	-	
Secondary indirect natural resistances (primary aspects influences by culture)	*The scarcity of wood drove on shipbuilding country after another. To turn to metal, first iron and then steel, and again coal proved indispensable. (p456)*	Due to the scarcity of wood, a resistance created by the extended usage of wood by man, man looked for other substances which could take over (part of) the function of wood. This substance was iron and steel for which the substance coal was necessary.
Secondary indirect culture resistances (dead hand from the past. Abortive policies)	-	

Secondary indirect human resistances (war, conflict)	-	
Space handicap	*The history of the united states is railroad history. The iron and steel rails, the locomotives, are unthinkable without the coal of Pennsylvania and Ohio; and to this day, though hard pressed by diesel oil, coal is premier source of energy which keeps the wheels of the railroads moving; not only that, but coal also furnishes the railroads with their largest single item of revenue freight. Thus coal is the backbone of America's land transportation system, as it was, throughout critical decades, of the water transportation system upon which rests the British empire. Coal has been "the key to the carrying trade" when that trade grew from its formative stage to its world-conquering manhood. (456)*	The substance coal could be used for functions which were able to reduce the space handicap, such as transport.

Comments:

- During this operationalization on the substance coal, only statements which underlined the importance of the factors "Primary indirect natural resistances", "Secondary indirect natural resistances", and "Direct primary human resistances" could be found. However, the other types of resistances will be maintained in the diagram, since for every substance other resistances may apply. Therefore these types of resistances may be of importance to understand the development and functionality of other resources.

Changes to the framework: -

Man

Table 226 Operationalization Primary factor Man

Man	Information from Zimmerman	Comments
Population	-	
Population growth	*The declining role of coal in the energy economy of the united states is the result of the triumph of negative forces of decline over positive forces of growth. Pertinent factors of expansion and contraction are as follows:* *1) Expansion* *a.* ***Growth of population*** *b. Expansion of industrial output* *c. Increased coal requirements of particular industries which have been growing* *d. New uses of coal* *e. New techniques of coal* *2) Contraction* *a. The depressed status of such important coal-consuming industries as railway and steamship transport.* *b. The displacement of coal as a fuel by fuel oil, natural gas, and water power.* *c. Its displacement as a raw material by the shift to a process whereby more steel is obtained through the remelting of scrap than through the remelting of iron ore* *d. Higher fuel efficiency in the coal consuming industries, particularly iron and steel manufacture, electricity supply, railway and steamship transport.* *The forces of contraction, which as we have said, proved stronger than the expansion forces, fall into two distinct categories:* *1) Those stemming from outside the*	The growth of the population is of influence on the demand for a substance and may therefore cause an expansion.

	coal economy, especially competition from other fuels and of water power, and, indirectly, the greater reliance on scrap as a source of steel *2) Those connected with the more efficient utilization of coal itself.*	
Man land ratio	*The mechanical proficiency of considerable portions of our coal mining industry is high. Favorable natural conditions, however, are probably the underlying cause of our low costs. Coal output by miner is in this eastern bituminous coal province is very high. But the methods of recovery used are more wasteful than those employed in typical European countries. In the United States roughly one ton of coal is lost for every two tons mined. European recovery rates are much higher. It will not do, therefore to count on the 3.2 trillion tons of coal that are supposed to be in the ground as available for use. Actually, if our current wasteful methods of recovery are continued, little over 2 trillion tons will be available. (p462)*	Due to amount of coal offered by nature, i.e. the amount of coal which can be exploited per person, the prices are very low.
Increased human contact	-	
Primary factors of resource production man (native abilities and drive)	-	
Secondary human factors of production (human capacities through training, experience)	-	

Primary human conditioning factors (social attitudes favorable to "living together)	-	
Secondary human conditioning factors (Constructive labor, attitudes, management)	*The fact that coal is still used as widely as it is, is due to a number of reasons. In the first place, there is no substitute for metallurgical coke in extracting iron from ore. In the second place, industries have been built over or around coal fields; this means that, in many industrial areas, coal has the advantage of being on the spot or nearby, whereas other fuels must be brought in over considerable distances. Also, some industries tend to cluster around the iron and steel industry, which in turn is dependent on coal. Above all, coal near the mine is a cheap fuel; it's low price is its strongest point. Premium fuels tend to sell at premium prices. Only as high transportation charges are added to a low mine price does coal lose its advantage of cheapness and therefore have to yield to more mobile and otherwise more desirable fuels. (487)*	Since Man has decided to locate industries around the iron and steel industries, and therefore around the coal fields, the location may be seen as human conditioning factor for resources. Man has developed conditioning circumstances for the usage of the substance coal.

Comments:

- The factor "Population" was not used to describe the functionality of the substance coal as a resource. The definition of population is given as "The total amount of people living in certain area or being part of a race of class". So, the population reasons about the amount of people in certain area or the amount of people which are part of a group. It may be questionable if this variable may be of influence on the functionality of a substance as a resource. However, it may be that due to a very high population amounts and types of resources are used, which would not be used in with low population. For this reason, the variable is still maintained in the framework.
- The factor "Increased human contact" is not used to describe the functionality of coal as a resource. When analyzing this factor with the help of the causal relation diagram, it shows that this factor is influenced by the variables "Improved transportation system" and "Improved communication system" and leads to "Enriched cultures". Since, these three factors are all

included in the framework, the variable "Increased human contact" may be abundant. Furthermore, it is questionable what the influence of increased human contact will be on the functionality of a substance as resources. Therefore this factor will be removed from the diagram.

- The factors "Primary human factors of resource production", "Secondary human factors of production "and the "Primary human conditioning factors" were not used to describe the functionality of the substance coal. However, these factors may be applicable to describe the functionality of other substances. Therefore, these variables will be maintained in the framework.
- It may be considered to place the variable "Primary human factors of resource production" and the variable "Secondary human factors of resource production" under the primary factor "Human capacities" since these variables consider the human abilities and capacities.

Changes to the framework

- Removal of the variable "Increased human contact".
- Placement of the variables "Primary human factors of resource production" and the variable "Secondary human factors of resource production" under the primary factor "Human capacities"".

Human capacity

Table 227 Operationalization Human capacity

Type of arts	Information from Zimmerman	Comments
Human capacity	-	
Human effort and behavior	-	
Human actions	-	
Human folly and cussedness	*The mechanical proficiency of considerable portions of our coal mining industry is high. Favorable natural conditions, however, are probably the underlying cause of our low costs. Coal output by miner is in this eastern bituminous coal province is very high. But the methods of recovery used are more wasteful than those employed in typical European countries. In the United States roughly one ton of coal is lost for every two tons mined. European recovery rates are much higher. It will not do, therefore to count on the 3.2 trillion tons of coal that are supposed to be in the ground as available for use. Actually, if our current wasteful methods of recovery are continued, little over 2 trillion tons will be available. (p462)*	Due to a wasteful attitude, less of the 'resource' coal will be available than there could have been with mindful and economic attitude.

Comments:

- For the analysis of this primary factor, the primary factor is also included in the table as a category. This because, the other factors do not provide categories under which information on the "Human capacity" could be placed. Also, the other three factors "Human effort and behavior", "Human actions" and "Human folly and cussedness" together do not cover the same as the primary factor "Human capacity". Therefore, the primary factor "Human capacity" was also included in the table.
- Zimmerman does reason about the relation between human capacity and the development and functionality of coal. However, he does this indirect by reasoning on the state of arts, which are

the result of human capacity. No statements which indicated that there was a direct relation with the “Human capacity” and the development and functionality of coal could be found. However, the writer perceives that the human capacity is an important aspect in the functionality of resources, and therefore the factor is maintained in the framework.

- Furthermore no statement which underlined the importance of the factor “Human effort and behavior” to understand the functionality of the substance coal could be found. Though, for the same reason as for the factor “Human capacity”, this factor will stay included in the framework.
- Moreover, Zimmerman does not provide information which underlines the importance of the factor “Human actions” in the framework. However, since there are many examples of, for instance, public policies which were of influence on the functionality of a substance, this variable will be maintained.
- When considering these factors, it is possible to reason that all these factors could also be placed under the primary factory “Man”, since all factors consider human aspects. With both the primary factor “Man” and “Human capacity” present in the framework, it could be unclear under which factor information should be placed since “Human capacity” is a part of “Man”. Therefore, in order to simplify the framework and provide a clear framework in which it is clear under which factor information should be placed, the factor “Human capacity” will be placed under the factor “Man”.

Changes to the framework:

- Placement of the primary factor “Human capacity” under the primary variable “Man”.

Economy

Table 228 Operationalization Primary factor Economy

Type of economy	**Information from Zimmerman**	**Comments**
Activities left to individual and private initiative	*The first important step in helping at least part of the industry was probably the supreme Court decisions of 1933 upholding Appalachian Coals, Inc. a sales agency organized in 1931 to market collectively the aggregate output of many mines. The decision clearly recognized the crucial fact that unbridled competition is fatal for an industry sick unto death when it exempted a segment of the industry from the competition insured by the Sherman Antitrust Act. (487-489)*	This example presents a change of the activities around the exploration of coal from individual initiatives to the public control.
	The next step was the Bituminous coal code of the NRA. This time the coal	Economic activities are more regulated by governmental control

	industry of the entire nation was organized to orderly marketing, and cutthroat competition was eliminated. The code flatly abrogated the philosophy of the Sherman Act. When the NRA was declared unconstitutional, a special law, the coal Conservation Act of 1935- the first "Guffey Act"- was passed, but it too was declared unconstitutional. A new act two years later passed the scrutiny of the Supreme Court and was just beginning to bring order out of chaos when world war II broke out, bringing it general price control legislation which included coal. When these wartime price control laws were rescinded in 1946, the coal industry found itself back where it had started – facing unregulated competition. So long as an expanded economy clamors for all the coal mines can produce, there is no immediate problem. Although it too much to hope that this will last, it perhaps is not much too hope that science and technology will come to the rescue. (487-489)	and left less to the individual in order to eliminate cutthroat competition.
Activities left to public and social control	-	
Activities of the third economy	-	
Weight overhead burden	-	
Returns social economy	-	
National wealth	*In general, the world dominance of the nations bordering the North Atlantic can hardly be explained without*	The location and the amount and type of resources can bring wealth to a country.

	reference to the striking concentration of useful materials within their borders, especially of major coal deposits and workable combinations of iron and coking coal. (p455).	
	Realizing the connection between industrial progress, economic well-being, and political power, many other nations have likewise made strenuous efforts to develop their coal resources. (Examples of Japan, India, China, Brazil etc.) (p456)	Many countries realized that coal could bring them national wealth, and therefore started to develop their coal resources.
Transportation costs	-	

Comments:

- No statements of Zimmerman could be found to underline the function of the factor “Activities left to public and social control”. However, information was found concerning the importance of the shift from individual activities to public activities. So, indirectly there are statements on the variable factor “Activities left to social and public control”, since the activities are replaced from individual initiatives to public and social control. Thus, Zimmerman indirect provides a statement on the importance of the factor “Activities left to social and public control”. Therefore, this factor is maintained in the framework.
- Also for this example for statement was given which support the importance of the variable “Activities third economy”. However a resource does not necessarily have to involve activities in the third economy. These activities may also be solely public or individual. In the case of coal, no activities could be found in the third economy. However for some resources it may be an important factor to understand the development and functionality. Therefore this factor is kept in the framework.
- For this example no statements were found on the functionality of the substance coal in relation to a reduction of weight of the overhead burden. However, since the reduction of the overhead burden may be an important incentive for governments to make use of a specific resource, this factor may important to understand the development and functionality of a specific resource. Therefore this factor is retained in the diagram.
- Also, no statement could be found which underlined the presence of the factor “Returns social economy” in the framework. However, just as for the factor “Weight overhead burden”, if a substance is able to generate social economic returns can be a significant incentive for governments to develop a specific resource. Therefore this factor is maintained in the framework.
- No specific information on the development and functionality of coal could be placed under the category “Transportation costs”. However, the determination of the profitability is in some cases

dependent on the transport possibilities and its associated costs. Therefore, it seems that this factor is already integrated in the factor "Determination of profitability" and may therefore be abundant. For this reason, the factor "Transportation costs" will be removed from the framework.

Changes to the framework:

- Removal of the variable "Transportation costs".

Human appraisal of resources

Table 229 Operationalization of the Primary factor Human appraisal of resources

Type of human appraisal	**Information from Zimmerman**	**Comments**
Human appraisal of resources	*To be sure, in recent years petroleum, water power and other forms of energy have made serious inroads in the field formerly held by coal. The fact that coal has lost some its importance during recent decades is in part due to discoveries of new sources of heat and energy and to new developments affecting the use of fuels, and in part due to the fact that coal is less suitable for certain purposes than other fuels. (456)*	The human judgment may lead to a judgment in which another resource may be considered more suitable for a function which is now filled by a currently used substance. This currently used substance could then loose its function to this other substance.
Knowledge/wisdom (nature and culture)	*While to the layman the technical details concerning the varieties of coal may seem superfluous, to the businessman who buys or sells coal they are of fundamental importance. A thorough knowledge of properties is not only vital to the intelligent interpretation of coal prices, but it indispensable to economic utilization. (p457)*	So, it depends on the role of Man, if and which properties are important. Though no matter which role, the knowledge of the characteristics of a substance is always of high importance to judge value and possibilities of a specific substance.
Formulation of grand strategy along socio-economic lines	-	
Determination	*Not only do coal deposits differ widely in the nature of the coals they contain,*	The conditions under which coal is found and properties of coal are of

profitability	*they differ also as to the conditions under which these coals are found. These factors go far to determine the mining methods which can be applied and the costs of production (p457).*	influence on the costs of production. These production costs are of influence on the profitability of a substance as a resource.
	In other cases, coal mining has ceased to be profitable; hence private capital has pulled out and left to the state to hold the fort. Coal is so important to the entire economy that mere profitableness must not decide its destiny. (430)	So, substances may still be appraised as resources even though, they may not profitable anymore.
	One conclusion should be crystal clear from this estimate of the coal reserves of the united states; unless truly fantastic improvements in the state of the arts are achieved, our descendants will have to pay far more for coal than the prices paid both in the past and at present. Large portions of the coal reserves listed by Campbell are of such poor quality, are located in such out-of-the-way corners, are so unfavorable as to thickness of vein, depth, etc. that only unheard-of-ingenuity or desperate need will render them available for use. In other words, they are not commercial reserves now, and they may never be. (p462)	These coal resources will not be resources until either profitability increases. This may be achieved by means of improved arts or by higher prices due to desperate needs.
	The mechanical proficiency of considerable portions of our coal mining industry is high. Favorable natural conditions, however, are probably the underlying cause of our low costs. Coal output by miner is in this eastern bituminous coal province is very high. But the methods of recovery used are more wasteful than those employed in typical European countries. In the United States roughly	Due to the natural conditions of the substance coal, the profitability of the substance coal is high. So, the natural conditions are of strong influence on the profitability of a substance in the function of a resource.

	one ton of coal is lost for every two tons mined. European recovery rates are much higher. It will not do, therefore to count on the 3.2 trillion tons of coal that are supposed to be in the ground as available for use. Actually, if our current wasteful methods of recovery are continued, little over 2 trillion tons will be available. (p462)	
	The value of coal deposits depends on its availability for use. A region which possesses coals unsuitable to its needs may not be much better off than one which lacks coal. (p467)	When a substance is unsuitable to satisfy the required needs, it will be unprofitable.
	A glance at figure 26.2 shows that the Bristol channel cuts way into this region, making such ports as Cardiff an Newport easily accessible to the merchant fleets of the world, to say nothing of the British navy (p467). The coal of Durham shire, on the other hand, is an excellent gas coal which could be readily sold not only to English and Scottish gas works but also to those on the continent. It moved via Hamburg to berlin, via le Havre to Paris, up to the Rhine to cologne and all the way to Mannheim. Just to the north of this lies another field of excellent steam coal made famous by the expression "carrying coals to Newcastle". In the black country or the midlands region, coal suitable for conversion into metallurgical coke was found in close proximity to iron ore and limestone. (p468)	Due to the excellent transportation system, coal could be sold to the regions where it could satisfy wants. This had a positive influence on profitability of the substance coal.
	The Rurh district possesses an unusual combination of favorable circumstances. It has the greatest coal	Due to the excellent transportation system, coal could be sold to the regions where it could satisfy wants.

	reserves in Europe, the seams being, relatively both thick and numerous. Its coal field is the best located on the continent. The deep and regular Rhine river provides a magnificent navigable waterway through the western part of the field, and adjoining canals lead through the district. A dense network or railroads connects the Ruhr with other parts of Germany and Europe. The high state of German technical development found expression in efficient mining and extensive use of coal products. A powerful national organization of production and sales stabilized exploitation. (p469)	This had a positive influence on profitability of the substance coal.
	Moreover, a coal mine is inevitably compelled to product joint products. No mine can produce only one size of coal; it necessarily produces several. There may be a brisk demand for some of them but not for others. This means that some coals are produced which are a drug on the market.; to get rid of them the operator resorts to the questionable practice of consignment sales, i.e. consigning them to an agent with instructions to sell them at whatever the market is willing to pay. Coal loaded in railroad cars in the sidings of at the coal mine is a costly luxury, for demurrage charges soon eat up the profit the coal may have promised. (481-482)	The determination of the profitability of the resource is not only dependent on the profit made with the main products. By products, may also increase the profitability of the substance.
	The fact that coal is still used as widely as it is, is due to a number of reasons. In the first place, there is no substitute for metallurgical coke in extracting iron from ore. In the second place, industries have been built over or	It is the low price of coal which makes it a profitable substance. However, when coal needs to be transported it may lose this profitability.

	around coal fields; this means that, in many industrial areas, coal has the advantage of being on the spot or nearby, whereas other fuels must be brought in over considerable distances. Also, some industries tend to cluster around the iron and steel industry, which in turn is dependent on coal. Above all, coal near the mine is a cheap fuel; its low price is its strongest point. Premium fuels tend to sell at premium prices. Only as high transportation charges are added to a low mine price does coal lose its advantage of cheapness and therefore have to yield to more mobile and otherwise more desirable fuels. (487)	
	All this is to the good and the coal-mining machine industry deserves much credit for its remarkable performance. But the upshot has been little more than the neutralization of higher wage costs. A far smaller number miners- working for much shorter hours, receiving much higher wages, and provided with far more equipment – produce about the same amount of coal as was produced during world war I. Wages still constitute about 60 percent of the costs of mining. Mechanization has lessened the dependence on large numbers of miner but not on labor as such, and at the same time it has added to overhead and thus reduced flexibility. It has played into the hands of larger, more heavily capitalized concerns. (487)	In order to still have the substance coal function as a profitable resource, changes appeared in the production process. This led a stronger position of large companies in the production of coal.
Determination technical feasibility	*To be sure, in recent years petroleum, water power and other forms of*	Due to discoveries and new developments, other substances may

	energy have made serious inroads in the field formerly held by coal. The fact that coal has lost some its importance during recent decades is in part due to discoveries of new sources of heat and energy and to new developments affecting the use of fuels, and in part due to the fact that coal is less suitable for certain purposes than other fuels.(456)	become more technical feasible for certain functions than the substance currently used to satisfy these functions.
	Not only do coal deposits differ widely in the nature of the coals they contain, they differ also as to the conditions under which these coals are found. These factors go far to determine the mining methods which can be applied and the costs of production (p457).	The technical feasibility of a substance conditions under which a substance is found.
	While to the layman the technical details concerning the varieties of coal may seem superfluous, to the businessman who buys or sells coal they are of fundamental importance. A thorough knowledge of properties is not only vital to the intelligent interpretation of coal prices, but it indispensable to economic utilization. (p457)	It depends on which role one takes, which properties of a substance may be important. For some the technical feasibility will be more important than the profitability. Though, thorough knowledge on the substance is always necessary for the rights appraisal of resources.

Comments:

- The only factor for which no relation is found concerning the development and functionality of coal, under the primary factor "Human appraisal of resources", is the factor "Formulation of grand strategy along socio economic lines". It may be considered that there was no real strategy about coal when the functions of this substance were discovered and the resource was developed. These days, the appraisal of resources may stem for a great part out of the strategy of country. An example of this could be found in the development of renewable resources in order to achieve the 2020 targets concerning CO_2 emissions. This example presents that the strategy of a country may have a strong influence on the appraisal of its resources. Therefore the factor will be maintained in the framework.
- It appears that Zimmerman is also missing a factor when it comes to the human appraisal of resources. When considering all the factors which Zimmerman presented, he does not name

environmental problems. Since the judgment of human beings on resources today also depends on the environmental influences and effects of a resource, it is suggested to add the variable “Environmental feasibility” under the primary factor “Human appraisal of resources”. This aspect may be a decisive factor to determine if a substance will be accepted and used as a resource in country. Since the framework which will be used to analyze the development and functionality of resources of the current, it is suggested to add the variable “Environmental feasibility”.

Changes to the framework:

- Adding of the variable “Environmental feasibility”

2. The changes to the test framework

In this paragraph the results for the operationalization of the framework are presented. This will start with the suggested changes per primary factor. This is followed by a table which shows if statements are found which underline the presence of the primary factors. These statements relate to the statements found for the secondary and tertiary factors, categorized under this primary factor. So, the table will present if statements were found, for the factor under this primary factor. Finally, a conclusion will be provided which shows the suggested alterations and the ‘Zimmerman framework’ after these adjustments.

Arts

For the primary factor “Arts” the following alterations for the framework are identified:

- Removal of the factor “Technology”, because its importance was not underlined in the operationalization.
- Removal of the factor “Discovery ways of new and inexhaustible fuels”, since this factor appears to be abundant and because its importance was not underlined in the theory.
- Removal of the factor “Methods/means”, since this factor appears to be abundant since this variable may be considered as an art to attain a specific end.
- Removal of the factor “Search for means/methods”, because this factor implies the same as the factors “Development of arts” and “Improvement of arts”.

Wants

For the primary factor “Wants” the following alteration for the framework is identified:

- Removal of the factor “Necessity” since this factor leads to the same information as the factor “Basic Wants”. Basic wants are considered a necessity for human beings, which makes the factor “Necessity” abundant.

Nature

For the primary factor “Nature” the following alteration for the framework is identified:

- Removal of the factor “Nature’s opportunities”, since nature’s opportunities stem from the natural and natural-cultural resources and the nature’s primary and secondary conditioning factors. Therefore the factor “Nature’s opportunities” is abundant.

Culture and resistances

Even though, there are no statements found to underline all the elements of primary factors Culture and resistances, all the secondary and tertiary factors of these primary factors will remain included in the framework. The reason for this is that it is perceived that these secondary and tertiary factors might be of importance in the analysis and understanding of the development functionality of resources.

Man

For the primary factor “Man” the following alteration for the framework is identified:

- Removal of the factor “Increased human contact” since it is considered abundant.
- Placement of the factors “Primary human factors of resource production” and the variable “Secondary human factors of resource production” under the primary factor “Human capacities”, since the factors both relate to human aspects of resource production and should therefore be located under “Man”.

Human capacity

For the primary factor “Human capacity” the following alteration for the framework is identified:

- Placement of the primary factor “Human capacity” under the primary factor “Man”. Since the human capacity is part of Man and Human capacity cannot be present without Man. The secondary and tertiary factors of the factor “Human capacity” will become the secondary and tertiary factor of the primary factor “Man”.

Economy

For the primary factor “Economy” the following alteration for the framework is identified:

- The variable “Transportation costs” is considered abundant since this aspect falls under the variable “Determination of the profitability” of a resource. Therefore the variable “Transportation costs” will be removed from the framework.

Human appraisal of resources

For the primary factor “Human appraisal of resources” the following alteration for the framework is identified:

- Adding of the factor “Environmental feasibility”. When considering the functionality of resources today another aspect comes to mind, which is not yet named by E.W. Zimmerman. This aspect is the environmental feasibility of a resource. Today, substances which may harm the environment may have to overcome some severe resistances from the public before they can function as resources. Furthermore, today substances which have a lower environmental impact, such as wind may function as resources since they are considered environmental friendly, even though they are not necessarily profitable. Therefore, in order to complete this framework, the variable “Environmental feasibility” is added under the primary variable “Human appraisal”.

Summary primary factors

When considering the theory provided on coal, Zimmerman provides examples on the functionality of coal as a substance in all the categories of the primary factors. Therefore the basis of the framework, the primary factors, will largely remain unchanged. The only change considers the relocation of the primary factor “Human capacity” under the primary factor “Man”.

Table 230 Summary primary factors

Arts	Present
Nature	present
Culture	Present
Institutions	Present
Resistances	Present
Man	Present
Human capacity	Present, will be placed under the primary factor “Man”
Economy	present
Human appraisal of resources	Present
Wants	Present

3. Changes to the ‘Zimmerman framework’

With the information provided in the previous sections, the following alterations to the framework are done:

1. Removal of the variable “Technology”
2. Removal of the variable “Discovery ways of new and inexhaustible fuels”
3. Removal of the variable “Methods/means”
4. Removal of the variable “Search for methods/means”.
5. Removal of the variable “Cultural description”.
6. Removal of the variable “Increased human contact”.
7. Placement of the primary factor “Human capacity” under the primary variable “Man”.
8. Placement of the variables Primary human factors of resource production” and the variable “Secondary human factors of resource production” under the primary factor “Human capacities”. Though, since human capacity is placed under man, these variables stay in the same place.
9. Removal of the variable “Transportation costs”.

10. Adding of the variable “Environmental feasibility”.

The final Zimmerman framework, developed after these alterations, is provided in chapter three.

Appendix IV

In this appendix the additional information of chapter six is stated. This information is presented in the same order as chapter six.

Wants

The diagram of the International Energy Administration below presents the share of the undiscovered conventional energy resources of the U.S compared to the other regions in the world. This implies that also the share of undiscovered conventional oil and gas resources is not very high compared to other countries. Therefore, these conventional energy sources will not be able to satisfy the wants of the U.S. government to attain energy security and energy independency.

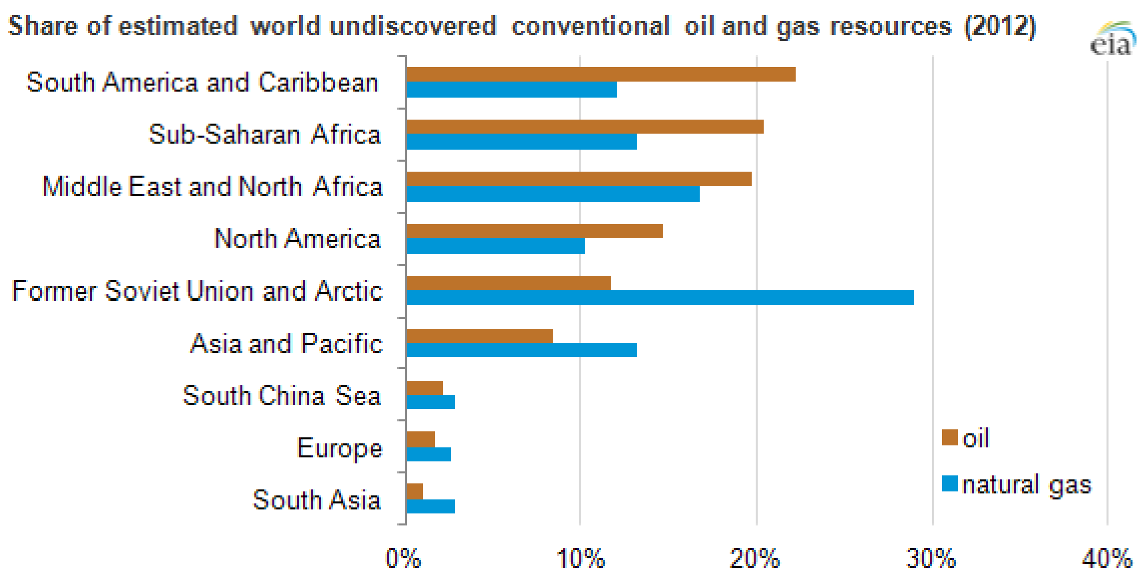


Figure 40 Estimated unconventional resources (U.S. Energy Information Administration, 2012b)

Nature

Properties shale gas

Shale is a fine grained sedimentary rock formed from the compression of silt and clay-sized minerals (Geology.com, n.d.-b). These clay size mineral particles are also referred to as mud (Geology.com, n.d.-b). The shale stone contains clay minerals , organic minerals and small particles of quartz and feldspar (U.S. department of the Interior & U.S. geological Survey, 2013). The grain size of shale is smaller than 1/256 mm which is one of its most important properties (U.S. department of the Interior & U.S. geological Survey, 2013). Furthermore it is fissile and laminated (Geology.com, n.d.-b)(U.S. department of the Interior & U.S. geological Survey, 2013). These properties lead to the characteristics of the rock which make that it easily tears along these laminations (Geology.com, n.d.-b).

Shale gas, which is natural gas stored in shale formations, may either be absorbed in the organic material of the formation or be present as free gas in the fractures and pores (U.S. department of the Interior & U.S. geological Survey, 2013). The shale gas formations are considered both as the source rocks as the seals for the gas reservoirs (U.S. department of the Interior & U.S. geological Survey, 2013). If there are conventional sources of natural gas present above or below a shale formation, hydrocarbons coming from the shale source rock may migrate into these reservoirs (U.S. department of the Interior & U.S. geological Survey, 2013).

Formal institutions

Introduction formal institutions U.S.

Divisions of laws

There are three branches of government applicable in the U.S., these are:

- Legislative branch
- Judicial branch
- Executive branch(“Overview of the Legal System,” n.d.)

The legislative branch has the task to enact the law (“Overview of the Legal System,” n.d.). The United states congress is an example of an element of this branch (“Overview of the Legal System,” n.d.). The judicial branch has the function to interpret the law in the role of for example a court (“Overview of the Legal System,” n.d.). Finally the executive branch carries out the law, examples of this are for example the president of the U.S. or a governor (“Overview of the Legal System,” n.d.). .

The four sources of law

Every branch of government is responsible for a source of law (“Overview of the Legal System,” n.d.). The three branches described above are responsible for three of the four primary sources of law (“Overview of the Legal System,” n.d.). The fourth source of law considers the federal and state constitutions (“Overview of the Legal System,” n.d.). These four types of law account for all citizens in the U.S. and are referred to as the “primary sources of law” and form the foundation of the American legal system (“Overview of the Legal System,” n.d.)

The four primary sources of law are:

1. Constitutions: Federal & State
2. Statutes: legislative branch
3. Cases: Judicial Branch
4. Regulation: Executive Branch

Mineral rights

In the united states, the ownership of the minerals which lie beneath the surface was initially provided to owners of the surface (Geology.com, n.d.-a). These owners had the complete private ownership of both the “surface rights” as the “mineral rights”(Geology.com, n.d.-a). The owners had the right to sell, lease of give these right to another legal person (Geology.com, n.d.-a).

Today, the transfer of mineral rights is subject to state laws (Geology.com, n.d.-a). These laws may differ per state (Geology.com, n.d.-a). The mineral rights may be separately sold from the surface rights to for example a drilling operator (Geology.com, n.d.-a). The owners will remain owner of the surface rights (Geology.com, n.d.-a).

When selling these mineral rights, it may concern all the minerals which appear beneath the surface, or it may be specified to one mineral (Geology.com, n.d.-a). With these mineral rights, the buyer has the rights to exploit the minerals of the contract (Geology.com, n.d.-a). This may lead to consequence in appearances on the surface for the surface owner (Geology.com, n.d.-a). The surface owner often does not have a say in when and how the resources will be exploited and how the area will left behind (Geology.com, n.d.-a).

Another option is to lease the mineral rights (Geology.com, n.d.-a). This agreement provides the mining company with the rights to access the property, do tests and identify if the required minerals are present (Geology.com, n.d.-a). For this lease agreement, the mining company will pay the owner in order to be able to access the property and for the reservation of the rights for a certain time period (Geology.com, n.d.-a). If the operator does not decide to start exploring before the end of the lease term, the mineral rights are transferred to the owner again (Geology.com, n.d.-a). When a mineral owner, leases the mineral rights to an operator the owner normally receives a "signing bonus" in advance (Geology.com, n.d.-a). Furthermore if the operator does decide to start exploring in his lease period, he normally pays the owner of the property a "Royalty payment"(Geology.com, n.d.-a). The agreement of payment will be fixed in a contract made prior to the mining activities, and may occur in the form of a percentage or in a price per ton of minerals (Geology.com, n.d.-a). Other forms are also possible.

If the operator finds gas, operators often have to pay the owner a royalty share which is paid during the lease period (Geology.com, n.d.-a). In some states the laws obligate the operator to pay the owner a minimum royalty (Geology.com, n.d.-a) A regular royalty share is a percentage of 12.5 percent of the value of the production (Geology.com, n.d.-a). Though there are cases in which the owner receives 25 percent of more of the value of the oil or gas production (Geology.com, n.d.-a).

As, in the previous case, the owner of the property does has to adapt to the activities required and done by the operator (Geology.com, n.d.-a). Though with a leasing contact, agreements on what, when and how operations are executed can be developed which may prove beneficial for both sides (Geology.com, n.d.-a).

Oil and gas also fall under these mineral rights (Geology.com, n.d.-a). The rights to exploit gas and oil may both be sold or leased, however leasing is more common (Geology.com, n.d.-a). This because, the operator is often not sure in advance if oil and gas will be found(Geology.com, n.d.-a).

Taxes

The federal tax section 29 for conventional fuel production tax credit, was of strong influence on the development of new technologies(Martineau, 2007). The value of this tax credit was $3/bbl (Haas & Goulding, 1992). With a conversion of 5.8 Mcf of gas per bbl., the tax credit was initially worth $0.52 per Mcf (Haas & Goulding, 1992). Though, the tax credit was also adjusted for inflation of all of the unconventional gasses except gas from tight sands (Haas & Goulding, 1992). This resulted, for instance, for coal bed methane in an increase in the worth of this tax credit to 0$.94 per Mcf (Haas & Goulding, 1992). All the gas which was produced from tight formations and drilled later than December 31 1979 and before the first of January 1993 and sold before January 1, 2003 was subject to this credit (Martineau, 2007).

Safe water drinking act

Private wells which are used by less than 25 people are not protected by this act (Environmental Protection Agency, n.d.-a).

Initially the SWDA focused only on the treatment of drinking water, however currently it focusses on the whole drinking water system. This means it also aims at the protection of resources, public information and the optimization of waste water systems (Environmental Protection Agency, n.d.-a)

Public Water Supply Supervision

As a federal agency, the EPA is responsible for the exploitation of the SDWA (Sakmar, 2012). Though it is allowed to depute the primary enforcement and implementation authority (primacy) to the individual states (Sakmar, 2012). The Public Water Supply Supervision is the basis of the program which regulates the public water systems (Sakmar, 2012). The EPA has deputed the primacy for this program to all the states except Wyoming and the district of Columbia (Sakmar, 2012)

Underground injection

Class I wells

According to the EPA and several other studies, the injection of hazardous waste in class I wells is a safe technology which includes minor risks *for the human health and the environment* (Hammer & Levine, 2012). For these wells an analysis of the risks of earthquakes, an assessment of the area around the well and stricter procedures for the handling of issues and the way of reporting are required (Hammer & Levine, 2012). Furthermore, these wells need be drilled beneath the level of the lowest underground drinking water resources in order to rule out the risk of contamination (Hammer & Levine, 2012) Moreover, these wells will be cemented and cased in order to prevent the leakage of fluids (Hammer & Levine, 2012)

Granted primacies

EPA has provided the primacy of the UIC program to thirty three states, including Texas, but still maintains the enforcement and implementation authority in 10 states (Sakmar, 2012). Pennsylvania, where the Marcellus shale is located is one of the states which have not assumed the primacy and for which the EPA still contains it (Hammer & Levine, 2012). Again, the states may provide more stringent rules and regulations for underground injection, than necessary by federal law (Hammer & Levine, 2012). Some states (New York) require and evaluation of the impact of the well on the environment, others do not (Pennsylvania) (Hammer & Levine, 2012)

Risks usage of diesel during hydraulic fracturing

The risks concerning the usage of diesel during the hydraulic fracturing process are found in the chemicals which are possible present in diesel such as *impurities or additives* which are very mobile in groundwater and may provide a risks for human health (Environmental protection agency, 2012). These chemicals are for example, benzene, toluene, ethyl benzene, and xylene compounds (BTEX) (Environmental protection agency, 2012). These chemicals may pose a risk for the quality of drink water.

Clean water act

Development NPDES permits

The NPDES permits are developed out of standards of the clean water act and the state law, which may pose stricter water quality standards than the CWA (Hammer & Levine, 2012). These standards contain the Effluent Limitation Guidelines (ELG) and are based on what is technologically possible and on what the desired water quality of the receiving water is (Hammer & Levine, 2012). The technology based conditions provide requirements for the minimal treatment of the contaminants based on the current technologies (Hammer & Levine, 2012). The water quality conditions provide maximum allowances for the discharge contaminants which could harm the water quality (Hammer & Levine, 2012). This maximum allowance is based on the required standards of the quality of the surface water (Hammer & Levine, 2012). These required standards are again based on the necessary quality to use the water body for a specific purpose (Hammer & Levine, 2012). Therefore the standards based on the desired water quality differ per location and are based on the water criteria (Hammer & Levine, 2012).

Contaminants present in the effluent

Evidence that contaminants are really present in the effluent of treatment facilities is challenging to achieve. There is not much data present on the levels of the chemicals used during hydraulic fracturing or the chemicals which have evolved from the formation and which are present in the treated effluent of CWT's and POWT's (Hammer & Levine, 2012). It would require a deeper analysis to determine if the chemicals of concern are still present in the effluent after the treatment of the waste water (Hammer & Levine, 2012). In the paragraph 'Technical system' of this appendix an example of such an analysis is presented, though this concerns only the data from four plants. In order to provide a valid conclusion more plants have to be evaluated. Furthermore, the input of these plants should be known, in order to understand which chemicals are present and what the amount of these chemicals is which is processed in the plants.

Example of stricter regulations on state level

As stated before the states may set stricter regulations than the federal standards (Hammer & Levine, 2012). This happened in Pennsylvania. The regulations of Pennsylvania are explored in order to present what laws may apply on state level.

Pennsylvania regulations

With the Marcellus shale being present in its state, Pennsylvania is one of the states which applies stricter rules to the discharge of treated water into surface water. In 2011 the state has updated the chapter 95 regulations for 'New and expanding' waste water streams to be disposed (Hammer & Levine, 2012). In order be allowed to discharge these new and expanding streams, a state permit is required. This permits poses maximum concentrations for the TDS and chlorides which may be present in the releases of CWT's POTW's (Hammer & Levine, 2012). Additionally, if new or additional streams of treated shale gas waste water are to be discharged, consent should be given by means of the permit (Hammer & Levine, 2012). These permits may only be granted to CWT's (Hammer & Levine, 2012). POTW's can only dispose other types of waste water or high volumes of waste water if this waste water was processed in a CWT first (Hammer & Levine, 2012). The effluent is than allowed to have a maximum of 500mg/L of TDS (Hammer & Levine, 2012).

Furthermore the regulations require an implementation plan from drilling operators to both reduce the amount of waste water produced as to maximize the amount of waste water recycled and reused (Hammer & Levine, 2012). Furthermore, the chapter 93 regulations complement these chapter 95 regulations. The chapter 93 regulations pose water quality standards for the water in Pennsylvania (Hammer & Levine, 2012). These standards are of influence on the NPDES permits (Hammer & Levine, 2012). If these standards are violated, the permits will be changed to such extent that this will not happen again (Hammer & Levine, 2012).

However, from July 2011 15 treatment facilities were lifted from their obligations to meet these regulations (Hammer & Levine, 2012). This implies that they are still allowed to release treated water into the surface water which exceeds the maximum concentration limits stated by chapter 95. From these 15 facilities 9 are POTW's (Hammer & Levine, 2012).

Clean air act

According to the EPA the Clean Air Act costs $65 billion dollar, but leads to $2 trillion in economic benefits. Furthermore, it will prevent 230.000 early deaths in 2020 (Environmental Protection Agency, 2013c).

In 1955, the air pollution act of 1955 was derived (Environmental Protection Agency, 2012d). This act, describes the first federal air pollution legislation (Environmental Protection Agency, 2012d). Also, it formed the start for research on the sources of air pollution and its impact (Environmental Protection Agency, 2012d). In 1970 the first National Ambient Air Quality standards and the implementation plans were developed (Environmental Protection Agency, 2012d). Also, the New Source Performance standards and National Emission Standards for Hazardous Air Pollutants were authorized (Environmental Protection Agency, 2012d). The last amendments to the clean air act of 1970 were in 1990 (Environmental Protection Agency, 2012d). In these amendments the requirements for the permit program were established and the conditions for the National Ambient Air quality standards and the enforcement authority were changed and extended (Environmental Protection Agency, 2012d).

Negative effect exploration natural gas

The exploration of natural gas may cause a negative impact on the air quality (Environmental Protection Agency, 2013a). It may lead to increases in methane emissions, volatile organic compounds (VOC's) and Hazardous Air Pollutant (HAPs) (Environmental Protection Agency, 2013a). Furthermore, during the production of natural gas, it is possible that some gas escapes and cannot be retrieved by the operator anymore (Environmental Protection Agency, 2012c). Methane, the main element of natural gas, is a greenhouse gas with an high impact (Environmental Protection Agency, 2012b). It is 20 times as powerful as CO_2 when released into the air (Environmental Protection Agency, 2012b). The oil and gas industry is responsible for 40% of the methane emissions, and are therefore the main single source of these emissions (Environmental Protection Agency, 2012b).

Resource conservation and recovery act

The Resource Conservation and recovery Act (RCRA) regulates the treatment and discharge of waste (Hammer & Levine, 2012). Subtitle C of this program is a federal program which regulates hazardous waste from *cradle to grave* (Hammer & Levine, 2012). This implies that it regulates the transportation, treatment storage and disposal of this waste (Hammer & Levine, 2012).Though, the waste evolving from activities in the oil and gas sector is not regulated under this act (Hammer & Levine, 2012). The reason for this lays in the fact that in 1980 an amendment to the statute, excluded the waste of oil and gas sector for a period of two years (Hammer & Levine, 2012). In these two years, the EPA had to explore if the waste from oil and gas activities should be managed under this act (Hammer & Levine, 2012). In 1988 the EPA came to the decision that this was not the case (Hammer & Levine, 2012). The reason for this was the applying the regulations of subtitle C of the RCRC on the oil and gas industry would create too high costs for the industry (Hammer & Levine, 2012). The EPA decided that the gaps in law could be overcome by strengthening of the clean water act and the UIC program (Hammer & Levine, 2012). Also EPA considered the possibility to develop *management criteria* which would provide *environmental performance* standards in order to dispose the solid waste (Hammer & Levine, 2012). However it never did this (Hammer & Levine, 2012). Subsequently, the waste coming from oil and gas activities does not have to meet the standards and precautions which are established for hazardous waste by the RCRA regulations (Hammer & Levine, 2012).

However, the contaminants present in the waste water may be individually categorized as hazardous components. In order to identify the toxicity of a hazardous waste, the waste has to be tested. This is done with a toxicity characteristic leaching procedure (TCLP)(Hammer & Levine, 2012). During this procedure the chemicals present in the leachate are compared to maximum TCLP allowance for arsenic, barium, chromium, lead, mercury, selenium and silver and several other organics. In addition some states demand the execution of tests on zinc, copper and nickel (Hammer & Levine, 2012). When the produced water from the Marcellus shale was evaluated, the concentration of bromium fell in a range between non-detected and above the TCLP maximum(Hammer & Levine, 2012).

Clean construction program

The EPA is encouraging the usage of more efficient technologies and cleaner fuels for hydraulic fracturing equipment and transport vehicles (Environmental Protection Agency, 2013a). This is done through the Clean Construction USA program (Environmental Protection Agency, 2013a). This is also a voluntary program and part of EPA’s national Clean Diesel campaign (U.S. Department of energy, 2013). It is developed to minimize the emissions coming from equipment and vehicles using diesel (U.S. Department of energy, 2013). This is done by supporting suitable operations and maintenance, the utilization of environmentally friendly fuels, and the usage of technologies which reduce emissions (U.S. Department of energy, 2013).

The new regulations clean air act

These regulations were required by the clean air act and were developed based on feedback of several stakeholders such as the public, public health groups, the states and the industry (Environmental Protection Agency, n.d.-g)(Environmental Protection Agency, 2012c). These regulations pose the premier federal air standards for natural gas production with hydraulic fracturing (Environmental Protection

Agency, n.d.-g). Furthermore, these regulations are considering other sources of air pollution which are caused by the oil and gas industry, but for which federal rules were not existing yet (Environmental Protection Agency, n.d.-g). EPA has posed some changes to some of the initially proposed regulations as a result of the public comments (Environmental Protection Agency, n.d.-g). This in order to increase flexibility while maintaining the environmental benefits (Environmental Protection Agency, n.d.-g).

The final standards appear to be achievable and have low implementation costs (Environmental Protection Agency, 2012c). According to the analysis of EPA, these rules are cost effective and make use of technologies and practices which are already used in 50 percent of the fractured wells and which are congruent with the path the industry is taking in seizing natural gas which may now be sold (Environmental Protection Agency, 2012c). Furthermore EPA, states that these rules will establish a saving of $11 to $19 million per year for the industry (Environmental Protection Agency, 2012c). Moreover a decrease of 190.000 to 290.000 tons of VOC emissions is expected which complies to a reduction 95 percent (Environmental Protection Agency, 2012b)(Environmental Protection Agency, 2012c). Furthermore a decrease of air toxics of 12.000 to 20.000 tons and a decrease in methane of 1.0-1.7 million short tons is predicted (Environmental Protection Agency, 2012b).

New source Performance Standards

The New Source Performance Standards (NSPS) for the natural gas and crude oil industry are established to regulate VOC emissions from produced from gas wells and *centrifugal compressors, reciprocating compressors, pneumatic controllers, storage vessels and leaking components at onshore natural gas processing plants* (Environmental Protection Agency, 2012a). Furthermore the NSPS regulate the sulfur dioxide emissions coming from onshore natural gas processing plants(Environmental Protection Agency, 2012a). Oil wells are not regulated by this rule.

Well completion is for these rules defined as the flow back period which starts directly after the hydraulic fracturing and ends when the well is shut of when a continuous stream to *the flow line or storage vessel* has been achieved(Environmental Protection Agency, 2012a).

When wells are fractured or refractured, the NSPS in general necessitates owners/operators to make use of reduced emissions completions, also referred to as ”RECs” or “green completion” in order to decrease VOC emissions derived *from well completions* (Environmental Protection Agency, 2012a). During the green completion process, the gas and liquid hydrocarbons are removed from the rest of the flow back and may be sold after treatment (Environmental Protection Agency, 2012b). This both reduces the emissions due to flaring and increases the revenues for the operator. These technologies are already implemented at many wells (Environmental Protection Agency, 2012c).

Furthermore, from the beginning of October 2012, companies are required to notification the state or the EPA before they start the well completion (Environmental Protection Agency, 2012e).

Technical system

Hydraulic fracturing

Hydraulic fracturing concerns the process which follows after the drilling of the well. The first step the process of hydraulic fracturing concerns the evaluation of the well (U.S. department of the Interior & U.S. geological Survey, 2013). In this first step data about the field is collected (U.S. department of the Interior & U.S. geological Survey, 2013). This data concerns the properties of the field and the dynamics of the present and important relations (U.S. department of the Interior & U.S. geological Survey, 2013). The operator aims at creating *effective permeability* by means of fracturing the shale in such a way that it links with the naturally present fractures (U.S. department of the Interior & U.S. geological Survey, 2013). The natural fractures are helpful to increase the hydraulic fractures since these are fissile and weak spots in the formations (U.S. department of the Interior & U.S. geological Survey, 2013). Though, the large natural fractures may also cause problems (U.S. department of the Interior & U.S. geological Survey, 2013). These may limit the length of the horizontal part of the well, *absorb hydraulic energy*, or cause the leakage of water(U.S. department of the Interior & U.S. geological Survey, 2013).

After the evaluation of the well the process of hydraulic fracturing is started. A mixture of sand, water and chemicals is then injected in the well under high pressure (Kefferpütz, 2010)(Chevron, 2012). This in order to fracture the shale formation and create a network of fractures (Kefferpütz, 2010)(Chevron, 2012). This networks of small cracks makes it possible for natural gas to migrate into the well (Chevron, 2012). This process is presented in the picture below.

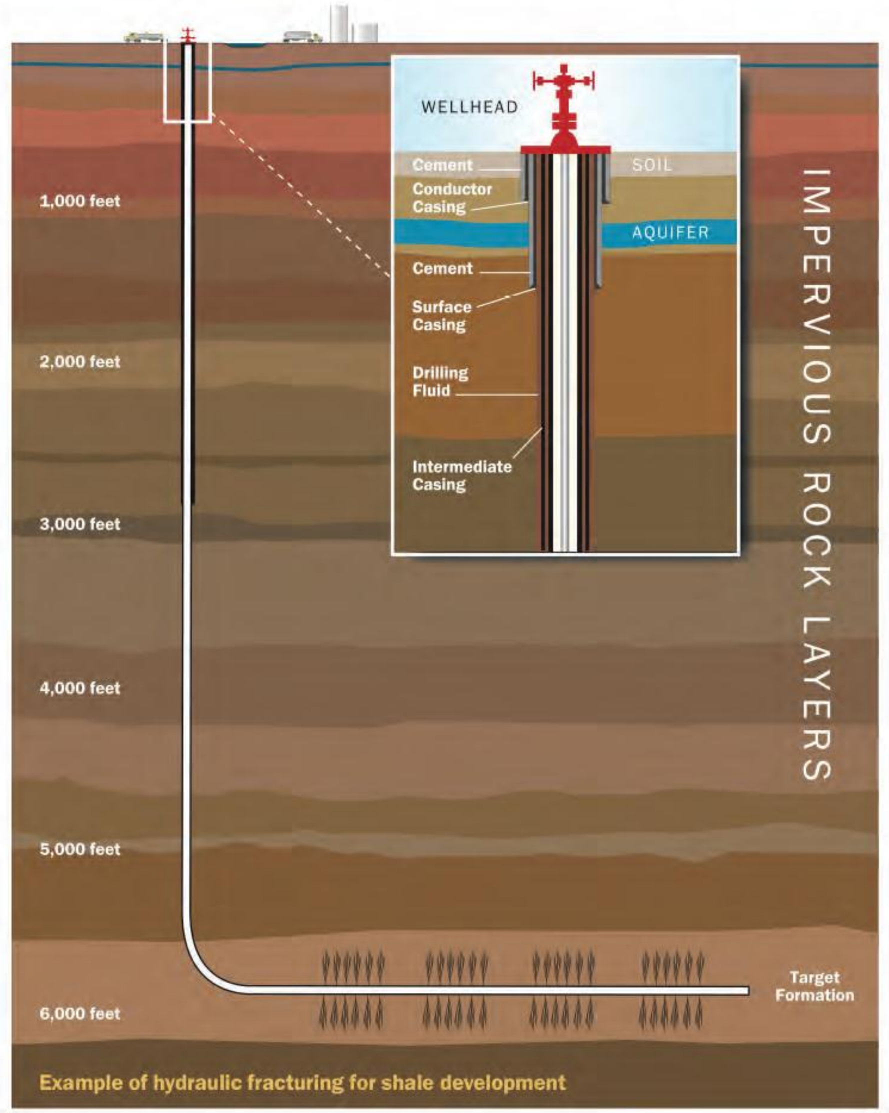


Figure 41 Hydraulic fracturing

Wellbore construction

The function and construction of a wellbore

The construction of a wellbore is aimed at the protection of the direct surrounding of the well and the ground water. If the technology is not correctly applied, this may lead to contamination of the surrounding formations, and if present, the ground water. When this happens, the exploration processes could have to be terminated.

If a wellbore is drilled, it requires a seal to eliminate the chance that drilling fluids, production fluids or work over fluids enter the surrounding formation, in which the groundwater may be present (Prohaska & Thonhauser, 2012). This obligation must be met from the start of wellbore construction process and is maintained throughout the life of the well, even when the well is not used anymore (Prohaska & Thonhauser, 2012).

The casing and the cement are the elements used to prevent this leakage of fluids into the environment (Prohaska & Thonhauser, 2012). The cement is placed between the wall rock, the border of the area in which the geological activities take place, and the steel pipe (Prohaska & Thonhauser, 2012). It has the function to eliminate the flow of fluids between the casing and the wall rock (Prohaska & Thonhauser, 2012). This area between the wall rock and the casing is also referred to as the annulus (Prohaska & Thonhauser, 2012). The amount of layers of cement and casing depends on the depth of the well and the types of formation which are to be drilled (Prohaska & Thonhauser, 2012). The picture below presents the upper part of a well ready to be used, also referred to as well completion (Prohaska & Thonhauser, 2012).

Figure 42 Wellbore completion (Prohaska & Thonhauser, 2012)

In order to prevent the leakage of fluids and the contamination groundwater, the wellbore should be constructed in a proper way. First of all, the cement should be established in such a way that it meets the requirements of good cements and that it can be placed in a satisfying way (Prohaska & Thonhauser, 2012). Furthermore, the wellbore should be formed by a number of casing strings (Prohaska & Thonhauser, 2012)

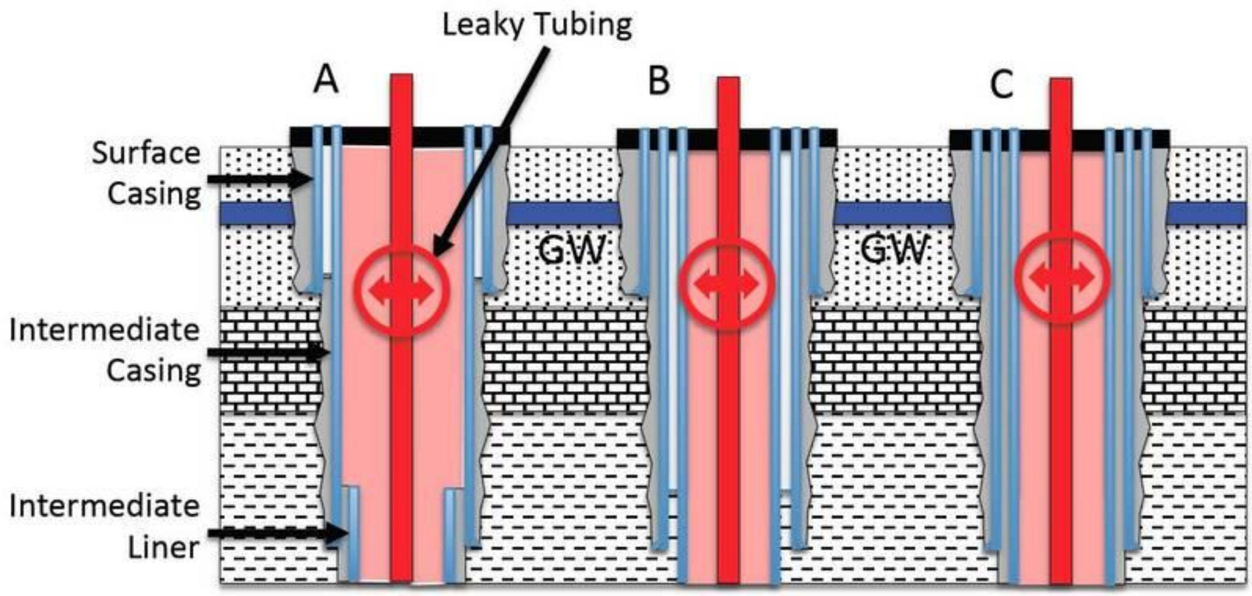


Figure 43 Three options of wellbore construction (Prohaska & Thonhauser, 2012)

The layers of cement and casing strings are, especially in the upper part of the wellbore, overlapping. These layers should prevent the leakage of the production fluid, which could happen if a tubing is leaking, as presented in the figure above (Prohaska & Thonhauser, 2012). Scenario A, B and C all provide different categories of the strength of well bore and therefore in the protection of groundwater. In wellbore type A, the top of the cement layer belonging to the intermediating casing starts just above the formation which contains the ground water (Prohaska & Thonhauser, 2012). This type is a common wellbore used for the production of conventional gas (Prohaska & Thonhauser, 2012). In scenario B, the ground water is better protected since there are two layers of cements and three layers of casing from top to bottom (Prohaska & Thonhauser, 2012). Scenario C, provides the safest option for groundwater protection since it provides another layer of cement and casing compared to scenario B (Prohaska & Thonhauser, 2012).

Next, to the fact that the casing and cement layers prevent the leakage of drilling fluids into the environment, it also protects the annulus from fluids leaking in from the environment (Prohaska & Thonhauser, 2012). The isolation is used to protect the wellbore from its environments is referred to as zonal isolation (Prohaska & Thonhauser, 2012). The zonal isolation enables the migration of fluids only from the produced fractures into the production tubing and not reversed (Prohaska & Thonhauser, 2012). Perfect zonal isolation is accomplished by the throughout cementation of the intermediate and production liners (Prohaska & Thonhauser, 2012). This perfect zonal isolation is shown in figure 57.

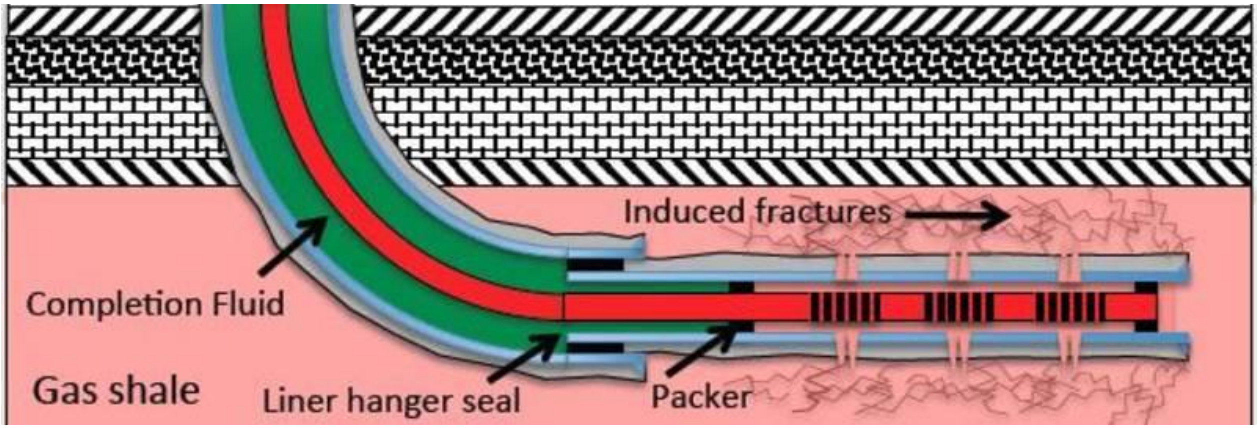


Figure 44 Zonal isolation (Prohaska & Thonhauser, 2012)

Possible problems

It may happen that sections of the wellbore are not optimally cemented. This could especially happen in the deviated and horizontal section of the wellbore. Reasons for this can amongst others be poor casing centralization or the impossibility to rotate the casing strings (Prohaska & Thonhauser, 2012). When the wellbore is not optimally cemented, there are still two barriers the fluids need to overcome before they can enter the annulus. First, in the horizontal part, the liner hanger seal (see the picture above) eliminates the possibility for fluids from the environment to migrate into the wellbore (Prohaska & Thonhauser, 2012). Second, in the vertical part, the casing shoe which is closest to the poorly cemented area will prevent the fluids to enter the wellbore (Prohaska & Thonhauser, 2012). This situation for the vertical part shown in figure 58.

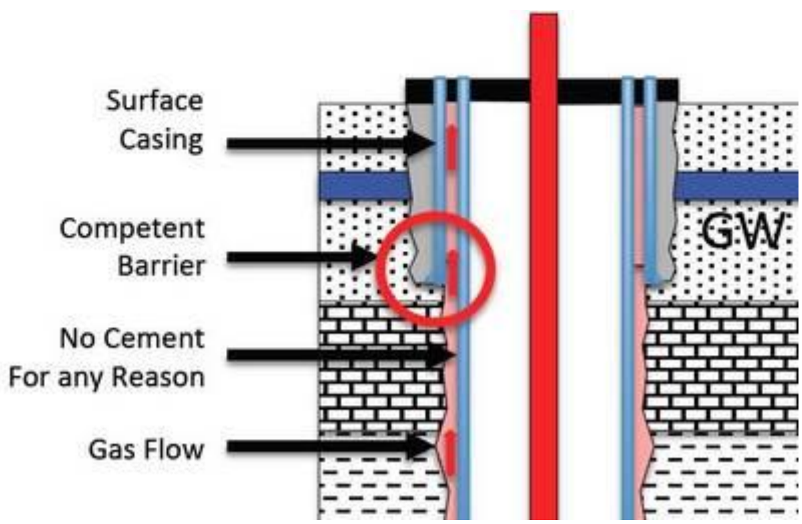


Figure 45 Poorly cemented part of the wellbore (Prohaska & Thonhauser, 2012)

If the cementation is poor along the whole wellbore and the there is no other *lower pressure* around and there are no other permeable rocks between the production zone and groundwater zone, groundwater contamination could happen (Prohaska & Thonhauser, 2012). In this scenario, the fluid would flow through the annulus into the zones in which the groundwater is present (Prohaska & Thonhauser, 2012). This scenario is showed in figure 59.

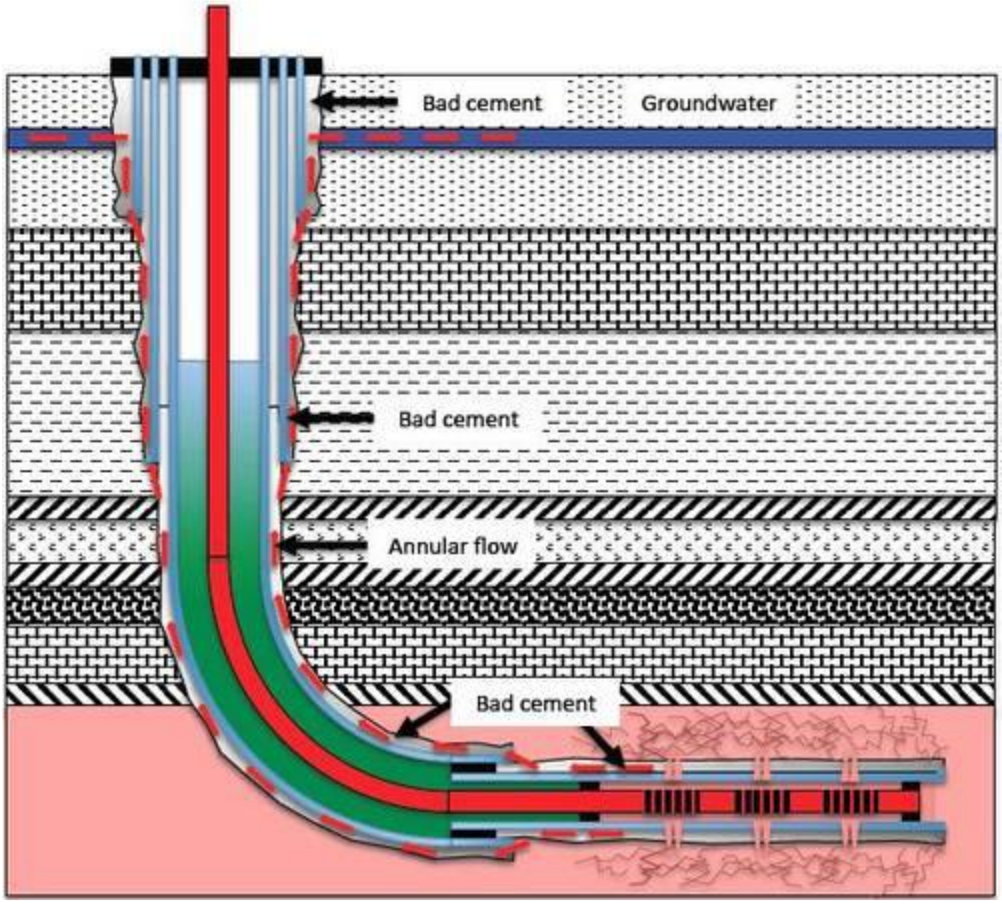


Figure 46 Contamination of groundwater (Prohaska & Thonhauser, 2012)

Though, there several indicators which show the quality of the cementing job, both during the cementing process as during the individual cementing operations of the different sections of the well (Prohaska & Thonhauser, 2012). These indicators provide important information for the operators on the status of the cement and could lead to on time prevention of problems (Prohaska & Thonhauser, 2012). When the worst case scenario's take place, the operators may not complied to the usage of best practices and their duty to operate in a responsible way (Prohaska & Thonhauser, 2012).

Flow back water

The period in which in the flow back water returns to the surface is around 10-14 days and the amount of water which flows back to the surface is about 10-25% of the initial fluid injected (Hammer & Levine, 2012). This is about 420.000 to 2.520.000 gallons of fluid per well per hydraulic fracture (Hammer & Levine, 2012). This flow back water typically contains the chemicals which were added to the fracturing fluid and the chemicals which were present shale formation (Hammer & Levine, 2012). This water is more commonly recycled than the water which will be produced in a later stage and will contain more chemicals derived from the formation (Hammer & Levine, 2012).

Produced water

The well may produce 200-1000 gallons per Mcf of natural gas produced (Hammer & Levine, 2012). Since a shale gas well may produce for a period of 40 years, the amount of produced water may lead to millions of gallons of water (Hammer & Levine, 2012). Though the amount of produced water is related to the properties of the formation which is fractured (Hammer & Levine, 2012). The Marcellus shale is for instance, a pretty dry formation, which produces less water than other shale formations when fractured (Hammer & Levine, 2012).

Radioactive elements

The NORM types which are present in the highest volume are radium-226 and radium-228 which evolve from the radioactive *decay of uranium and thorium which is present in shale formation* (Hammer & Levine, 2012).

Desalination

For the desalination of the waste water many different, both thermal and non-thermal, technologies may be used (Hammer & Levine, 2012). Since, desalination is a very energy intensive, and therefore costly process, many facilities only treat the water until the standard for which it may be used again for processes in the oil and gas industry (Hammer & Levine, 2012). The full desalination of water brings such significant costs that as long as there are reuse opportunities for the water which is not completely desalinated, treatments which offer complete desalination are not likely to be used (Hammer & Levine, 2012).

Underground injection

In the U.S. almost all waste water which evolves from onshore wells is injected (Hammer & Levine, 2012). This may either be just because of the easy option of disposal or it may be related to the function of disposal to preserve the formation pressure of the oil field (Hammer & Levine, 2012). There are 14.000 class II wells, in which the disposal of waste water coming from oil and gas activities is allowed (Environmental Protection Agency, n.d.-c). These wells are mostly located in Texas, California, Oklahoma, and Kansas (Environmental Protection Agency, n.d.-c). More than 2 billion of gallons of brine is injected in these well per day (Environmental Protection Agency, n.d.-c).

Treatment for reuse hydraulic fracturing or underground injection

If the waste water is to be recycled for the usage in hydraulic fracturing operations or when it will be injected underground, the treatment aims at the elimination of organic and inorganic pollutants which could lead to the adhesion of particles to the surface of the well which would reduce its functionality (Hammer & Levine, 2012).

Required Pretreatment POTW's Pennsylvania

In Pennsylvania operators are not allowed to release their waste water without pretreatment to these POTW's (Hammer & Levine, 2012). (See appendix IV) Furthermore, the permits of these plants often present a maximum allowance of 1-5 percent of the total flow of waste water coming from oil and gas activities (Hammer & Levine, 2012). Finally, the total treatment capacity of POTW's is often limited and these treatments plants are developed to handle a constant flow of waste water (Hammer & Levine, 2012). If the volume of the incoming waste water is increased or the timing of the delivery of the waste water to the plants is different this could lead to *uncontrolled overflow conditions* (Hammer & Levine, 2012)

Treatments used in practice

In order to understand the situation concerning the treatment and discharge of shale gas waste water, this section will provide a brief example on how and to what extent the waste water is treated in the Marcellus shale. First the components of the waste water will explained. Second, the standards for the discharge of waste water in Pennsylvania are presented. These standards are then compared with the waste water coming from the Marcellus shale and the concentrations of contaminants which are present in the effluent water of treatment plants.

Components shale gas waste water

The figure below provides an overview of the components of waste water (Hammer & Levine, 2012). By means of filtration the suspended chemicals are separated from the dissolved chemicals (Hammer & Levine, 2012). Both the suspended and dissolved chemicals contain organic and inorganic contaminants (Hammer & Levine, 2012)

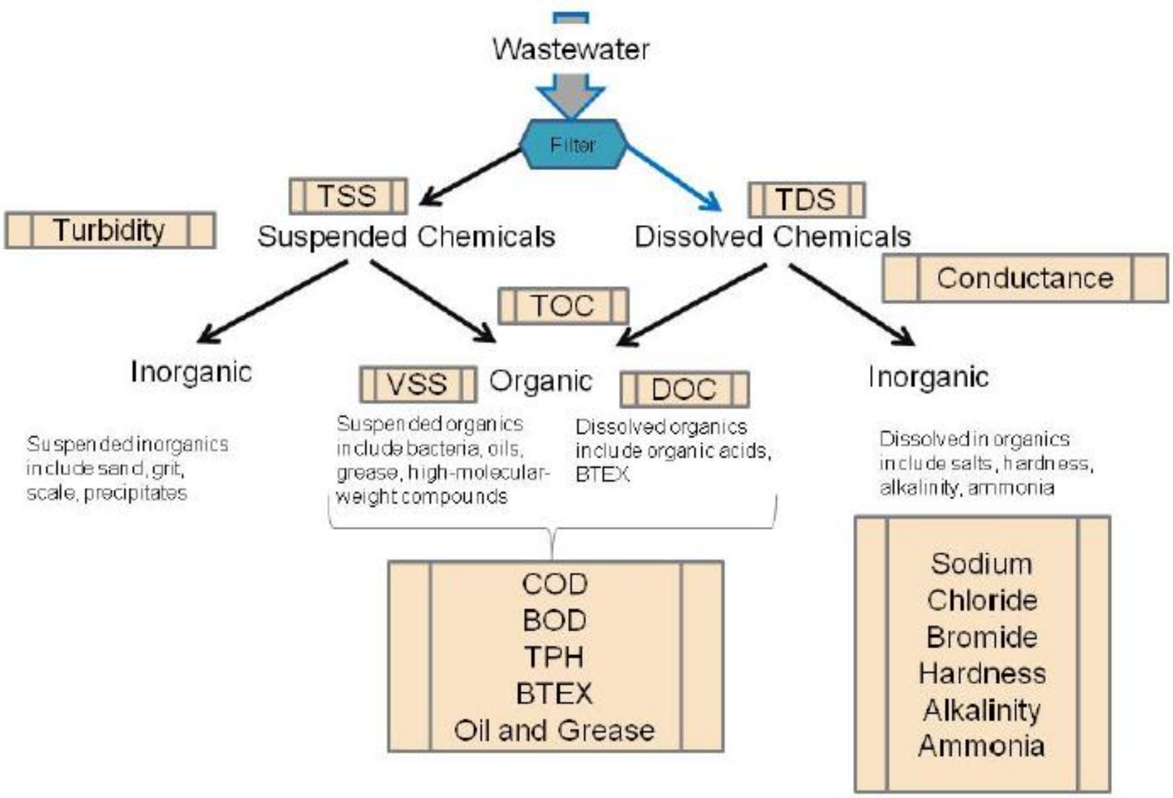


Figure 47 Components waste water (Hammer & Levine, 2012)

The dissolved contaminants may either be measured in total dissolved solids (TDS) or through the exploration of the electrical conductance of the water (EC, in Ms/cm) (Hammer & Levine, 2012). The organic particles which are dissolved may be quantified as the measure of their concentration or may be identified in a comprehensive term such as hardness of alkalinity (Hammer & Levine, 2012).

If waste water is aimed to be discharged into surface water, all steps in the table below have to be taken (Hammer & Levine, 2012). The water which will come out of this process is fully desalinated and may be used for all purposes (Hammer & Levine, 2012).

Table 231 Necessary steps water treatment (Hammer & Levine, 2012)

Class	Examples	Surrogate Parameter	Treatment Methods
Suspended solids	Sand, grit, scale Bacteria	Total suspended solids Turbidity	• Coagulation/flocculation with sedimentation and filtration • Microfiltration or ultrafiltration
Suspended organics	Oil, grease, colloids, bacteria	Oil and Grease Total organic carbon Chemical or biological oxygen demand	• Dissolved air flotation • Biodegradation • Adsorption (activated carbon, zeolites) • Microfiltration and ultrafiltration
Dissolved organics	BTEX: benzene, toluene, ethylbenzene, xylene Phenols, organic acids	Dissolved organic carbon BTEX VOC Specific chemical additives (see Table 4 in Chapter 1)	• Adsorption (activated carbon, organoclays, zeolite, resins) • Chemical (ozonation, fenton) • Electrochemical or photocatalytic oxidation • Biodegradation • Nanofiltration or reverse osmosis
Dissolved multivalent ionic species	Scale-formers: Ca, Mg, Fe, Sr, Ba, sulfate NORM	Hardness Specific metals (Iron, Strontium, Barium) Specific anions (sulfate, nitrate-nitrogen)	• Metals: aeration, settling, filtration; ion exchange, reverse osmosis • Hardness: ion exchange • NORM: ion exchange, lime softening, reverse osmosis
Dissolved monovalent ionic species	Na, K, Cl, Br, I NH_4^+	Specific ions: Na, Cl, Br Ammonia-nitrogen	• Thermal desalination • Membranes • Electrochemical

The final stage, the desalination stage, is the most energy intensive stage (Hammer & Levine, 2012). Therefore many facilities remove the suspended solids, suspended organics, dissolved organics and dissolved multivalent ionic species and then deliver the treated water again to customers which will use it for oil and gas activities (Hammer & Levine, 2012).

Water criteria chapter 95 regulations Pennsylvania

The table below presents the water quality criteria for specific end uses such as the reuse for hydraulic fracturing or dust control on roads. In this table the maximum allowances for TDS, chlorides, sulfate, barium and strontium which are subject to the chapter 95 regulations of Pennsylvania are presented.

Table 232 Chapter 95 regulation limitations (Hammer & Levine, 2012)

Treatment Goal	Water Quality Needed	Potential for Use
Discharge to surface water in Pennsylvania	<500mg/L TDS <250 mg/L chloride <250 mg/L sulfates <10mg/L total barium <10mg/L total strontium	Only with extensive treatment.
Reuse for hydraulic fracturing	Moderate TDS Low SS Low Ca, Mg, Fe, sulfate (scale formers)	Very likely and routinely practiced, often with partial treatment or dilution.
Deep well disposal	Low Ca, Mg, Fe, sulfate (scale formers) Low SS	Very likely and routinely practiced, sometimes with partial treatment to reduce scale-forming potential.
Crop irrigation	Low salinity (TDS) Low sodium adsorption ratio (SAR <6) Low toxicity	Only with extensive treatment.
Wildlife and livestock consumption	Moderate TDS (<5,000 mg/L) pH 6.5-8 SAR 5-8	Only with extensive treatment.
Aquaculture and hydroponic vegetable culture	Moderate TDS Low metals	Only with extensive treatment.
Dust control on roads and in mining	Low SS Low in specific constituents like metals	Possible for some produced water and for treated brines.
Vehicle and equipment washing	Low SS Moderate TDS	Possible with dilution.
Power-generation cooling	Low SS Moderate TDS Low Ca, Mg, Fe, sulfate (scale formers)	Possible but unlikely due to fouling problems.
Fire control	Low SS Low organics	Possible but unlikely.
Potable reuse	SDWA[v] criteria Low DBP formation potential Adequate mineral content	Very unlikely. Indirect potable reuse through aquifer recharge possible with extensive treatment.

Water is perceived as fresh water if the TDS is lower than 1500 mg/l(Hammer & Levine, 2012). The secondary standards for drinking water is that the TDS should be lower than 500 mg/l (Hammer & Levine, 2012). However, these secondary standards are not obligated (Hammer & Levine, 2012).

Shale gas waste water Marcellus shale

Now these stated water quality criteria will be compared with the waste water coming from the Marcellus shale.

Table 233 Waste water Marcellus shale

Chemical constituent or surrogate parameter	Unit of measure	Range reported in produced water from wells drilled in Marcellus Shale at 5 days post hydraulic fracturing	Range reported in produced water from wells drilled in Marcellus Shale at 14 days post hydraulic fracturing
Total Suspended Solids (TSS)	mg/L	10.8–3,220	17–1,150
Turbidity	NTU	2.3–1,540	10.5–1,090
Total Dissolved Solids (TDS)	mg/L	38,500–238,000	3,010–261,000
Specific Conductance	umhos/cm	79,500–470,000	6,800–710,000
Total Organic Carbon (TOC)	mg/L	3.7–388	1.2–509
Dissolved Organic Carbon (DOC)	mg/L	30.7–501	5–695
Chemical Oxygen Demand (COD)	mg/L	195–17,700	228–21,900
Biochemical Oxygen Demand (BOD)	mg/L	37.1–1,950	2.8–2,070
BOD/COD Ratio (% biodegradable)			0.1 (10%)
Alkalinity	mg/L	48.8–327	26.1–121
Acidity	mg/L	<5–447	<5–473
Hardness (as $CaCO_3$)	mg/L	5,100–55,000	630–95,000
Total Kjeldahl Nitrogen (TKN)	mg/L as N	38–204	5.6–261
Ammonia Nitrogen	mg/L as N	29.4–199	3.7–359
Nitrate–N	mg/L as N	<0.1–1.2	<0.1–0.92

What can be concluded from this table is that the TDS has a range of 3.010 -238.000 mg/l over the production process. This is 6 to 476 times the maximum allowance of 500 mg/l TDS according to regulations set in chapter 95 regulations in Pennsylvania. Furthermore the chloride concentration, barium concentration and strontium concentration all vary between ranges which are far above the maximum allowance of this chapter 95 regulations. This implies that the waste water requires a significant treatment before it may be discharged into the surface water.

Satisfaction treatment waste water plants

Thus, in order to find out if these treatment plants are capable of fulfilling this difficult task, data of the effluent of four treatment facilities are compared. Unfortunately no data are available on the exact input of waste water of these plants, so the exact effectiveness of these plants cannot be defined (Hammer &

Levine, 2012). The differences in the ranges in effluents between the different plants can be explained by the different inputs they receive (Hammer & Levine, 2012).

Table 234 Effluents treatment plants exempted from the chapter 95 regulations (Hammer & Levine, 2012)

Chemical Constituent or Surrogate Parameter	Unit of Measure	Pa Brine (Josephine) Discharge (PA0095273) Nov.–Dec. 2011	Pa Brine (Franklin) Discharge (PA0101508) Nov.–Dec. 2011	Hart Resources Discharge (PA0095443) March–Dec. 2011	Waste Treatment Corporation (PA0102784) Jan.–Dec. 2011
Flow	MGD	0.155	0.18	0.018-0.045	0.164-0.214
Total Suspended Solids (TSS)	mg/L	20.5-32	<10 to 33	6-19.5	<2.5-17
Oil and Grease	mg/L	5.25-10.6	2.25-9.49	3.8-22	<5-6.8
Total Dissolved Solids (TDS)	mg/L	133,050-198,400	91,600-108,000	7,200 – 179,900	Not reported
Alkalinity (as $CaCO_3$)	mg/L	185-236	57-95	45-258	45-56
Acidity (as $CaCO_3$)	mg/L	0	0	1 to <2	1-31
Chloride	mg/L	64,404-96,909	48,600-54,300	3300-91 , 728	69,800 – 131,725
Bromide	mg/L	1100-8290	603-727	76.20-6630	Not reported
Sulfate	mg/L	975-1000	634- 841	104-1500	Not reported
Iron	mg/L	0	0.31-0.519	0.14-1.37	0.13-1.84
Strontium	mg/L	Not reported	299-303	Not reported	Not reported
Barium	mg/L	12.3-18.5	6.78-8.99	2.775-13.78	Not reported
NORM:					
Uranium	µg/L	ND	ND	ND	Not Reported
Radium-228	pCi/L	8.39-15.6	3.6-15.6	2.63-8.31	
Gross Alpha	pCi/L	0.132	0.132-156	6.39-117	
Radium-226	pCi/L	1.75-2.23	1.75-1.77	0.815-7.94	

When comparing the data in this table with the maximum allowances set in the chapter 95 of Pennsylvania, it may be concluded the treatments is not sufficient enough to meet the required criteria for the effluent. First, The TDS ranges from 7200-198.400 mg/L while it should be lower than 500 mg/L. Second, The chloride concentration varies between 3300-131.725 mg/L while the maximum allowance is set at 250 mg/L. Third, the concentration of sulfates ranges between 104-1500 mg/l while it should be lower than 250 mg/l. Fourth the total barium should be under 10 mg/l while the range in the effluent is between 6,78 and the 18,5 mg/l. Finally the total strontium ranges, in the only available data, between 299-303 while it should be lower than 10 mg/l.

Another aspect, which is not integrated in the chapter 95 regulations, but which is regulated through the drink water standards are the requirements for NORM (Hammer & Levine, 2012). These standards demand that the uranium is below 30 µg/l and that the combination of radium-226 and radium-228 combined is below 5 pCi/L and the alpha emitters below 15 pCi/L(Hammer & Levine, 2012). However, as can be seen in the table above, the radium-226 and radium-228 levels are between the 0,815 and 15.6 Pci/L (Hammer & Levine, 2012). Furthermore the alpha emitters are reported between 0.132 and 156. This has led to concern about the level of radioactivity in drink water (Hammer & Levine, 2012). Therefore the PADEP (Pensylvania Department of Environmental Protection) demanded the evaluation of all drink water supplies in that area (Hammer & Levine, 2012). Though no risks concerning the drinking water were found (Hammer & Levine, 2012).

Treatment in options used Pennsylvania

When looking at the water treatment, it appears that half of the waste water in 2011 was treated at CWT's (Hammer & Levine, 2012). The state of Pennsylvania has posed discharge limits for these CWTs (Hammer & Levine, 2012). Approximately one third was recycled to be used in hydraulic fracturing processes again (Hammer & Levine, 2012). Ten percent was injected underground and another ten percent was processed in CWT's which did not comply with the chapter 95 regulations set by the Pennsylvanian state (Hammer & Levine, 2012). Furthermore about 1 percent was processed in the POTW's (Hammer & Levine, 2012). Finally the left-overs are stored and are waiting for treatment or discharge (Hammer & Levine, 2012).

Though, these number changed significantly in the second half of 2011 in which the amount of produced waste water has doubled (Hammer & Levine, 2012). The amount of water which was treated at CWT's quadrupled (Hammer & Levine, 2012). While the amount of waste water which is brought to CWT's exempted from the chapter 95 regulations, shrank with 98 percent (Hammer & Levine, 2012). More than three times the old volume was injected underground and recycling for hydraulic fracturing processes grew with on tenth of the old volume (Hammer & Levine, 2012). The processing of waste water in POTW's became so small that it was not reported anymore (Hammer & Levine, 2012).

Economics

Effects on gas price

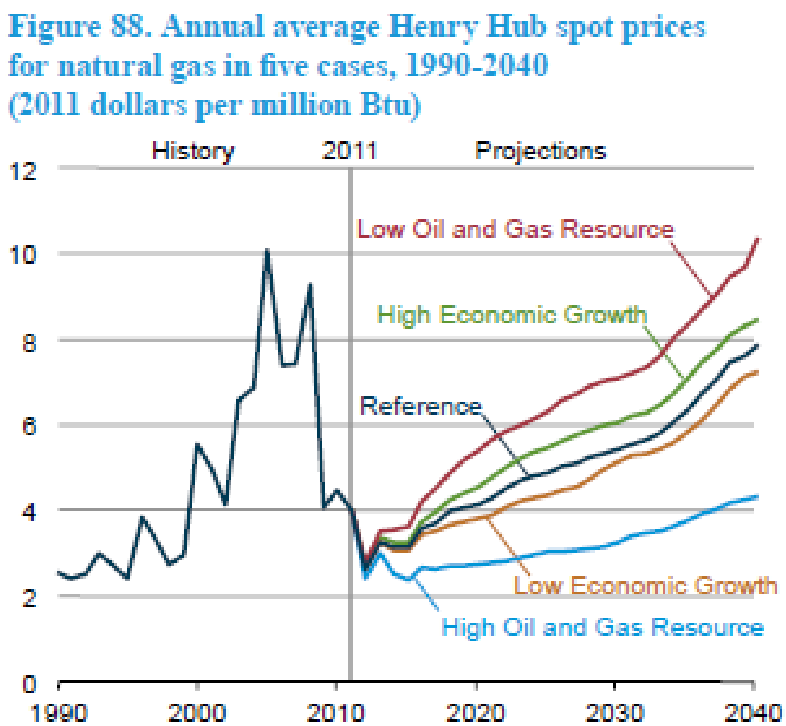


Figure 48 Average Annual Henry Hub Price (U.S. Energy Information Administration, 2013)

The figure above presents 5 scenario's for the natural gas prices. What can be derived from this figure is that the price of natural gas depends both on the economic growth and the speed of which resources are exploited. The price is the highest in the case when natural gas and oil are exploited at a slow rate (U.S. Energy Information Administration, 2013). Subsequently the price of natural gas is the lowest, if natural gas is explored at a fast rate way in which the demand is lower than the production (U.S. Energy Information Administration, 2013). Moreover, high economic growth creates a boost for the gas price, while low economic growth has a negative effect on this price. This economic growth may for example be found in the development of new houses, increased usage of offices and a growth in the usage of natural gas for industrial purposes (U.S. Energy Information Administration, 2013). This growth may increase the consumption of natural gas, and therefore the depletion of natural gas, which leads to higher prices (U.S. Energy Information Administration, 2013). When this economic growth is not present the demand for natural gas and the depletion rate will go down, which will lead to lower gas prices (U.S. Energy Information Administration, 2013).

However, when natural gas price are very low in a country, the export of natural gas may lead to an increase in consumption and therefore in price, which has an increasing effect on the price (U.S. Energy Information Administration, 2013). Furthermore, low prices decrease the incentive for exploration, which may also have a positive effect on the price, since less natural gas will become available (U.S. Energy Information Administration, 2013).

Production natural gas

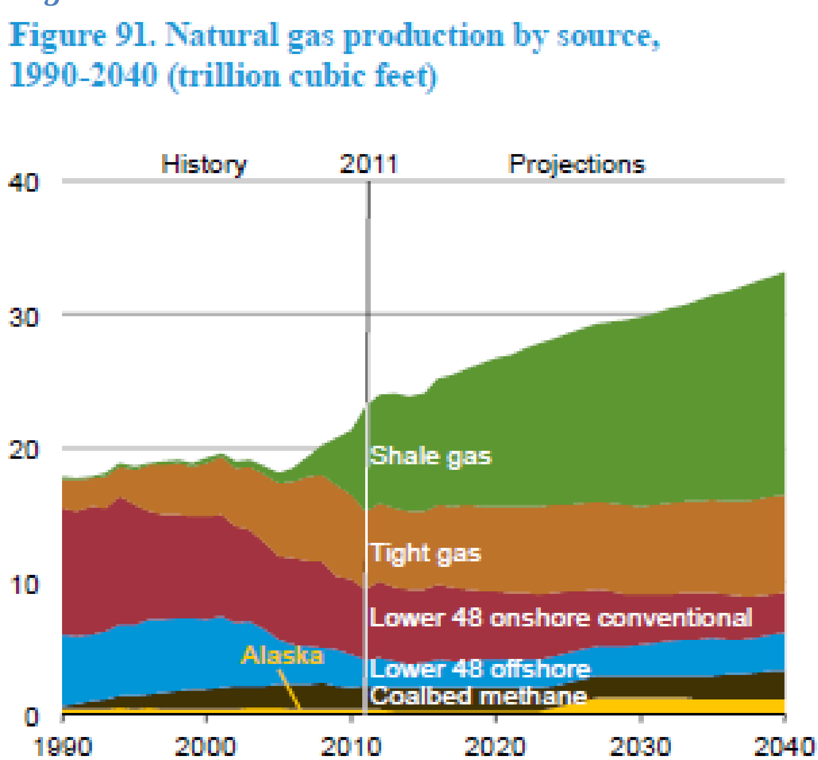


Figure 49 Natural gas production (U.S. Energy Information Administration, 2013)

The production of shale gas rose from 36.3 billion cubic meters (1.28 tcf) in 2007 to almost a fourfold of 179 billion cubic meters (6.3 tcf) in 2012 (Newman, 2012). This will lead to an increase in the production of shale gas of 113 percent in the period of 2011-2040 (U.S. Energy Information Administration, 2013). This production of shale gas is considered the main contribution of the growth of production of natural gas in 2011-2040 which will rise with 44% (U.S. Energy Information Administration, 2013).

Appendix V

Nature

Resistances overcome by nature

Table 235 Resistances overcome by nature

Resistance	Posed by variable	Overcome by
-	-	-

Resistances posed by nature

Table 236 Resistances posed by nature

Resistance	Is solved by	Solved by the factor
The natural gas is located in the shale formation from which it cannot be retrieved with conventional drilling technologies	Development of horizontal drilling and hydraulic fracturing	Technical system
Permeability shale formation	Hydraulic fracturing	Technical system

Informal institutions

Resistances overcome by Informal institutions

Table 237 Resistances overcome by informal institutions

Resistance	Posed by variable	Overcome by
Start-up shale gas evolution	Nature Technical system	Informal institutions (Entrepreneurial mind, attitude towards loans, attitude towards land, lack of priority for the environment)

Resistances posed by Informal institutions which are overcome

Table 238 Resistances posed by informal institutions which are overcome

Resistance	Is solved by	Solved by the factor
Citizens are not happy with the development of shale gas due to negative side effects.	The system of mineral rights and royalty shares	Formal institutions

Resistances posed by Informal institutions

Table 239 Resistances posed by informal institutions

Resistance	Could be solved by	Solved by the factor
Fear of the citizens for the negative side effects due to usage of chemicals during the process of hydraulic fracturing	1. Information on the properties of these chemicals 2. Prohibition of the chemicals which could form a risk for human health and the environment 3. Replacements of the chemicals which could form a risk for human health and the environment with other chemicals with the same function	1. Formal institutions 2. Formal institution 3. Technical system
Fear of citizens for decrease in safety and cleanness of their living environment	Making sure that people cannot get hurt by the exploration technologies and that the environment does not get contaminated with aspects which could be of harm for human beings	• Technical system • Formal institutions
Fear of people that their drinking water will not be safe	1. Decrease the possibility on water contamination by improving both the technical system as to increase the regulations around wellbore construction and the handling, transport and storage of waste water and chemicals onsite 2. Lift the exemption for waste from gas and oil activities under the RCRA 3. Develop new effluent guidelines for CWT's 4. Improve the treatments processes in water treatment facilities	1. Technical system/Formal institutions 2. Formal institutions 3. Formal institutions 4. Technical system

Formal institutions

Resistances overcome by Formal institutions

Table 240 Resistances overcome by formal institutions

Resistance	Posed by variable	Overcome by
Citizens are not happy with the development of initial shale gas due to negative side effects.	Informal institutions	Formal institutions (The system of mineral rights and royalty shares)
The possibility of contamination drinking water by diesel	Technical system	Formal institutions; requiring operators to obtain permits in the case diesel fuels are used in hydraulic fracturing processes
Negative effects for the environment due to flaring	Technical system	Formal institutions; Setting New Source Performance Standards under the Clean Air Act
Possibility of contamination of waste water due to discharge waste water into surface water	Technical system	Formal institutions; waste water may not be discharged into water bodies without treatment
Unprofitability for operators	Technical system	Formal institutions: Tax break/credit

Resistances Posed by Formal institutions

Table 241 Resistances posed by formal institutions

Resistance	Overcomes negative effects	Negative effect delivered by
Operators are obliged to obtain a permit if they want to use diesel during their hydraulic fracturing operations	The possibility of contamination drinking water by diesel and therefore negative effect for the environment and human health	Technical system
Operators are required to use green completion from the first of January 2015	Negative effects on air quality	Technical system
Operators are not allowed to discharge waste water directly into the surface water	Negative effects waste water on water quality surface water	Technical system

Risks which should become Formal resistances

Table 242 Resistances posed by Formal institutions

Resistance	Could be solved by	Solved by the factor
Risks of negative effects for the environment and human health due to lack of regulation of the injection hydraulic fracturing fuels	Lifting the exemption of hydraulic fracturing activities under the UIC program	Formal institutions
Risk negative effects for the environment and human health due to the injection of waste water residuals in class II wells, for which comprehensive studies on the effect on human health and environment have not been finished	1. Finishing the studies on the class II wells 2. In the case of possible negative effects on the environment or human health the exemption of waste coming from oil and gas activities under the RCRA act should be lifted	1. Formal institutions 2. Formal institutions
Risk of disruption of POTW's due to the fact that no pretreatment standards for shale gas waste water are developed under the CWA	Setting pretreatment standards for shale gas waste water under the CWA	Formal institutions
Risk for the quality of water bodies environment and drink water due to possibility of the presence of contaminants coming from shale gas waste water due to a lack of pretreatment standards for POTW's	Setting pretreatment standards for shale gas waste water under the CWA	Formal institutions
Risk for the quality of water bodies, environment and drink water due to possibility of the presence of contaminants coming from shale gas waste water, due to the lack of updated effluent guidelines for CWT's on the 'new' pollutants	Developing standards and effluent guidelines for the CWT's	Formal institutions
Risk for the quality of water bodies, environment and drink water due to possibility of the presence of contaminants coming from shale gas waste water, due to the lack of updated NPDES permits on the 'new' pollutants	Update the water criteria and the NDPES permits	Formal institutions
Risk for the environment since waste coming from shale gas activities does not have to handled, transported, stored or re-used on land according to precautions set for hazardous waste	Lift the exception that waste coming from oil and gas is not considered hazardous waste under the RCRA	Formal institutions
Risk for the environment since the	Lift the exception that waste coming	Formal institutions

residuals of shale gas activities do not have to handled, transported, stored or re-used on land according to precautions set for hazardous waste	from oil and gas is not considered hazardous waste under the RCRA	
Risk posed on the quality of drinking water, due to fact that impacts of hydraulic fracturing on drinking water are not yet fully understood (Report ready in 2014)	1. Speeding up the process of understanding, by providing priority to the development of this report 2. Stop the processes of hydraulic fracturing until the impact of these processes are fully understood	1. Formal institutions 2. Formal institutions
Risk for the environment and human health due to lack of understanding of the impact of usage of chemical additives in hydraulic fracturing, since these do not have to be made public	Enacting the FRAC act	Formal institutions
Risk of oversupply and resulting low gas prices due to the leasing structure	Regulate the leasing structure in order to decrease the risk of oversupply	Formal institutions

Technical system

Resistances overcome by the Technical system

Table 243 Resistances overcome by technical system

Resistance	Posed by variable	Overcome by
Presence of shale gas in shale formation	Nature	Technical system (horizontal drilling and hydraulic fracturing)
Permeability shale formation	Nature	Technical system (Hydraulic fracturing)
Low efficiency exploration large volumes of shale gas	Technical system	Technical system (Slick water-fracturing)
Not allowed to discharge waste water directly into the surface water	Formal institutions	Technical system (different treatment options)

Negative effects of the Technical system which could become resistances

Table 244 Negative effects of the technical system

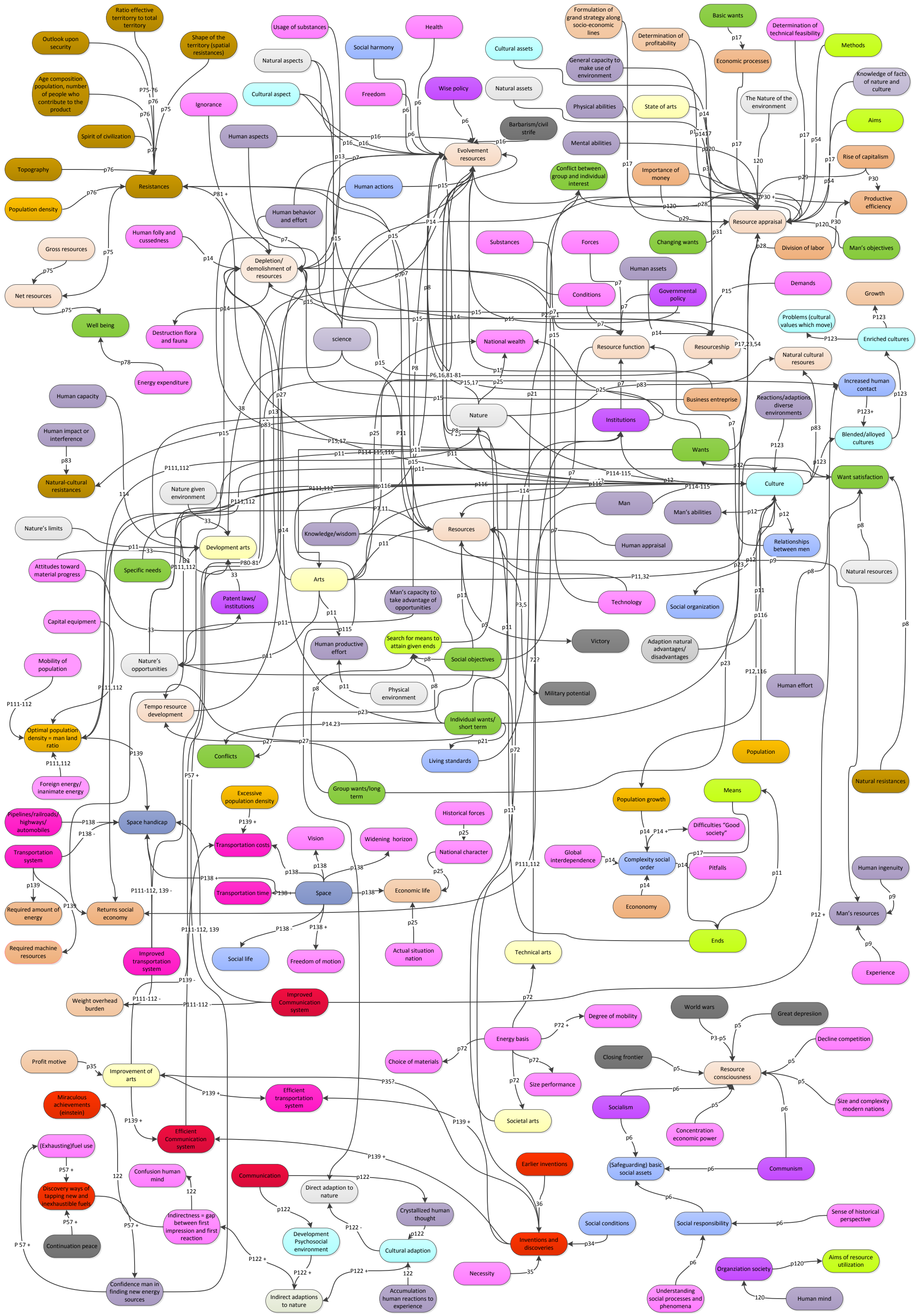
Resistance	Could be solved by	Could be solved by the factor
Contamination of the environment due to poor wellbore construction (due to implementation costs best practices)	Rules and regulations on proper wellbore construction and implementation of best practice technologies	Formal institutions
Water scarcity in certain areas due to significant water demand for the hydraulic fracturing of wells	1. Improvement of technology in order to necessitate less water 2. Provide rules on the maximum share of water which may be used for exploration activities in areas which require regulation	1. Technical system 2. Formal institutions
Fear for negative effects chemicals used	1. Confirmation of the Frac act which would obligate the operators to publish the chemicals 2. Explanation of the chemicals, their function and their effects on the environment and human health in order to increase the understanding	1. Formal institutions 2. Formal institutions
Presence TDS in effluent POTW's since the facilities are not capable of removing these particles	Prohibit the disposal of shale gas waste water to POTW's ,this waste water should be sent to CWT's	Formal institutions
Possibility breakdown of POTW's due to treatment of high concentrations of salt and metals	Prohibit the disposal of shale gas waste water to POTW's. This water should be sent to CWT's	Formal institutions
Poor quality of water body due to the presence of contaminants such Bromide in the effluent of CWT's	Improving treatment technologies to remove contaminants Developing effluent guidelines on these 'new 'contaminants	Technical system Formal institutions
Possibility of accidental leakage, especially since shale gas waste does not has to be handled as hazardous waste under the RCRA	Lifting the exempt of waste coming from oil and gas activities, in order to have waste coming from these activities managed under the precautions of the RCRA	Formal institutions
Possibility of intentional spills by man	Providing of knowledge to increase the understanding of risk of these leakages Development of sanctions for these spills	Formal institutions Formal institutions
Possibility of negative effects for the environment and groundwater due to the land application of waste water	Lifting the exemption of waste coming from oil and gas activities under the RCRA, so the waste water is treated as hazardous waste	Formal institutions

Increased costs due to the improvements of water treatments plants	Paying for these costs by means of the turnover of shale gas	Formal institutions
Possibility of ground water contamination, due to shale gas exploration processes	1. Proper construction well bore 2. Satisfactory handling procedures of waste water 3. Satisfactory storage procedures 4. Satisfactory transport procedures 5. Responsible handling of the operator	1. Technical system 2. Formal institutions 3. Formal institutions 4. Formal institutions 5. Formal institutions/ Technical system

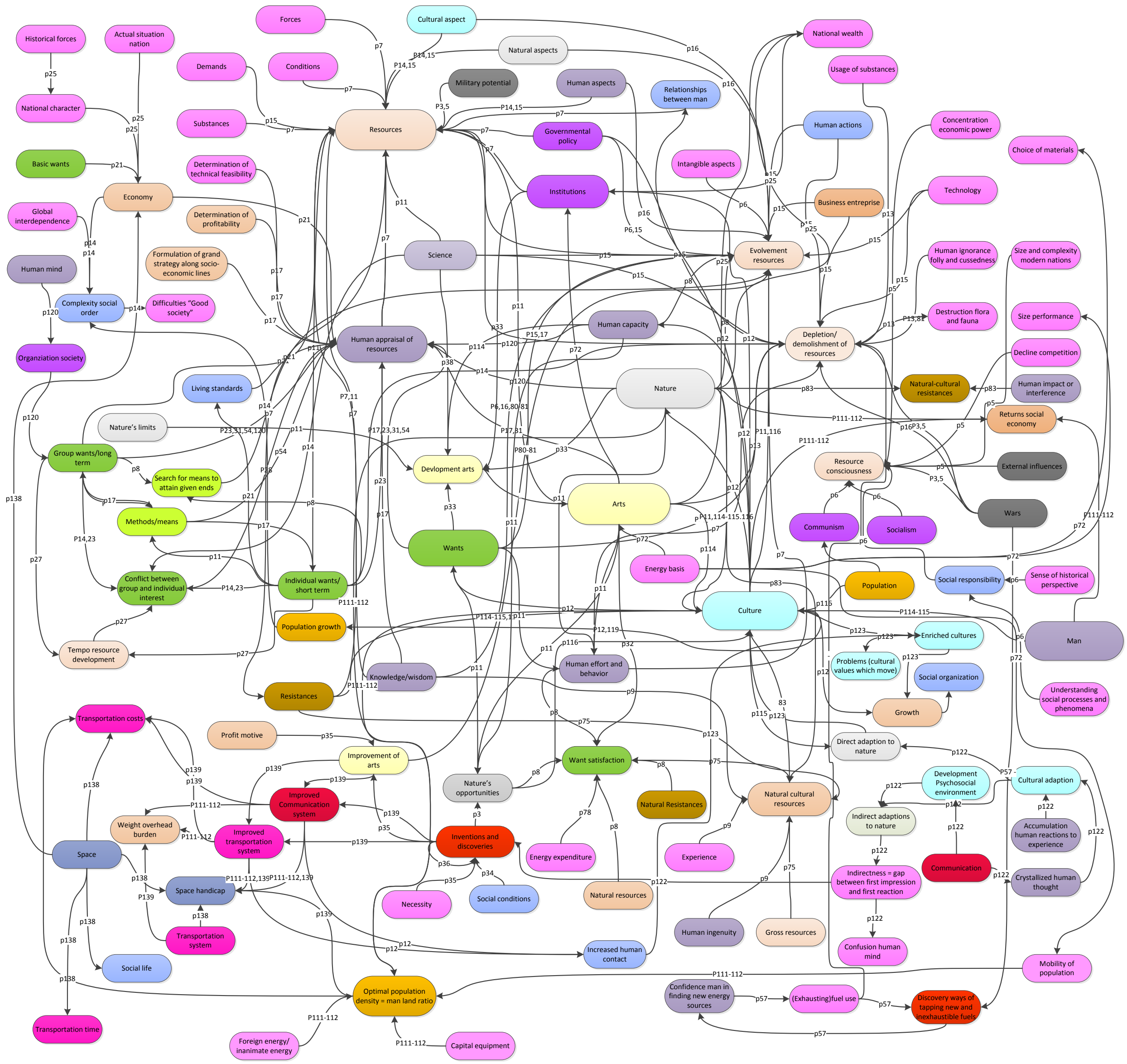
Appendix VI Readable versions of the causal relation diagrams and frameworks

In this appendix the readable version of the Initial causal relation diagram, the Simplified causal relation diagram, the initial Zimmerman framework, the Test Zimmerman framework, the Operationalized Zimmerman framework and the Institutionalized and Modernized framework are provided.

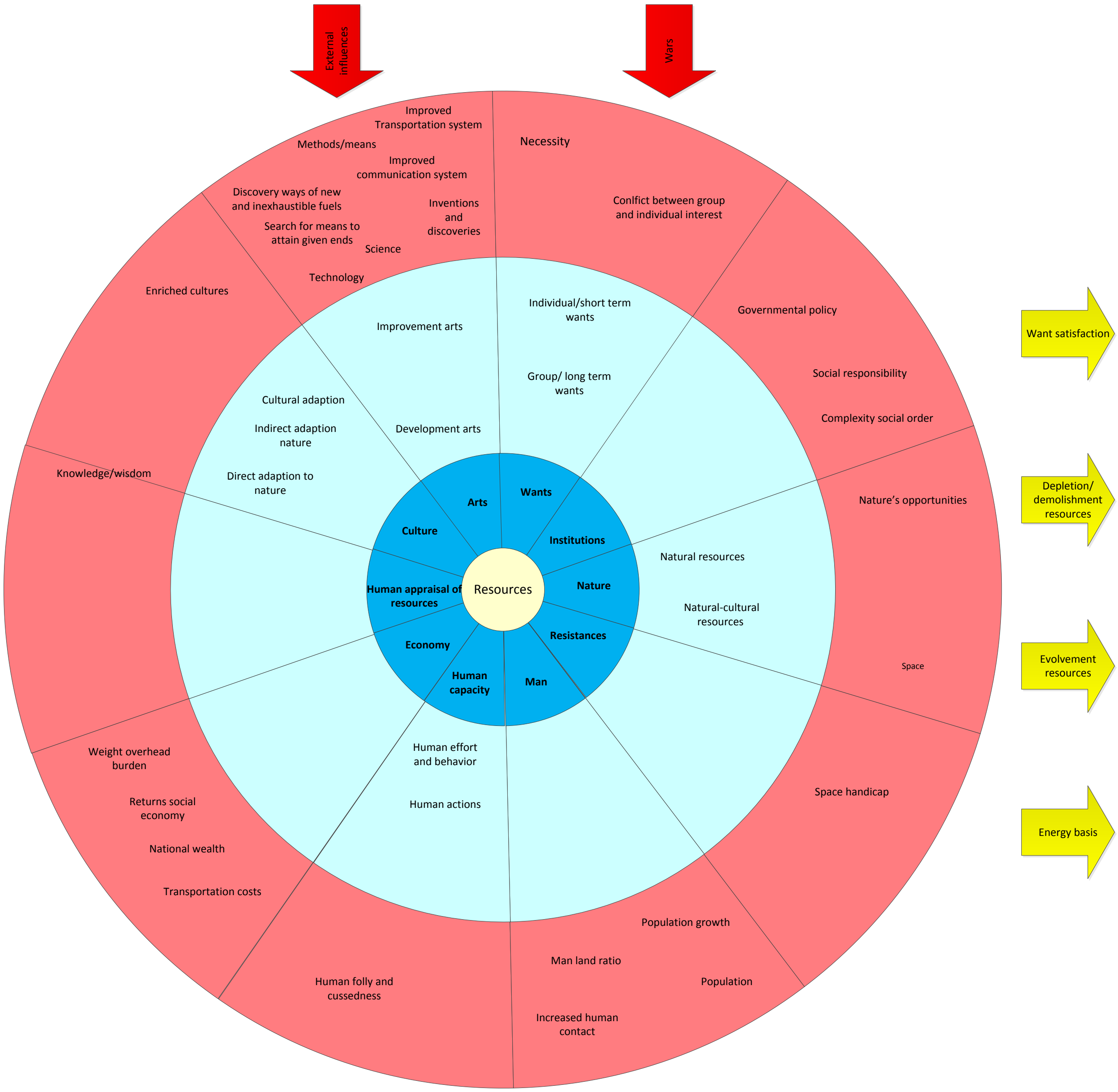
Initial causal relation diagram



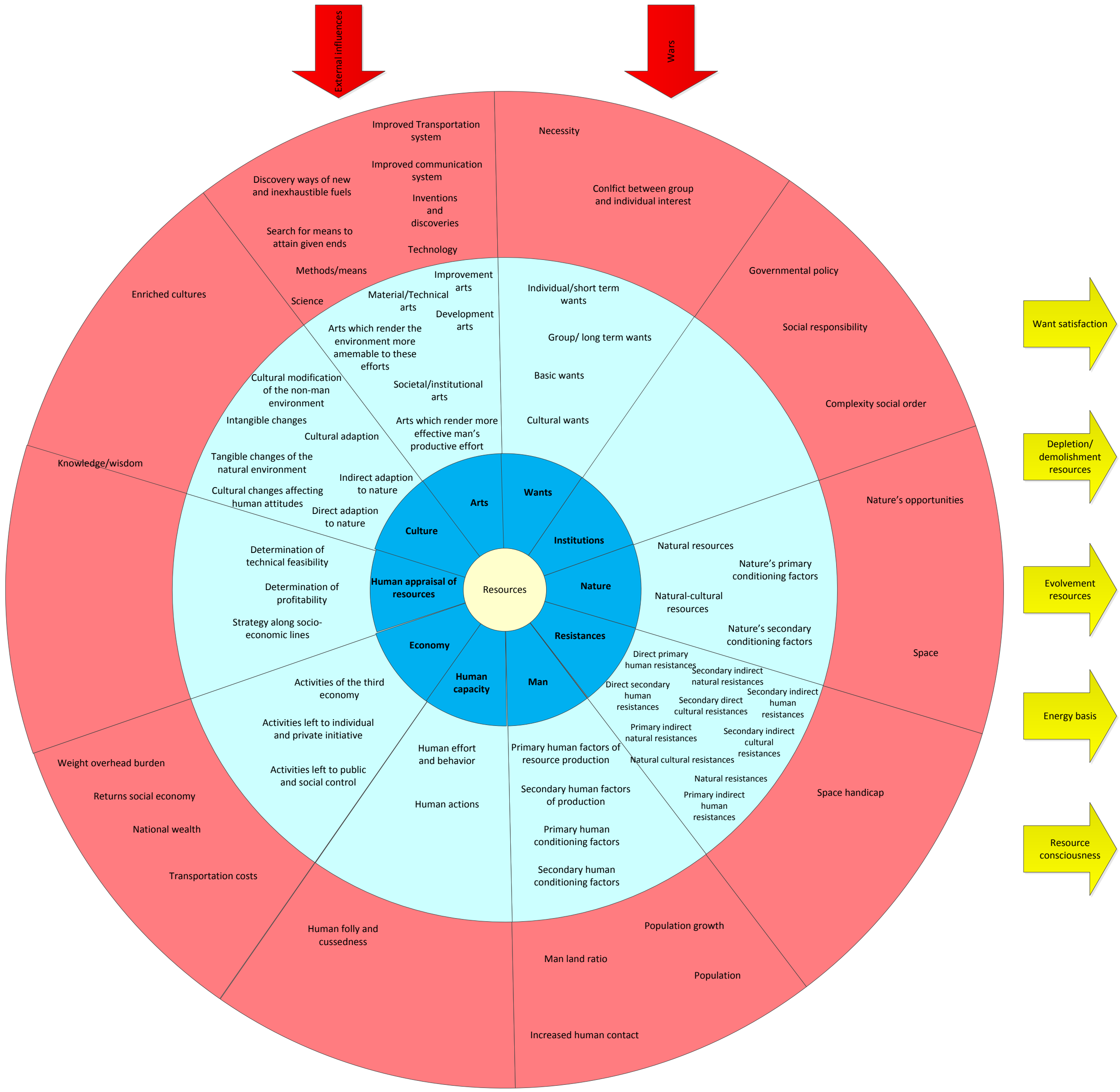
Simplified Causal relation diagram



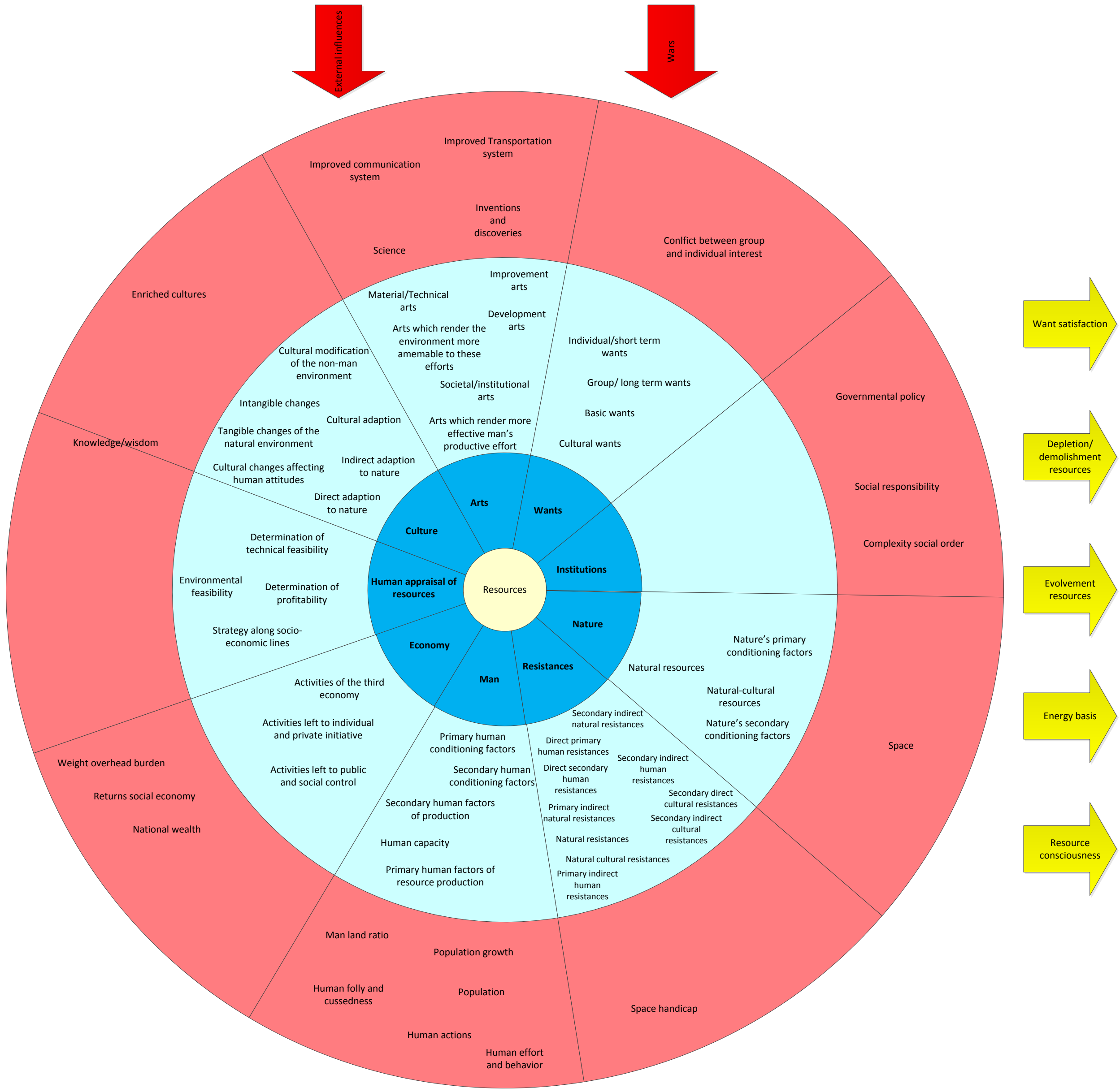
Initial Zimmerman framework



Test Zimmerman framework



Operationalized Zimmerman framework



Institutionalized and Modernized Zimmerman framework