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Subject
a method for analyzing complex societal problems
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Sub-division
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Dear Mrs De Lourdes Pintasilgo,

It was a great pleasure listening to your speech yesterday in Amsterdam. Especially the high work task and the low power participation of women worries me very much.

Herewith I send you my articles concerning the methodology I developed for analyzing guiding and evaluating complex societal problems, and some information about a International Society an Methodology for Complex Societal problems.

If you want some more information please contact me.

Yours sincerely,

Dr. Dorien J. DeTombe
chair International Society on Methodology
for Complex Societal problems

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TU Delft

THE INTERNATIONAL SOCIETY ON METHODOLOGY FOR COMPLEX SOCIETAL PROBLEMS

The goal of The International Society On Methodology For Analyzing Societal Problems is to increase and to combine the available scientifically knowledge regarding the handling of complex societal problems. Means to reach this goal are organizing workshops and conferences, and publishing proceedings and books in which discussion on this subject can take place.

The First International Conference on Methods and Tools for Analyzing Complex Societal Problems, including technical policy problems organized by the Society has taken place in the Netherlands in November 1994. The book based on this conference entitled 'Analyzing Societal Problems' DeTombe & Van Dijkum (Eds.) is published in September 1996.

The Second International Conference on Methods and Tools for Analyzing Complex Societal Problems, organized by the Society, was held in Munich, Germany 17-19 June 1996. This conference was organized in conjunction with WACRA-Europe Society on Case Method Research. The selected papers will be published in two Volumes of The International Journal of Research on Cases and Theories, Rainer Hampp Verlag, Mering, Munich.

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On a smaller scale Special Interest Groups meetings are organized at other conferences such as the ISAGA conference 1994 in Ann Arbor, Michigan, USA (ISAGA is the International Simulation and Gaming Association) and the Operational Research (OR '95) conference in 1995 in Jerusalem Israel and on IFORS '96 July in Vancouver, Canada.
The next Special Interest Group meetings will be held on the ISAGA conference in Tilburg The Netherlands 7-11 July 1997, the EURO/Informs Conference in Barcelona Spain 14-17 July 1997, and the WACRA Conference in Madrid, Spain 16-19 July 1997. See for more information the www address below.

To a new field of science: methodology for complex societal problems

Handling societal problems in an interdisciplinary way has become a must for our society and a challenge for the human sciences, especially because of the complex character of these problems. The problems society is confronted with are difficult to handle and there is a growing gap between the complexity of these problems and the human capacity to deal with them. In this situation there is a need for better methods and tools, more knowledge and imagination then there seems to be available in our standard domains of knowledge, even in the realms of scientific knowledge. Scientific knowledge is needed to survive amidst these problems, but the fragmentation of science in so many very different disciplines, which seems the standard way of not working together in science, is not an adequate starting point for the combined knowledge which is necessary to tackle these problems. Handling societal problems in an interdisciplinary way has become an urgent need for our society and a challenge for the (human) sciences. Combining the effort of scientists who are working in this field in an International Society On Methodology For Complex Societal Problems is an inspiring serious challenge from the perspective of a number of disciplines. Combining existing knowledge and creating new insights with methods and tools based on a new methodology especially for supporting complex societal problems is the task of the new society of scientists. The members of the society have studied and work in different disciplines, and in different fields at universities all over the world.

See for more information about our activities the www address below..

If you want to have more information about the society do not hesitate to contact us.

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Dorien J. DeTombe & Cor Van Dijkum
(editors)

Analyzing Complex Societal Problems

A METHODOLOGICAL APPROACH

Rainer Hampp Verlag München und Mering 1996

Analyzing Complex Societal Problems

CONTENTS

This book is the result of the First International Conference on Methodology for Analyzing Societal Problems that took place in November 1994 at Delft University of Technology and Utrecht University in the Netherlands.

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Liebe Leserinnen und Leser!
Wir wollen Ihnen ein gutes Buch liefern. Wenn Sie aus irgendwelchen Gründen nicht zufrieden sind, wenden Sie sich bitte an uns.

THE LONG ROAD TO A SCIENCE OF COMPLEXITY

Analyzing societal problems in an interdisciplinary way has become a must for our society and a challenge for the human sciences, especially because of the complex character of these problems. It is clear that the problems society is confronted with are difficult to handle and that there is a growing gap between the complexity of these problems and the human capacity to deal with them. In this situation there is a need for better methods and tools, more knowledge and imagination then there seems to be available in our standard domains of knowledge, even in the realms of scientific knowledge. Scientific knowledge is needed to survive amidst these problems, but the fragmentation of science in so many very different disciplines, which seems the standard way of not working together in science, is not an adequate starting point for the combined knowledge which is necessary to tackle these problems. Analyzing societal problems in an interdisciplinary way has become an urgent need for our society and a challenge for the (human) sciences. In this book we take the challenge seriously from the perspective of a number of disciplines.

The book is the result of the first international conference on methods and tools for analyzing societal problems. The conference was organized by the editors at the Delft University of Technology and Utrecht University in the Netherlands. A number of scientists from different countries were involved. These scientists have been active in the field of simulation, model building, gaming, using the case method and methodology for analyzing societal problems. From these fields the theme of 'analyzing complex societal problems' emerged in a natural way. Reflecting this theme there was soon realized that too little research was done to give essential answers to the fundamental questions which arises. That is the reason meetings to discuss the research and theory about handling complex societal problems were organized. The dissertation 'Defining complex societal problems' (DeTombe, 1994) is the basic work that was needed to organize the first international conference. The result was a very promising conference, and as a consequence, interesting papers which are sampled in this book. In the book the theoretical and methodological aspects of analyzing societal problems are highlighted, together with the practical impacts.

These issues are discussed in fields as ecology, computer simulation, management, social medicine, methodology, and social engineering.

A good frame for those efforts in analyzing complex societal problems is presented in the article of DeTombe. Several phases are distinguished in the process of analyzing complex societal problems, starting with the moment of awareness of the problem, and (for the time being) finishing with implementing and evaluating interventions. These phases are:

the first sub-cycle of the problem handling process: defining the problem

phase 1.1 becoming aware of the problem and forming a (vague) mental idea of the problem
phase 1.2 extending the mental idea by hearing, thinking, reading, talking and asking questions about the problem
phase 1.3 gathering data and forming hypotheses about the problem
phase 1.4 forming the conceptual model of the problem

the second sub-cycle: changing the problem

phase 2.1 constructing the empirical model and the desired goal
phase 2.2 defining the handling space
phase 2.3 developing hypotheses and suggesting interventions
phase 2.4 constructing and evaluating scenarios
phase 2.5 implementing interventions
phase 2.6 evaluating interventions

After being aware of the problem one has often only some vague mental idea about it. By reading, thinking, discussing and gathering data hypotheses can be formulated which in the end leads to the conceptual model of the problem by which the problem is defined. Then the empirical model is constructed and the desired goal formulated. After the handling space is defined one start formulating hypotheses for changes and interventions. Then scenario's are formulated and evaluated. Interventions can be implemented and the changes can be evaluated. There are many methods and tools that supports parts of these phases. Which methods and tools can support these phases best concerning what kind of problem, and circumstances is the leading question for research in this new scientific area.

In this book some of these methods and tools, that are used for analyzing complex societal problems are discussed, including some philosophical view points concerning these problems. One of the approaches for analyzing the dynamically and interrelated character of these kind of problems is the method of system dynamic analysis. Constructing models of societal problems should not be restricted to the local situation, but should be globally considered, because no society can isolate itself from the other societies in the world. It is not enough to deal with these problems on national level; these problems have to be handled internationally.

In science there was long time the belief that one can predict and control to a large extent the future of societal problems. However more and more scientists become aware that complex future developments are sometimes unpredictable. DeTombe and 't Hart are referring to that when they are criticizing the idea of system analysis that the future can be analyzed and predicted with their methods. Referring to chaos theory they argue that the science of mathematics has proved that there are fundamental boundaries to prediction and to the control of developments. Bahlman, who studied business economics, is reasoning in the same way, and concludes that organizations should be flexible in order to survive in a dynamically world. Stuhler and Vezjak discuss also approaches for complex problem solving, however now in regarding to the individual. Looking to the history of the interdisciplinary sciences and their (methodo)logical basis Dijkum criticizes the standard ambition of science to predict and control the future. According to him the concept of complexity is lend from the exact sciences and their attempts to describe the unpredictability and related complexity of nature. The question is in what way the mathematical theory of complexity can be used for the social sciences. Transfer of scientific knowledge from one discipline to another discipline involves fundamental philosophical and methodological questions. One of these questions is in what way unpredictability is found in nature itself and in what aspect it is constructed by science. Dijkum suggests that the science of complexity is grounded in a constructive realistic practice of science. The philosopher Birrer is exploring the social consequences of this practice. An example of the practice of the construction of a new sociology by scientists who are influenced by the theory of chaos is given by Gruetzmann and Hofinger. The transfer of knowledge from mathematics to sociology result in advanced mathematical instruments which are used to analyze the complex process of election in Austria. Also in this case dynamically models are used as fruitful instruments to explore the complexity of societal problems. In the act of balance between predictability and unpredictability the authors give priority to the first one, but are aware of the latter one.

This style of reasoning is followed by many other authors in the book. Vezjak, the agricultural economist Stuhler, and Kositer use simulation for analyzing the complex problems in ecology which are the result of tourism in developing countries. In this way they hope to support the right decisions for the development of an European region. Berrogi and Aebi from Delft University of Technology are suggesting to use dynamic modeling for policy analysis in order to improve the analysis of complex societal problems. The same suggestions come from Meinsma and Roozemond. Meinsma uses dynamically models to guide private entrepreneurs in handling the complexity of waste. In order to keep the traffic rolling Roozemond uses dynamically models, and being aware of the inevitability of chaos, he also explores the theory of self organization. Bras-Klapwijk explores in a more philosophical way the dynamic of managing production and consumption chains in industrial societies. Wolfe gives interesting examples of the way individuals try to construct facts by which the ethical side of global enterprising of a multinational is not lost. Insight may lead to consensus and consensus is a good basis for solving complex problems is the message in the article of Van Luijn. He uses an interesting procedure to get consensus among experts. This approach is illustrated by a case study. Westerhof, Frowein and Postma discuss the design of a diagnosis instrument for the analysis of teacher absenteeism.

Also in other fields the method of expressing complex societal problems in dynamic models for analyzing is used. In the field of health care simulation is used by Reinders and De Jager as a valuable tool for analyzing the complex prevention of epidemic diseases. The possibility of chaos is illustrated in their dynamic model. In the same field Joldersma, Heyne and Geurts analyze the unpredictability of the planning of health care for elderly people by introducing a game in which one can practice with the process of negotiating about future care. The construction of the game is on basis of a system analysis of the health care system. In such an analyses the planning of health care is considered as a cooperation between different individuals and groups. The analyzing of societal problems becomes, according to DeTombe also complex because of the interaction between actors. In the game one tries to represent complexity by introducing subjects who give their own unpredictable dynamic to the process of negotiating. The unpredictability of the world is represented in the unpredictability of the game. Another game and experiment in coordination between individuals is given by an article of Schuurman. This deals with an experiment in balancing on a rotating wheel (represented in a computer) in which individuals have to coordinate their actions to survive as an individual and as a group. Reflecting the results of this experiment in combination with theories about negotiating, he introduces the idea that the process of negotiating is best regulated by local rules. In this he advocates the idea that coordination should be decentralized and that coordination is a form of self organization. Self organization is a concept which plays also a prominent role in the theory of complexity in the natural science.

One can conclude that in all the articles a number of elementary questions are examined about the way complexity is showing up in societal problems and the way the natural and social science can work together to analyze and handle these problems. It also seems clear that we are only at the start of a long road to a science of methods and tools for analyzing complex societal problems, which by definition includes complexity. This science can support the humanities. It is because of this we plan regular international conferences on this topic to continue our struggle. It is only possible with the help of many dedicated scientists that such an enterprise can work out well. It is in this context that we like to thank the many reviewers for their participation in publishing the articles. Without them this book was not possible.

Dorien J. DeTombe — Cor van Dijkum
Amsterdam, January 1996.

COMPRAM, A METHOD FOR ANALYZING COMPLEX INTERDISCIPLINARY SOCIETAL PROBLEMS

Dorien J. DeTombe

Abstract

Many societal problems are complex and interdisciplinary. They involve a great number of phenomena and groups, and they have a large impact on society. These problems are seldom well defined, change constantly, and are very hard to handle.
Recently a method has been developed which supports the analysis of societal problems, namely Compram, that stands for Complex Problem Analyzing Method. The method is developed by DeTombe (1994). The method is based on the idea that complex interdisciplinary societal problems should be handled cooperatively by a team. The approach the method dictates, is to start analyzing the problem with a team of 'neutral' content experts in order to get a clear picture of the problem. The content experts are selected based on their knowledge of one of the domains, or of that of one of the involved groups.
After the 'neutral' team has analyzed the problem, the problem will be discussed by the different groups. Then a representative selection of all the teams select the required interventions and guide the implementations. In order to support the communication between the team members the problem will be expressed in different kind of models each using a different language. The problem handling process is supported by a facilitator, who uses special group facilitation tools to support the information exchange. Compram can be applied for all kind of policy problems.

1 Introduction

Complex interdisciplinary societal problems are problems which have a great impact on society, in which many people, organizations and countries are involved, and for which it is hard to find a 'solution'. Some real life examples are: the Aids problem, the building and utilization of a world-wide computer infrastructure system, such as Internet, finding a way to develop a sustainable environment by creating an equilibrium between the economical and environmental demands, creating an European transportation system, and protecting people and goods against water floods. Some of these problems are global problems, some of them are local.

2 The phases of problem handling

In handling complex societal problems one can distinguish two sub-cycles: the definition the problem and the changing of the problem. Each sub-cycle consisting of several phases (see figure 1).

The first sub-cycle of the problem handling process is that of defining the problem. Basically, it is a process of acquiring and communicating knowledge about why is it a problem, how the problem looks like, how the situation became what it is now, which organizations and groups are involved, which power they have, which phenomena are involved, and how all these things are related. The definition contains a description of the past and the contemporary situation. Sometimes the contemporary situation is not considered as a problem yet, but can become a problem in case no interventions are carried out. In this case a sketch of the future development of the problem is also a part of the definition of the problem. In other cases descriptions of future developments belongs to the second sub-cycle of the problem handling process. The first sub-cycle leads to the conceptual model of the problem.

The second sub-cycle is the cycle of changing the problem. Based on the conceptual model, an empirical model of the problem is made. The difference between the conceptual model and the empirical model is that the data in the empirical model are more precisely related with reality than in the conceptual model. Next the desired goal, that is the direction in which one likes to change the problem, can then be defined. After this, the handling space can be analyzed. Then one can start developing hypotheses for interventions. Several interventions can be suggested and evaluated in scenario's. The selected interventions can be implemented and later on evaluated on the effect they have towards the desired goal.

In order to handle a problem adequately all phases should be carried out in the given sequential order (see figure 1).

The first sub-cycle of the problem handling process: defining the problem

phase 1.1 *becoming aware of the problem and forming a (vague) mental idea of the problem*
phase 1.2 *extending the mental idea by hearing, thinking, reading, talking and asking questions about the problem*
phase 1.3 *gathering data and forming hypotheses about the problem*
phase 1.4 *forming the conceptual model of the problem*

The second sub-cycle: changing the problem

phase 2.1 *constructing the empirical model and the desired goal*
phase 2.2 *defining the handling space*
phase 2.3 *developing hypotheses and suggesting interventions*
phase 2.4 *constructing and evaluating scenarios*

phase 2.5 *implementing interventions*
phase 2.6 *evaluating interventions*

figure 1 The phases of the problem handling process

3 The method Compram

The method Compram is based on ideas developed in cognitive psychology, computer science, and theories about group-processes. The method may be regarded as a framework in which different information retrieval and information exchange methods are applied. These methods are used in combination with computer tools, where ever these are adequate and where ever these are available. The method might include simulation, gaming, observation, literature search and group decisions support tools.
Most of the time the knowledge about a societal problem is, as far as it is available, fragmented in many documents and over many experts. Complete

knowledge about the phenomena, the involved organizations and parties, how they are related, and what power they have, is seldom available. The data, knowledge and know-how needed for adequate handling of these problems are often insufficient, incomplete and/or in contradiction with each other.
Due to this, and to the complexity and the impact of the problem on society, these kind of problems have to be analyzed by a group of experts, who have much knowledge of (a part) of the problem. Therefore a team of experts will be selected to analyze the problem. The experts are invited to analyze the problem together. This process is guided by a facilitator.
In order to give an idea how the phases in the problem handling process are supported by the method, we list the essential points of the first sessions of the first sub-cycle of the problem handling process, and of the phases in the second sub-cycle. For more detailed description about the method see DeTombe (1994, pp. 197-298).

Compram emphasizes to define the problem before suggesting any interventions. In the beginning of the problem handling process each team member has a (partial) different, vague or sometimes even wrong idea of the situation. The different mental ideas the experts have of the problem will change in several rounds of discussion into a mutual conceptual model. This process is fed by thinking, discussing, reading, asking questions, and by collecting data, and is supported by modeling.

The final conceptual model is richer of knowledge and deeper in insight in the situation the problem creates than the knowledge each individual has. Based on the definition of the problem the empirical model will be constructed. After that the desired goal and the handling space will be defined. Then the interventions will be selected and implemented.
The method Compram emphasizes that the problem should be first analyzed by a 'neutral' team, before the groups, which are involved in and effected by the problem, are heard. Then the dispute over the definition of the problem and the suggested interventions will be evaluated by a representative selection of the members of all the teams. This team should try to reach a consensus on the proposed interventions. Later on the same team will guide the process of

implementation and will evaluate and compare the changes with the desired goal.
So far a short introduction to the method Compram. To stress the importance of the monitoring and controlling of the process and product three sections are devoted to this. More details of the organization of the phases in the two sub-cycles are found in section four and five, while section six gives a short overview about the final report of the process. Section seven holds detailed records about the different roles the persons hold in the problem handling process. Section eight describes the reason for using a neutral team before the parties and unorganized groups are invited. Working in teams one should be aware of certain pitfalls. In section nine the pitfalls are described. In section ten a communication model is presented to prevent some of the pitfalls in cooperative problem handling; the model is used to maximize the mutual understanding and communication about the knowledge of the problem.

4 The problem handling process

The problem handling process consists of individual investigations alternated by cooperative group discussions. Alternating group sessions with individual preparations is done in order to combine the benefits of the different ways of working.

Each group session is preceded by an individual preparation. The goal of the individual preparations is meanly data gathering, and thinking things over. Individual data gathering is supported by all kind of tools, such as databases, word-processors, spreadsheets and communication facilities such as Internet, fax, and telephone. The individual preparation sessions are alternated with discussions in small reference sub-groups, by which each participant is supported. The reference group consists of three or four colleagues of the same domain, who function as a knowledge support group for the participants. With their reference group the participants can discuss parts of the problem concerning their own domain. The reference group will not directly participate in the team sessions.
The goal of the group sessions is information exchange and discussion. In the group sessions the gained information is exchanged. The sessions are supported

by specific tools for group support such as groupware[1] for brainstorming and voting, and system dynamic simulation tools. At the end of a group session the team members are asked to do several assignments in order to prepare themselves for the next group session. After each group session a report about the process and the results of the problem handling process till that moment is distributed to all the team members.
The amount of sessions that are needed for defining the problem depends on many things, such as the complexity and the availability of time. It can vary from four to more then ten sessions. We will describe an example in which the problem will be defined in six sessions.

Session one
The first session takes care of a part of the problem handling phase 1.2, which is the forming of the mental idea of the problem by hearing, thinking, reading, talking, writing and asking questions about the problem. In this session an overall description of the problem will be given.
The preparation part begins with selecting a representative team of problem handlers. The team members will get a first global description of the problem from the facilitator, including what domains, which concepts and which phenomena are involved, based on the knowledge that is available on that moment. Each team member will study the material and describe in a paper their view on the problem with an emphasis on issues related to their own expertise.
In the first group session the team members get acquainted with each other, with each others background and expertise. The facilitator gives an explanation of the method and the tools to be used in the problem handling process, and explains about the scope and the focus of the problem. Each team member gives an explanation of their part of the knowledge and their view on the problem as it is written in their paper. This is followed by a discussion, and the team does a first attempt of formulating the problem.

[1] Groupware is software that can be used for multi interactive parallel use.

Session two

In the second session the team proceeds to the conceptual model of the problem. In this session a list will be made of concepts and phenomena involved in the problem. Based on this list new data will be gathered.

The members are invited to gather all the data they know concerning the relevant issues of the problem in their field, and to indicate what they need to know. In addition the members are asked to give a definition of the concepts and phenomena concerning their own field. They are encouraged to sum up the relation between the concepts and the phenomena. After this the facilitator makes an inventory of what is known about the problem and what is still unclear. This inventory will be discussed in the group session. Then the team describes the theoretical ideas[2] in which the connections between the concepts and the phenomena are interpreted. This way it becomes clear which part of the knowledge is based on theory, which on hypotheses, what the assumptions are, and what is known by experience or by intuition. In the description of the problem this status of the knowledge must be clearly indicated. In this way the team members are constantly aware which part of the knowledge is known and which part are only guesses. The known and unknown knowledge in turn can be expressed in, so called, knowledge islands. With knowledge islands one can indicate how much is known and how much is not yet known, but need to be known about a certain phenomenon (DeTombe, 1994, p. 281). Only after this mapping of knowledge a semantic model can be made. The semantic model indicates the relation between the concepts and phenomena.

In this session the selection of the team members will be critically reviewed in order to see whether the team covers the whole knowledge area that is needed to analyze the problem. Based on the knowledge about the concepts and the involved phenomena an evaluation can be made of what kind of knowledge is required, and whether the team has enough knowledge to cope with the problem or has to be extended.

[2] That is: ideas based on theory, hypotheses, assumptions, by experience or by intuition.

Session three

In the third session hypotheses can be formed about the relation between the concepts and the phenomena. This is phase 1.3 of the problem handling process. In this session the team members will again reflect on the relations between the concepts and phenomena. This leads to changes and extensions of the semantic model, the description of the problem, the concepts, the phenomena, the theoretical ideas and the knowledge islands.

Session four

The aim of session four is formulating the conceptual model of the problem. This is phase 1.4 of the problem handling process. In the preparation of this session the team members are asked to find new data regarding their field.

In the group session these new data are discussed. The team will make (if adequate) a causal model of the problem, based on the above given descriptions and models of the problem. This causal model is the start for a system dynamic simulation model of the problem.

Session five

In session five the emphasis is on avoiding group think; there is a critical reflection on the description of the problem.

In preparing the session each team member is asked to give a critical review of the description of the problem until now. Also external experts are asked to give a critical review of the description of the problem. In the group session these views are discussed together with the external experts.

Session six

In session six there will be an evaluation of all data and knowledge gathered in the description, and in the models of the problem. This is followed by a discussion about the still lacking knowledge, the white and the blind spots.

In the preparation of this session the team members are invited to try to fill in some white spots, and, again, to give a critical review of the description of the problem. In the group session the team members discuss these reflection together, and try to find blind spots.

In this iterative process of discussing, describing, reformulating and adjusting the description and the models, the problem will become more clear. Together the description and models form the main components of the conceptual model of the problem. When the conceptual model of the problem is sufficiently described, according to the opinion of the team members, the problem is defined.

5 The second sub-cycle of the problem handling process

In the same way as described above with regard to the individual preparation sessions and group sessions the problem handling process of the second sub-cycle take place. We restrict ourselves to a plain description of the actions in the different phases of the second sub-cycle of the problem handling process.

Phase 2.1

The second sub-cycle of the problem handling process starts with describing the problem in more or less the same way as is done for the conceptual model. However, now more detailed data are necessary. After this the team tries to formulate the desired goal. The desired goal is the direction to which one tries to change the problem.

Phase 2.2

In this phase the handling space will be defined. The handling space is a metaphor, a mental construct, for a space where interventions of the problem will be searched for that might in turn lead to the desired situation. The handling space limits the space in which, and to what extent, the problem can be changed. We distinguish four handling space levels.

The first level is the most restrictive, the fourth level is allows the most freedom. At the first level the interventions of the problem will be searched for within the current situation. At this level, in principle the whole situation remains as it is, only relatively small changes within the existing situation are allowed. This idea comes close to what is often called 'muddling through'.

The second level allows some more changes in the contemporary situation, although not too many, but the changes can be greater. There is more space to handle the problem and there are more possibilities for change.

The third level broadens the options as wide as possible, but still within the range of 'normal' possibilities of mankind and nature. Fundamental changes in organizations, and in politics may be considered and even including the way people think, hope, and believe. This may constitute a totally new form of society. The distinction between level one, two and three is gradual (DeTombe, 1994, pp. 95, 96). In contrast the fourth level abandons the constraints of human possibilities and escapes into imagination. It is a level that can no longer be fruitfully implemented, but at most may be used to 'unfreeze'[3] people in the problem handling process.

Phase 2.3
In this phase the hypotheses about the interventions are formulated, and interventions are suggested.

Phase 2.4
Based on the outcome of phase 2.3 scenarios can be created, evaluated and selected for intervention. The selected interventions must now be evaluated not only to the effect they have on the scope of the problem, but also on the environment of the problem. With the environment we mean the world beyond the artificial boundaries of the scope of the problem. Criteria to be used to evaluate the changes of the problem must be formulated next. Then this part of the problem handling process for this team is finished.

Intermezzo
Now, or already after the formulation of the conceptual model, the different groups involved in this problem are invited to formulate the same problem. The models, definition, interventions and scenarios of the different teams will be compared and evaluated. This can be done by a representative selection of people from all the teams. This composed team must then try to come to an

[3] 'Unfreezing' means inviting people to include, as a thought experiment, a higher level of handling space. This can be done in order to stimulate people to think about quite new situations, to realize that the present situation is also constructed by people and as a consequence is not rigidly determined. People may come up with quite new and creative ideas for changing the situation the problem creates.

agreement about the interventions. After selecting interventions this team will control the process of implementing the interventions.

Phase 2.5
The problem handling process may now be continued with implementing the interventions.

Phase 2.6
Some time after the implementation, the team of representatives will evaluate the interventions. It will make clear whether or not the changed problem is still bothering (and has to be considered again).

6 Report of the process and of the product

In order to evaluate the result of the process each team will make a report. The report must contain a description of the problem handling process, the method followed, and the tools used. It must also contain the names and roles of all of the participants, the problem owner, the facilitator, the names of the members of the reference groups, and the reasons the persons are selected. The report should contain a description of the products of all the phases of the problem handling process according to the different teams, and a description of the points on which the views of the teams differ.
The problem handling process will end with a presentation of the results of the problem handling process, followed by a discussion about the results and the remaining questions. For this presentation all the participants of the problem handling process, including the members of the reference groups, external experts and the problem owner are invited.

7 Different roles and responsibilities in the problem handling process

In the process of problem handling according to the method Compram there are several roles. The main roles will be described shortly.

The problem owner

The problem owner is the one who's assignment it is to handle the problem, and who has the authority to handle the problem. In case of a societal problem this is often the (local) government or an organization like the UNESCO. In most cases the problem owner appoints (directly) a facilitator or (indirectly) an institute (consultation bureau) to guide the problem handling process.

The facilitator

The problem handling process is guided by a facilitator who will not interfere with the content of the discussion. The facilitator is neutral towards the outcome of the process, however he or she is responsible for the cooperation within the teams and for the problem handling process. The facilitator does not have to be a content expert. On the contrary the content can be made more clear for all the participants when there is a neutral outsider who guards the concepts that are used. Needed for the facilitator is general knowledge of the world at an academic level and concerning the subject knowledge at the level of journals like the New York Times. This way the facilitator is able to guard the logic's of the discussion and the meaning of the concepts. However, the facilitator must be a professional in handling the process of analyzing complex societal problems.

Knowledge about guiding the process belongs to the field of methodology. So, the facilitator should be well trained in social science methodology. In addition since the method Compram is a framework method, he or she should be able to decide on her or his own authority which method and which tool can support the problem handling process best on a given moment. Among the methods and tools that are used in this framework are methods for data retrieval, data manipulation, for selecting participants, and for stimulating the information exchange, such as brainstorming and for considering the results such as gaming.

The facilitator should be able to guide group processes, be aware of hidden agenda's, jalousie, and group think. Therefore next to methodological expertise knowledge of the field of cognitive psychology, and of guiding group processes, and, in order to support the process with computer tools, some knowledge of information science, is required.

The participants of the problem handling team

The process of cooperative problem handling begins by selecting a team of 'neutral' experts by the facilitator and/or the problem owner. Selecting the experts does not only depends on the major domains, and involved groups, but also on the kind of problem, on how much is already known, and of the aggregation level of the problem.

At the start of the problem handling process it may still be very unclear which domains are involved. In that case the facilitator can first have some in-depth interviews with experts in order to get more information about the domains, the parties and the unorganized groups that are involved. During the process the composition of the team can be adjudge according to the knowledge needed.

The selection of participants is very important. Together they are responsible for the result of the process. The participants will influence the specific outcome of the process, and have an effect on the credibility and the acceptance of the suggested interventions.

8 Neutral experts and different groups

The method Compram makes a distinction between a knowledge problem and a power problem. A knowledge problem is knowing how the problem looks like, knowing which groups are involved, which power they possess, and which views they have with regard to the problem. In contrast a power problem is how these different powers and views influence the definition of the problem and the interventions. The method Compram prescribes, in order to understand the problem, to analyze the problem first as a knowledge problem, before it can be approached as a power problem.

An important reason of this is that beforehand it is often not clear which groups are involved. Inviting groups to the problem handling process before it is actually clear what the problem looks can push the 'solution' of the problem into the direction the most powerful groups want it to go. This way the interest, and the effect the interventions have on other groups may be overlooked.

Another reason for this approach is that members of the groups are often reluctant to reflect the problem carefully before suggesting interventions. They often want to rush by pushing their 'solutions'. However, this way too often important parts in the first sub-cycle of the problem handling process are skipped or only performed very superficially. Not only because of lack of time and money, but also because of arrogance, 'we know already how the problem looks like', or for methodological reasons (see, DeTombe, 1994, p. 113; Doerbecker, 1979). In practice there is a tendency to invite directly the involved parties and to ask them to handle the problem. They often want to start directly with the second half of the phase 2.3 of the above model (see figure 1). This is the phase of suggesting interventions. The consequence of this approach is that too many problems are handled neither adequately nor optimal. Sometimes, even the wrong problem is handled by the wrong kind of people.

That is the reason the method Compram starts by analyzing the problem with a 'neutral' team of experts, meaning that the experts are neutral towards the results of the problem handling process. The experts will be selected in such away that their knowledge is complementary to each other, and cover the whole range of important parts of the problem as far as it is known at that moment.

In analyzing these problems we distinguish two kinds of experts. First the so-called domain knowledge experts, who have knowledge of a part of the domain in which the problem is involved. The domain experts are, for instance, technicians, lawyers, economists, psychologists, environmentalists and health care specialists. Second the experts who have knowledge about a group involved in the problem. For example experts with knowledge about: an industry branch, farmers, a political party, elderly people, or about mental handicapped.

After the problem is analyzed by the 'neutral' team the different groups are invited to give their view on the problem. The same problem handling process can then start for each group in order to see what their view of the problem is, which parties they recognize, and which interventions they consider. This way it becomes easier to compare the outcomes, to see the differences and the similarities between the view of the teams. Then a representation of all the teams is selected. This representative team is invited to come to acceptable changes.

In the process of analyzing which groups are involved, and/or effected by the problem the method Compram makes a distinction between organized and unorganized groups. By an organized group is meant a party which is a rather well organized, and identifiable group of people. It has often a physical address, and a legal status, and a common interest which one wants to defend. Parties

could be action and pressure groups, organizations, political parties, countries, industry branches or a union.
With an unorganized group is meant a not well organized group of people which share common interest. This group can also be involved because when there is a chance the group will be effected by the interventions. The difference between a party and an unorganized group is also that a party, in contrast with an unorganized group, often announces itself in wanting to have an active influence in the suggestion of the interventions. Unorganized groups are seldom invited to handle the problem. Also in view of democracy it is necessary to involve the unorganized groups into the problem handling process.

9 Pitfalls to avoid

There are many pitfalls in the process of handling a problem. Some of these are, as far as possible, taken care of by the method Compram. A few prevention's of pitfalls are described here.

- Many times when there is a complex problem one start suggesting interventions directly, even before it is clear which problem it is. This way there is a great chance of handling the wrong problem.
- Many problem handlers start analyzing a problem directly by inviting parties to talk about the problem before it is even known with groups are involved. How the method deals with these two pitfalls is described above.
- There is an interaction between the mental idea of the problem and the search for data. In doing this people tend to look for data supporting their theoretical ideas, instead of looking for data that is in contradiction with their ideas. This pitfall is taken care of by stimulating the participants to look for non supporting data.
- When a problem is analyzed by a team, there is the danger of group think ('t Hart, 1990; DeTombe, 1994, pp. 209-211). The method Compram tries to prevent this by using groupware in which brainstorming, idea generating and selecting ideas can be done anonymously. An other applied approach is by inviting team members to play the role of the devil's advocate, and by inviting experts from outside to comment on the results of the process.

- Communication within a multi-disciplinary team is difficult. Some of the usual problems in group interaction are hidden agendas, group think, and collective blind spots. The difference in professionally habits, language and methodology may frustrate the communication between the members of the team. Therefore a good information exchange should be stimulated as much as possible. In order to cope with the different professional backgrounds of the participants, the method prescribes that, besides a verbal description of the problem, a definition of concepts and phenomena must be made.
- In communication one often has the tendency of not emphasizing the distinction between facts and guesses. This tendency to disguise the distinctions can lead to many misunderstandings during the problem handling process. Therefore the method emphasizes that for each statement should be explained what the status of the knowledge is.
- In a complex situation as these problems create, there is a tendency to overlook and forget things. This can be prevented by drawing knowledge islands, which visualizes the knowledge needed to handle the problem properly by indicating what is known about the problem, and what knowledge is still lacking, the white spots, and the possible blind spots (see figure 2, layer IV).

- When a problem is analyzed one defines the scope and the aggregation level by making an artificial delineation between the problem and its environment. Therefore, after formulating the interventions, it is necessary to evaluate the interventions too on the environment in which the problem is embedded.
- Experts of different disciplines express their knowledge in different ways. Some of them express their knowledge mainly in verbal languages, others are used to express the knowledge in a graphical way, and some in a mathematical language. Ignoring this leads to many misunderstandings. Therefore the method uses different languages for expressing the same problem. Each language has strong points and weak points. Using different languages to express a problem one benefits from the strong points and compensate the weak points.

10 The seven layer communication model

In order to maximize the mutual understanding and communication about the problem, the problem will be expressed in different ways in a seven layer model. Expressing the problem in different ways and in different languages makes it more easy to see what is missing. The different ways of describing helps to adjust the models. This way it can become clear how the phenomena are related. The verbal language can be the start of defining the phenomena and concepts and making a semantic model. This semantic model can make it easier to adjudge the verbal description of the problem.
The methods uses this iterative way of formulating by expressing the problem in different ways, different models, using different languages. This is done step by step in a seven layer model (see figure 2).

In *layer I* the entire problem is described in natural language, in words, that each team member can understand.
In *layer II* the concepts and the phenomena used in the description of the problem in layer I are defined. In this way the team members are stimulated to operationalize and define the concepts and phenomena they use. This gives other team members the opportunity to learn the concepts of other professions; it prevents verbalism[4].
In *layer III* the relations between the concepts and the phenomena of the problem are verbally described. These relations can be based on theories, hypotheses, assumptions, experiences or intuition. This layer is related with the description of the problem in layer I, with the definition of the concepts and the phenomena in layer II. It is also related with descriptions in layers IV, V, VI, and VII.

[4] Verbalism is using words without knowing what they mean.

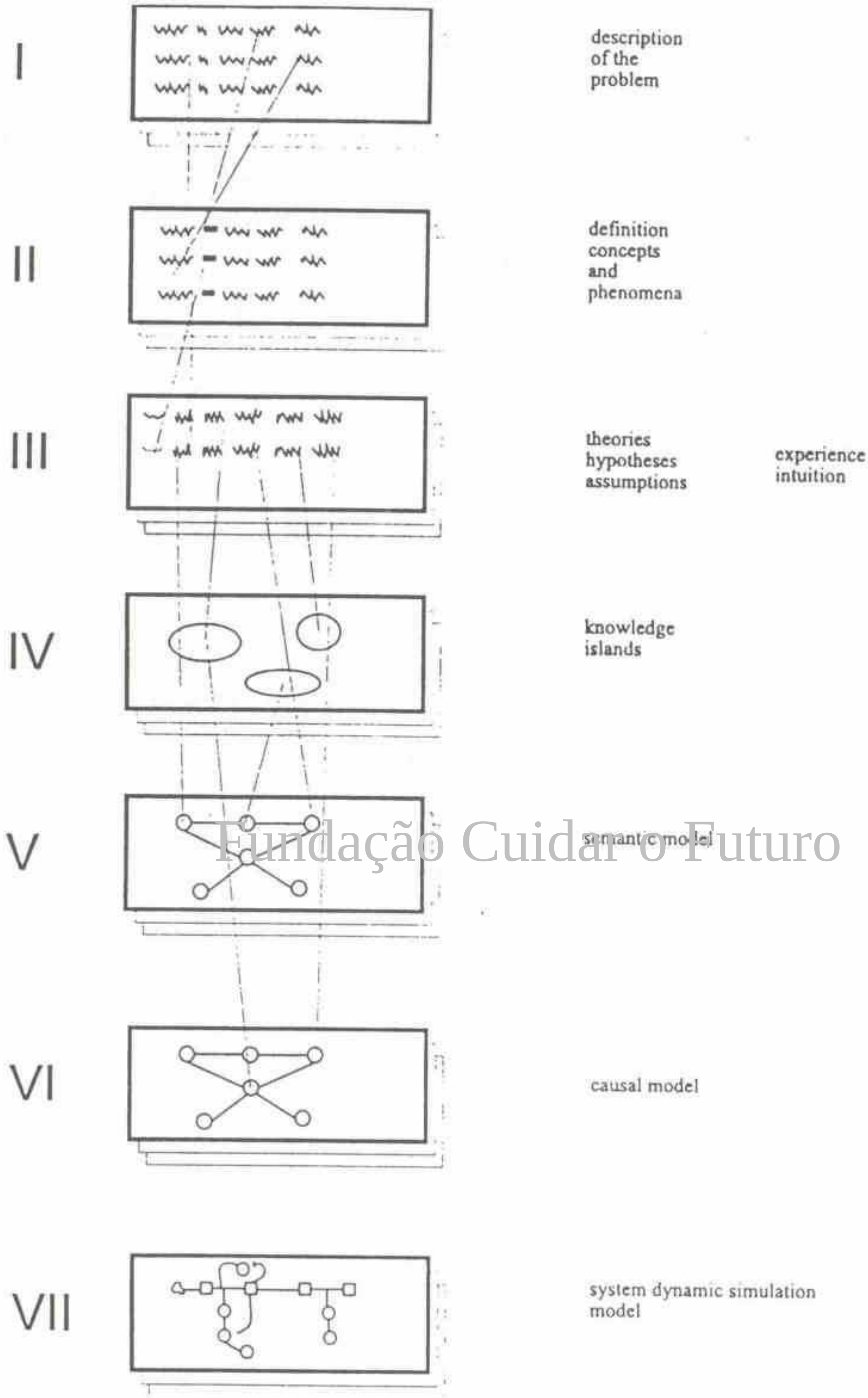

figure 2 The seven layer model

Layer IV shows a graphic representation of the knowledge described in the other layers in the knowledge islands. The way the knowledge islands are filled indicates the completeness of the knowledge.

In *layer V* a semantic model of the problem is made. A semantic model is a graphic representation of the relations between the concepts and the phenomena involved in the problem.

Layer VI describes a graphic representation of the causal relations between the concepts and the phenomena.

Layer VII contains a system dynamic model of the problem based on the causal model.

Parts of the problem and the different domain knowledge can be worked out in more detail in sub-sheets of the layers I to VII. The sub-sheets of one domain are connected with each other, and are connected with the overall problem. It is often necessary to focus on a part of the problem in detail, in order to get a better view, since otherwise the models are too large to comprehend. The model is used to support the first sub-cycle of the problem handling process as well in the second sub-cycle.

References

Adams, J. (1989) *Aids: the Hiv myth.* London: Macmillan.

Aggleton, P. & H. Homans (Eds.) (1988) *Social aspects of Aids.* New York: The Falmer Press.

Botkin, J. W., M. Elmandjra & M. Malitza (1979) *No limits to learning: Bridging the human gap*. Oxford: Pergamon.

Bots, P.W.G. (1989) *An environment to support problem solving*. Delft: Delft University of Technology.

Bruckmann, G. & P. Fleissner (1989) *Am Steuerrad der Wirtschaft. Ein ökonomisch-kybernetisches Modell für Österreich* (mit diskette). Wien: Springer-Verlag.

Bruner, J. S. (1973) *Beyond the information given.* New York: Norton.

Bruner, J. S. (1973) *The relevance of education*. New York: The Norton Library.

Crombag, H. F. M.(1984) Slecht gedefinieerde problemen. Kennis, mens en computer/2. *Intermedair*, **20-3.**

DeSanctis & R.B. Gallupe (1989) Group Decision Support Systems: A New Frontier. In Sprague, R.H. & H.J. Watson (Eds.) *Decision Support systems. Putting theory in to practice.* London: Prentice Hall (second edition), pp. 259-271.

DeSanctis, G. & M.S. Poole (1991) Understanding the differences in collaborative system use through appropriation analysis. In Nunamaker, J.F. Jr. (Ed.) *Proceedings of the Twenty-Fourth International Conference on System Sciences*, Kauai, HI, vol. III, pp. 750-757.

DeTombe, D.J. (1991) Developing problem solving skills. *European Journal For High Ability*, vol. **2**, pp. 18-27.

DeTombe, D.J. (1991) Using System Dynamics method for defining the Aids problem. In Saeed, K., D. Andersen & J. Machuca (Eds.) *System Dynamics'91*. System Dynamic Society, Massachusetts Institute of Technology, Cambridge USA & Asian Institute of Technology, Bangkok, Thailand, pp. 152-162.

DeTombe, D.J. (1991) (Ed.) Earli Special Interest Group 'Manager Training for Setting Complex Domain Exceeded Problems', **2,1**., p. 18.

DeTombe, D.J. (1992) Onzekerheden in de voorspelling van de Aids epidemie. In Dijkum, C. van & D. de Tombe (Red.) *Gamma Chaos. Onzekerheid en orde in de menswetenschappen.* Bloemendaal: Aramith uitgevers.

DeTombe, D.J. (1993) *An interdisciplinary process of problem handling for policy making on environmental problem.*

DeTombe D.J. (1994) *Defining complex interdisciplinary societal problems*, A theoretical study for constructing a co-operative problem analyzing method: the method COMPRAM. Amsterdam: Thesis publishers.

Dijkum, C. van (1991) Towards a new methodology: from Popper to Social Cybernetics. In Glanville R. & Zeeuw, G. de (Eds) *Mutual Uses of Cybernetics and Science*, special issue of Systemica, vol. **8**. Amsterdam: Thesis publishers.

Dijkum, C. van, (1991) Constructivism in Informatics. In Dijkum, C. van & Wallner F., *Constructive Realism in Discussion*. Amsterdam: Sokrates Science Publisher.

Dijkum, C. van & DeTombe, D.J. (Eds.) (1992) *Gamma chaos*. Bloemendaal: Aramith Uitgevers.

Doerbecker, C. (1979) Het iteratieve zoekproces en het cognitieve kader van de cliënt. *Tijdschrift voor Agologie*, **9**, pp. 355-368.

Duyne, van P.C. (1983) *Beslissen in eenvoud.* Hoe officieren van justitie over strafzaken beslissen. Arnhem: Gouda Quint b.v.

Elshout, J. J. (1984) Experts en beginners. *Intermediair*, **20-4**.

Elshout-Mohr, M. (1976) *Training in probleemoplosingsstrategieën.* Proefschrift Universiteit van Amsterdam.

Elstein, A. S., Schulman, L.S. & Sprafka, S. A. (1978) *Medical problem solving: an analysis of clinical reasoning*. Cambridge, Mass.: Harvard University Press.

Forrester, J.W. (1969) *Principles of Systems.* Cambridge, Mass: Wright-Allen Press.

Forrester, J.W. (1987) Lessons from system dynamics modeling. *System Dynamics Review*, vol. **3-2**, pp. 136-149.

Forrester, J.W. (1990) System Dynamics as a Foundation for pre-College Education. In Anderson, D.F., G. P. Richardson & J. D. Sterman (Eds.). *System Dynamics '90*, pp. 367-381. Boston, MA: The System Dynamics Society.

Frijda, N.H. & J.J. Elshout. Probleemoplossen en denken. In: Michon, J.A., E.G.J. Eyleman & D.L.W. de Klerk (Eds.) *Handboek der Psychonomie.* Deventer: Van Loghum Slaterus.

Fleissner, P., W. Böhme, H.-U. Brautzsch, J. Höhne, J. Siassi & K. Stark (1993) *Input-Output-Analyse.* Eine Einfhrung in Theorie und Anwendungen. Wien: Springer-Verlag.

Hart, P.'t (1990) *Group think in Government: A study of small groups and policy failure.* Leiden (thesis).

Hart, P.'t, P. de Jong & A.F.A. Korsten (1991) *Groepsdenken in het openbaar bestuur. Cruciale beslissingen in kleine groepen.* Alphen aan den Rijn: Samson H.D. Tjeenk Willink.

Jager, J.C. & Ruitenberg, E.J. (Eds.) (1988) *Statistical analysis and mathematical modelling of Aids.* Oxford: Oxford University Press.

Janis, I.L. (1972) *Victims of Groupthink: A psychological study of foreign-policy decisions and fiascoes.* Boston: Houghton Mifflin.

Janis, I.L. (1982) *Groupthink: Psychological studies of policy decisions and fiascoes.* Boston:Houghton Mifflin (second and renewed edition of *Victims of Groupthink*).

Meadows, D.H., D.L. Meadows, R. Randers & Behrens III, W.W. (1972) *The Limits to Growth*. London: Potomac Associates Book, Earth Island Limited.

Meadows, D. (1980) The unavoidable a priori. In Randers, J. (ed.) *Elements of the System Dynamics Method.* Cambridge, Mass: the MIT Press.

Meadows, D.H., D.L. Meadows & J. Randers (1991) *Beyond the limits.* Confronting Global Collapse; Envisioning a Sustainable Future. London: Earthscan Publications.

Newell, A. & H.A. Simon (1972) *Human problem solving.* Englewood Cliffs NJ: Prentice-Hall.

Rittel, H. W. J. & M.M. Webber (1973) Dilemmas in a general theory of planning. *Policy Sciences*, **4**, pp. 155-169.

Rosenthal, U. (1984) *Rampen, rellen, gijzelingen.* Amsterdam: De Bataafsche Leeuw.

Rumelhart, D.E. (1984) Schemata and the Cognitive Sytem. In Wyer, R.S. & T.K. Srull (Eds), *Handbook of Social Cognition.* vol.**1**, pp. 161-188. Hillsdale, N.J.: Erlbaum.

Simon, H.A. (1973) The structure of ill-structured problems. *Artificial Intellligence*, **4**, pp. 181-202.

Simon, H.A. (1978) Information processing theory of problem solving. In Estes, W.K. (Eds.) *Handbook of learning and cognitive processes.* Hillsdale, N.J.: Erlbaum.

Simon, H.A. (1979) *Models of thought*. London: Yale University Press.

Snoek, J.W. (1989) *Het denken van de neuroloog.* Groningen: Dijkhuizen van Zanten.

Strien, van, P.J. (1986) *Praktijk als wetenschap.* Methodologie van het sociaal-wetenschappelijk handelen. Assen: Van Gorcum.

Wierda, F.W. (1991) Developing interorganizational information systems. Delft: Wierda (thesis).

Wortman, P.M. (1966) Representation and strategy in diagnostic problem solving. *Human Factors*, **8**, 45-53. (50: 48-53)

Zelger, J. (1989) *SOLCC as a new method for innovation.* Preprint nr.8. Innsbruck: Universität Innsbruck.

USING SYSTEM DYNAMIC MODELING TECHNIQUES FOR CONSTRUCTING SCENARIOS OF SOCIETAL PROBLEMS

Dorien J. DeTombe & Harm 't Hart

Abstract

A system dynamic simulation model expressing the relations between the aspects of a societal problem can be used to make scenarios. Scenarios can be defined as explorations of future development (Jager, 1990). Scenarios are useful for making policy decisions only if the model and the data in the model represent reality. Given the uncertainties in a model of a societal problem we raise the question in how far a system dynamic simulation model of a societal problem can be used for future exploration and future prediction of the development of a problem. In reflecting on this question we discuss criticism of the use of system dynamic modeling for scenarios from the theory of complex societal problems (DeTombe, 1994), from chaos theory (Gleick, 1987), and from system theory (Flood & Jackson, 1992). We conclude that models which express societal problems contain much uncertainty. Scenarios based on these models will also contain a large amount of uncertainty. This makes it hard to make reliable predictions based on these scenarios for future development of the problem.

1 Introduction

Mankind has always been interested in the future. Predicting future developments of societal phenomena has been of much interest to scientist as well as non-scientists. The use of system dynamic modeling for creating scenarios for societal problems has increased greatly from the time it was initiated by Forrester and Meadows in the sixties and seventies (see Forrester, 1961; Meadows, Meadows, Randers & Behrens III, 1972). We discuss the use of system dynamic modeling for predicting the future development of societal problems, because system dynamic modeling seems to be a useful tool for creating scenarios for this kind of problems. However, there are limitations to the use of this specific tool for system dynamic modeling. These limitations are highlighted by the ideas from system theory (Flood & Jackson, 1991). There are also fundamental limitations to the correct prediction of future developments of societal problems, which are made clear by the criticism from the theory of complex societal problems (DeTombe, 1994) and chaos theory (Gleick, 1987). These restrictions will, in our view, not be removed by other tools.

2 Complex interdisciplinary societal problems

Many societal problems, for instance, many of the complex technical policy problems, as the rapid growth of metropolises, the pollution of rivers and the problems this creates concerning the tension between ecology, economy and the living conditions of the people, can be categorized as complex interdisciplinary societal problems.
Some shared characteristics of complex interdisciplinary societal problem are (DeTombe, 1994, p. 9, 10):

- there is uncertainty about the starting point, the development and the end of the problem
- knowledge and data about the problem are incomplete or not directly available
- there are often many phenomena involved, phenomena (people, institutes, countries) often with different interests.

A definition of a (complex interdisciplinary societal) problem is (DeTombe, 1994, p. 33)

> *"Something is called a problem when there is a discrepancy between the actual or (near) future situation and the desired future situation and/or there is a lack of knowledge and/or a lack of know-how, and/or a lack of relevant data; as for complex interdisciplinary societal problems, the problem is often undefined and the actual and the desired situation is not always clear."*

3 *From an empirical model to a scenario*

A problem can be expressed with a model or with a combination of models. Our definition of a model is (DeTombe, 1994, p.77):

> *"A model is a goal related image of a problem in reality, consisting of phenomena and relations between phenomena that the subject(s), who formulate(s) the problem, consider(s) relevant."*

A model can be based on theor(y)(ies), assumption(s), hypothese(s), experience(s), intuition(s) or any combination of these. Theoretical ideas differ with respect to their validity. Theories can be strictly founded or merely be a hypotheses, an assumption, or an idea based on experience and/or intuition. These theoretical ideas determine the way reality is viewed. In our opinion it is not possible to formulate an objective model of a complex interdisciplinary societal problem. It is only possible to formulate a model according to the subjective view of the modeling team. Whether a model is a correct or incorrect, a complete or incomplete representation of a problem is a matter of the inter- and/or intra-subjective opinion of the subject(s) that create(s) or use(s) the model.

A problem is defined by a description of the conceptual model of the problem, which can be expressed in several (sub-)models (see the seven-layer-model of DeTombe, 1994). Based on the conceptual model an empirical model can be created. This model can also consist of several sub-models. An empirical model is more detailed, and is more based on data, than the conceptual model. One of the sub-models for describing an empirical model of a problem can be a system dynamic simulation model. Figure one shows an example of a graphical representation of a (simplified) system dynamic model of the transportation of people and goods in relation to economy and environmental demands of fast growing metropolises[1].

[1] Fast growing metropolises are, for example, Mexico and Calcutta.

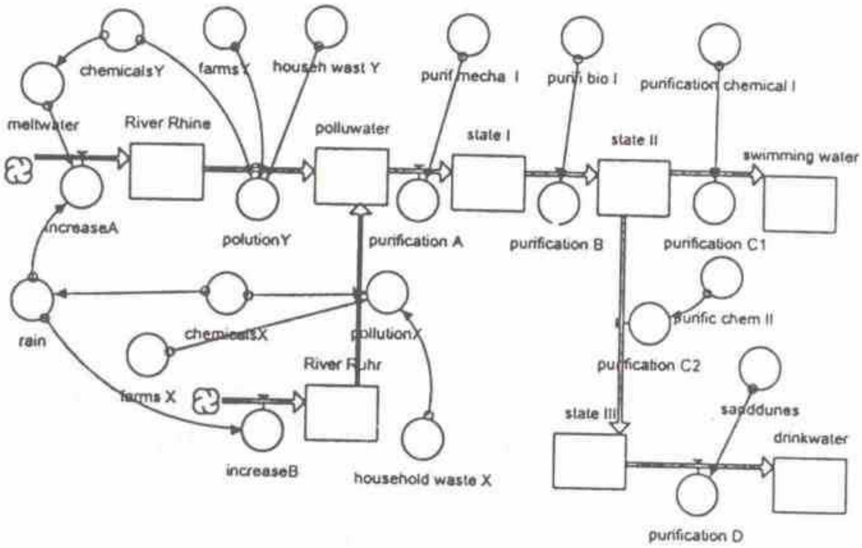

figure 1 A beginning of a system dynamic model

In order to use a system dynamic empirical model as a representation of reality, the discrepancy between the model and reality should not be too large. Given complex interdisciplinary societal problems, it is not always possible to determine exactly when a conceptual or empirical model contains enough aspects captured in the way that they can be used as an adequate representation of reality. There can be many causes for a model not to be formulated according to reality. This can be caused by blind spots[2], by forgetting to include phenomena in the model, by not knowing that certain phenomena should be included, by deliberately excluding phenomena because of the limitations of the model, by a wrong interpretation or estimation of the relations between the phenomena, by missing relevant data (white spots[3]), or by having data that are in contradiction with each other.

[2] Blind spots indicate something that is basically known, but has been unintentionally omitted.
[3] White spots indicate that some areas that one is aware of, are not explored yet. These spots indicate the gaps in our knowledge.

The system dynamic simulation part of the empirical model can be the start for making scenarios. Scenarios can be defined as explorations of future development (Jager, 1990). Exploring the future with scenarios is done in the expectation to 'predict' the future development of the problem, and/or to select an optimal strategy for changing the problem in the desired direction. Selecting an optimal strategy for changing the problem is done by comparing the assumed effect of interventions with the desired situation.
Several kinds of scenarios may be distinguished. There is the so-called null-option scenario. This is the scenario in which, at least by the members of this problem handing team[4], no deliberate interventions are included[5]. One could translate the null-option scenario into: 'the development of the problem without our interventions'. The null-option scenario could also be called and considered the basic scenario. Because there may be several major possible changes in the future which might influence the problem, one can start creating scenarios with creating several basic scenarios. Based on these different basic scenarios one can reflect on the effect of different (combined) interventions. In a scenario, the future can be explored by simulating the expected changes in and between the aspects of the problem. The effect of the changes can be explored by simulating the changes in time steps.
The basic scenarios, the interventions and their assumed effects are based on theoretical ideas about the development of the future, the phenomena, their relations and their reaction to the suggested interventions.

Using a system dynamic simulation model as a start for a scenario for exploring future developments of societal problems and situations is done by many researchers and institutes. Examples are Bruckmann & Fleissner (1989), who made a prediction of the Austrian economy based on a system dynamic model, and Meadows, Meadows, Randers & Behrens III (1972), who use system dynamic modeling to predict the use of future resources in the Club of Rome book 'Limits of Growth' and in their book 'Beyond Limits of Growth' (Meadows,

[4] These kind of problems should, in our view, always be handled by a group of persons (see DeTombe, 1994).
[5] However when the team decides intentionally not to interfere, one could also call this an intervention, a so-called deliberate non-intervention.

Meadows & Randers, 1992). In the Netherlands system dynamic models are used for future prediction at the National Institute for Public Health and Environmental Protection (RIVM)[6] and at the Research Center of Public Mental Health Care (NcGv)[7].

The outcomes of these studies sometimes have a significant impact on society, in the way of policy making and policy advises. Because of that it is interesting to reflect on the question: "Is it possible to predict the future of such a complex societal issue?"

One may wonder whether it is possible to create an empirical model and scenarios reliable enough to base policy decisions on.

This question will be discussed from the point of view of system theory (Flood & Jackson, 1991), the theoretical ideas of complex societal problems (DeTombe, 1994), and chaos theory (Gleick, 1987). In this discussion we first reflect on models, then on scenarios. Is it possible to make a complete and objective model of the situation which can serve as a basis of a scenario?

4 What is the relation between a scenario of a complex interdisciplinary societal problem and reality?

4.1 Criticism coming from system theory

There is criticism on using system dynamic simulation models for future predictions from system theory. System thinking emerged as a response to the failure of mechanistic thinking to explain biological phenomena. This thinking was soon transferred to the study of other 'systems' such as organizations. However, since the system view was originally born in biology it tended to rely on biological analogies, introducing ideas such as survival, adaptability, development, growth, flexibility and stability. Flood & Jackson (1991, pp. 5, 6) write about systems:

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[6] Rijksinstituut voor Volksgezondheid en Milieuhygiene (a Dutch semi-governmental institute).

[7] Nederlands Centrum voor Geestelijke Volksgezondheid (an independent Dutch institute on information, research and advice in the field of public mental health and public mental health care).

"A system consists of a number of elements and the relationships between the elements. A richly interactive group of elements can be separated from those in which few and/or weak interactions occur. This can be achieved by drawing a boundary around the richly interactive group. The system identified by a boundary will have inputs and outputs, which may be physical or abstract. The system does the work of transforming the inputs into outputs. The processes in the system are characterised by feedback, whereby the behavior of one element may feed back, either directly from another element by way of their relationship, or indirectly via a series of connected elements, to influence the element that initiated the behavior."

The way an organization is viewed in system thinking to represent problems and to use a system thinking approach for analyzing them can be applied for complex interdisciplinary societal problems. For instance, the 'temporary' boundaries of an open system, including input and output and the communication between the elements may be compared with to boundaries of the model of a problem. There is also a hierarchy by which a system can be a part of a wider system and in return can consist of smaller sub-systems like Flood & Jackson write (1991, p. 6, 7). The system dynamic approach is created in order to be able to tackle greater complexity than is possible with other approaches. In doing so it loosens some of the characteristics of the scientific method.

In the field of system theory there are two standpoints, one viewpoint is held by those who call themselves hard system theoreticians and the other by those who call themselves soft system theoreticians. According to the hard system theoreticians the system dynamic method is too soft and too weak, and cannot quantify enough. According to the soft system theoreticians the system dynamic method is not soft enough, it wants to quantify too much. Using system dynamic modeling techniques has been criticized from these two viewpoints. These respective critiques refer to theory, methodology, ideology and utility. We will discuss some points described in Flood & Jackson (1991, p. 78-83).

Soft system thinkers question the underlying assumptions of system dynamic modelers that there is an external world made up of systems, whose structure can be grasped using models built upon feedback processes. To soft system thinkers, social systems are much more complex than this. Social systems cannot be structured 'objectively' from the outside. System dynamic failed to embrace the 'subjectivity', which is an essential part of the complex-pluralist situation. We agree, to a certain point, that it is not possible to grasp the complex reality into a model. However we think that although the reality of complex societal problems is far more complex than any model can show, models can be very useful in trying to comprehend at least some parts of the problem.

The soft system scientists state that the phenomena and their relations in a model cannot be quantified. We agree that it is very hard, and sometimes not very useful to quantify all aspects, all phenomena and their relations and that one often has to be satisfied with an estimation with an amount of uncertainty (see also de Tombe, 1992). However, we think that, where it is possible, some quantification can be very useful. Although we realize that one can easy step into the pitfall of giving numbers to not quantifiable phenomena.

More fundamental criticism coming from soft system thinkers, is that subjective intentions of human beings cannot be captured in such 'objective' models. In the opinion of soft system thinkers models are designed to increase mutual understanding, not to represent external reality. Social systems are in their point of view (Flood & Jackson, 1991, p. 79)

> *".. the creative construction of human beings whose intuitions, motivations and actions play a significant part in shaping 'system' behavior. ..System dynamics do not deal with the innate subjectivity of human beings and the consequences of this for the study of social systems."*

Soft system thinkers say that societal systems cannot be captured, because in a model the natural subjectivity of the human beings cannot be captured in a model. Although we agree that societal systems are created by humans with all their hidden agenda's, motivation, subjectivity, personal and historical background, and we do know that these original drives and motivation to create a system cannot be shown in the model, however we still think that some aspects of a societal system can be captured in the model, at least enough aspects to justify making models. In our view one of the aims of a conceptual model is to increase the understanding of the problem, and when it is used and/or built by the same group of persons it can be used as a vehicle for communication (Sol, 1982). To this point we agree with soft system scientists. However, we have the opinion that for understanding the problem the model must be representative as well, and the deviation from reality should not be too large. Where it concerns the empirical model we, like many others, use the model or would like to use the model to represent reality.

Hard system scientists (Flood & Jackson, 1991, p. 78-83) emphasize that the group that did the modeling should be the same group that suggests interventions and policy. One of the reasons is that this group knows exactly the value of the knowledge and the data on which the model is based. We recognize that uncertain factors can be interpreted as objective factors when they are captured in a model. This is one of the reasons why we agree on this point and emphasize that the same group of modelers should interpret the subjectivity of a model (see DeTombe, 1994).

Ideology critique coming from hard system thinkers emphasizes that the people who build the model have the idea that they are elite technicians: the model is theirs. They do not allow any involvement of other 'stakeholders' (Flood & Jackson, 1991, p. 81). This is also our critique on making models by one to three people, as often happens. The model is made by a few modelers, and not by a small group of content experts or members of the different parties involved in the problem. Another theoretical critique from hard system thinkers is that conclusions are based on uncertain data and knowledge.

> *"It (system dynamic) apparently jumps to conclusions about whole system behavior before the data have been collected and the laws verified which would make such conclusions justifiable." (Flood & Jackson, 1991, p. 79)*

This is also in agreement with another critique of the hard system scientists on the methodology. The information to make the empirical model is insufficient. Models should only be made when sufficient information is available on the issue.

The critique of the hard system scientists is also directed at the utility of the model. This also concerns the availability of data. The system dynamic model

uses poor data. These last three theoretical critiques correspond with our critique coming from the theory of complex interdisciplinary societal problems[8].
Based on the critique above we could say, that modeling of societal problems according to the ideas of system dynamic modeling is subjective, the data that are used are incomplete, and the boundaries are relative and depending on one's subjective view. The utility of the model is limited. This means that the model based on system dynamic modeling efforts should not be given to others than the modelers themselves to base conclusions on, because the model is, depending on the complexity, more or less deviant from reality.

4.2 Criticism coming from the theory of complex interdisciplinary societal problems

This criticism of the use of system dynamic models as a scenario for future prediction is based on the idea that it is impossible to make a model of a complex interdisciplinary societal problem that is complete and reliable enough to base policy making on. This critique not only concerns system dynamic modeling but modeling and making scenarios in general.
According to the theory of complex interdisciplinary societal problems (DeTombe, 1994) making a suitable model of a societal problem is very difficult. The problem is complex and imbedded in a dynamic environment, which in turn reacts to the problem. This prevents us from knowing all the aspects and their relations. Not all existing phenomena, data, and relations are imbedded in the model, which is in our view impossible. A model of a societal problem often comprise phenomena, relations between the phenomena that are certain and relations that might be possible. The model comprises data that are certain and that are uncertain, the modelers sometimes even have to chose between data in contradiction with each other. Concerning the empirical model, the data of the model will in many cases be uncertain, unreliable and incomplete (DeTombe, 1992). Not all data and phenomena we do know can be included in the model in detail as much as one could wish.

[8] See the next paragraph.

The model of a complex interdisciplinary societal problem will contain much uncertainty and scenarios based on those models will also contain much uncertainty, even more so because in scenarios the uncertainty will be enlarged. Developing scenario based on these models increases the amount of uncertainty. There is uncertainty about the main basic scenarios: are they well selected, what is the chance that they will be become reality, and concerning the interventions: are they well chosen, which effect will they have, what will be the cumulative effect etc.? This shows that one should be very careful to base policy decisions on using scenarios of societal problems.

4.3 Criticism coming from chaos theory[9]

The third critique on system dynamic modeling of societal problems comes from chaos theory, includes fundamental criticism with respect to the ability to create reliable scenarios in general. This criticism concerns two aspects, the unpredictability based on incomplete data and the unpredictability based on non-linear feedback loops.

It is hard to find a suitable definition of the chaos theory. Tennekens (1990b, p. 8) describes chaos as a feature of a non-linear system. He states (p. 9)[10]:

"The theory of chaotic behavior of simple dynamic systems has been thoroughly examined the last 25 years."

Chaos theory[11] seems able to give a description and an explanation of certain issues which, until some decades ago, were not noticed, were neglected or seemed to be inexplicable. The knowledge of chaos theory enables to notice things not noticed in the same way before. The language of chaos theory enables to describe some of these views. Chaos theory, as far as it is developed now, describes many, and sometimes totally divergent matters. In reflecting this, the

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[9] Chaos refers here to a certain way of unpredictability. This differs from the commonsense use of the word, which means unordered.

[10] Translation by the authors.

[11] See for a historical overview of the development of chaos theory Gleick (1989, p. 11-54) and Verhulst (1990, p. 15-33).

phenomenon 'chaos theory' seems more a collective noun to describe certain phenomena, then a thoroughly worked out theory. One of the general focuses of chaos theory is unpredictability and non-linear feedback loops.
Scientists like Newton (1642-1727) and Laplace (1749-1827) had the idea that everything can be known, predicted and may be even controlled at the moment all the data and the connections between the data are known (Laplace, 1796). In physics the common opinion is that unpredictability is a matter of incomplete data and limited capacity of computers. However, chaos theory shows that even in physics it is sometimes impossible to predict future developments (Broere & Verhulst, 1990). Tennekens (1990) pointed out that according to meteorological models, even if one triples the data collecting points and ten times doubles the computer capacity, the weather cannot be predicted for more than five to seven days in advance with reasonable certainty, and often not even that. Van Dijkum states in his article about unpredictability and chaos theory (1992, p. 26):

> *"A process that is unpredictable is undetermined. Time is a variable in a prediction which together with the values of other variables determines the state of the process. If there is no prediction possible then there is also no determination of all values of the chaotic function possible."*[12]

The opposite is that, when there is no definition of all the values of a function, there is no prediction possible.
The theory of complex societal problems (see DeTombe, 1994) shows that data of a complex interdisciplinary societal problem are never complete. Even when there are no blind and white spots, and there are, the data would never be complete because of the changing problem and the changing environment.
A part of chaos theory describes unpredictability of non-linear processes (Gleick, 1987; Prigogine & Stengers, 1984; Lorenz, 1979). The models of complex interdisciplinary problems contain many non-linear feedback-loops. There can be moments in which these non-linear feedback loops lead to unpredictability (see DeTombe, 1992b).

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[12] Translation by the authors.

5 The risk of using scenarios for policy making

In this paper we tried to give some answers to the question: "Is it possible to use a model and scenarios of societal problems to base policy decisions on?" We first answered this question by indicating the limitations of using a system dynamic tool for predicting. We then approached the question in a more fundamental manner: "Is it possible to make models and use them for prediction of such complex things as societal problems?"

Even when making a model of a societal problem is carried out with as much knowledge, tools, methodological support and human effort available, these models will still contain a large amount of uncertainty (DeTombe, 1994). It will be clear that a reasonable matching empirical model cannot be made. Although the quality of interventions and scenarios will depend on the way the whole process of problem handling is performed, there will always be a large amount of uncertainty in the estimated effect of the interventions and thus in the scenarios. Models made of complex interdisciplinary societal problems contain much uncertainty, and scenarios based on these models will even contain a larger amount of uncertainty. Developing scenarios, that correspond to the future, will almost be impossible. The range of uncertainties can be that large that one can hardly expect to be able to make real policy decisions based on these scenarios. Policy making based on scenarios of complex interdisciplinary societal problems is a risky thing to do and as a consequence one should be very restrained using scenarios for this (DeTombe, 1992a). A scenario provides at most some directions in which the problem might develop, and it should only be used as a tool for discussing the future development of the problem.

Nevertheless, for the want of anything better, many scenarios are used for policy making. When we exclude intentional misuse, there is still the danger that, although the designers of the model are aware of the problematic data and the uncertainties of the relations in the model, when taken out of the hands of the creators, the scenario may live a life of its own. Other people may use the scenario as a correct representation of reality, instead of using the scenario as a tool to discuss the problem. Even the creators take the risk of interpreting their own subjective model as a fact.

In using scenarios we can make a comparison between predicting the future development of societal problems and the weather forecast. In both cases that some short term predictions can be made with a reasonable chance on success, however the longer the period the more difficult it will be to predict the future development. This might even be impossible.

References

Bahlmann, J.P. & B.A.C. Meesters (1988) *Denken & Doen. Een studie naar ontwikkeling en strategische heroriëntatie van zes Nederlandse ondernemingen rond een crisis.* Delft: Eburon.

Broer, H.W. & F. Verhulst (Red.) (1990) *Dynamische systemen en chaos.* Utrecht: Epsilon.

Bruckmann, G. & P. Fleissner (1989) *Am Steuerrad der Wirtschaft. Ein ökonomisch kybernetisches Modell für Österreich.* Wien: Springer-Verlag.

Checkland, P.B. (1981) *Systems thinking, systems practice*. Chichester: Wiley.

Checkland, P.B. (1982) Soft systems methodology as process. A reply to M.C. Jackson. *Journal of Applied Systems Analysis*, 9, 37-9.

Checkland, P.B. & J. Scholes (1990) *Soft Systems Methodology in Action.* Chichester: Hohn Wiley & Sons.

Dangerfield, B. & C. Roberts (1990a), *OR Work in HIV/AIDS.* London: ORS Publication Unit.

Dangerfield, B. (1990b). *Listing of the variable infectivity model.* Salford: University of Salford.

DeTombe, D.J. (1992a). Using a simulation tool for defining global problems. *ISAGA'91; 22nd Annual International Conference of the International Simulation and Gaming Association.* Kyoto, Japan (abstract).

DeTombe D.J. (1992b). Onzekerheden in de voorspelling van de Aids epidemie. In: Dijkum, C. van & D. DeTombe (Red.). *Gamma Chaos. Onzekerheid en orde in de menswetenschappen.* Bloemendaal: Aramith uitgevers, pp. 126-137.

DeTombe, D.J. (1994). *Defining complex interdisciplinary societal problems. A theoretical study for constructing a co-operative problem analyzing method: the method COMPRAM.* Amsterdam: Thesis publishers.

DeTombe, D.J. (1995) Co-operative Handling of Complex Interdisciplinary Societal Problems. In Guangzhong Liu, Kang-Hoh Phua, Jigang Ma, Juping Xu, Fuwen Gu &

Changzheng He (Eds.) *Optimization Techniques and application*, ICOTA '95, vol. **2**. Chendu University of Science and Technology, Chengdu, China. Singapore, New Jersey, London, Hong Kong: World Scientific, pp. 1408-1416.

Dijk, J.A.G.M. van (1989) Popularising Delphi Method, Developing an Instrument to Control Technological Change for Employees. *Quality and Quality 23*, pp. 109-203.

Dijk, J.A.G.M. van (1990). Delphi questionnaires versus individual and group interviews, A Comparison Case. *Technological Forecasting and Social Change 37*, pp. 399-407.

Dijk, J. van, M. de Goede, H. 't Hart & J. Teunissen (1991) *Onderzoeken en veranderen. Methoden van praktijkonderzoek*. Leiden: Stenfert Kroese.

Dijkum, C. van (1988) *Spelen met paradoxen. Een methodologische studie naar vicieuze cirkels in denken en handelen*. Utrecht: Rijks Universiteit Utrecht.

Dijkum, C. van & F. Wallner (1991) *Constructive realism in discussion*. Amsterdam: Sokrates Science Publisher.

Dijkum, van C. & DeTombe, D.J. (Red.) (1992). *Gamma chaos. Onzekerheid en orde in de menswetenschappen*. Bloemendaal: Aramith uitgevers.

Dörner, D. (1989) *Die logik des Mißlinges. Strategisches Denken in komplexen Situationen*. Hamburg: Rowohlt verlag.

Dörne, D., H.W. Kreuzig, F. Reither & Th. Städel (1983) *Lohhausen: vom Umgang mit Unbestimmtheit und Komplexität*. Bern: Huber.

Fleissner, P., W. Böhme, H.U. Brautzsch, J. Höhne, J. Siassi & K. Stark (1993) *Input-Output-Analyse. Eine Einfuhrung in Theorie und Anwendungen*. Wien: Springer-Verlag.

Flood, R.L. & M.C. Jackson (1991). *Creative problem solving. Total systems intervention*. Chicester: Wiley.

Flood, R.L. & E.R. Carson (1992). *Dealing with complexity: an Introduction to the Theory and Application of Systems Science*. New York: Plenum, 2nd edition.

Forrester, J.W. (1961) *Industrial dynamics*. Cambridge, Mass.: The MIT Press.

Forrester, J.W. (1969) *Urban dynamics*. Cambridge, Mass.: The MIT Press.

Forrester, J.W. (1973) *World dynamics*. Cambridge, Mass.: Wright-Allen Press , 2nd edition.

Forrester, J.W. (1969) *Principles of systems*. Cambridge, Mass.: Wright-Allen Press.

Forrester, J.W. (1987) Lessons from system dynamics modeling. *System Dynamics Review*, **3-2**, pp. 136-149.

Forrester, J.W. (1990) System dynamics as a foundation for pre-college education. In Anderson, D.F., G.P. Richardson & J.D. Sterman (Eds.) *System Dynamics '90*. Boston, Mass.: The System Dynamics Society, pp. 367-381.

Gleick, J. (1987) *Chaos: making a new science.* New York: Viking.

Gleick, J. (1991) *Chaos. De derde wetenschappelijke revolutie.* Amsterdam: Uitgeverij Contact.

Hart, H. 't (1991) Onderzoek en praktijkfasen. In Dijk, J. van, M. de Goede, H.'t Hart & J. Teunissen *Onderzoeken en veranderen. Methoden van praktijkonderzoek.* Leiden: Stenfert Kroese, pp. 55-65.

Heisterkamp, S.H., B.J. de Haan, J.C. Jager, J.A.M. van Druten & J.C.M. Hendriks (1992) Short and medium term protections of the AIDS/HIV epidemic by a dynamic model with an application to the risk group of homo/bisexual men in Amsterdam. *Statistics in Medicine*, **11**, pp. 1- 17.

Jager, J.C. & E.J. Ruitenberg (1987) Statistical analysis and mathematical modelling of AIDS. *AIDS* 1987, **1**, pp. 129-130.

Jager, J.C. & E.J. Ruitenberg (Eds.) (1988). *Statistical analysis and mathematical modelling of AIDS.* Oxford: Oxford University Press.

Jager, J.C. & M.J. Postma (1989a). De AIDS-epidemie: prognoses en economische gevolgen. In Vuysje, H. & R.A. Coutinho (Eds.) *Dilemma's rondom AIDS.* Amsterdam: Swets-Zeitlinger, pp. 185-205.

Laplace, P.S. (1796). *Exposition du systeme du monde.* Paris: Courier.

Lorenz, E. (1979) Predictability: Does the flap of a butterfly's wings in brazil set off a tornado in Texas? *Paper presented at the annual meeting of the American Association for the Advancement of Science.* Washington, December 29th 1979.

Meadows, D.H., D.L. Meadows, R. Randers & W.W. Behrens III (1972) *The limits to growth.* London: Potomac Associates Book, Earth Island Limited.

Meadows, D. (1980) The unavoidable a priori. In Randers, J. (Ed.) *Elements of the system dynamics method.* Cambridge, Mass.: The MIT Press.

Meadows, D.H., D.L. Meadows & J. Randers (1992) *Beyond the limits. Global collapse or a sustainable future.* London: Earthscan Publications.

Poincaré, H. (1913) *The foundations of science.* New York: Science Press.

Prigogine, I. (1980) *From being to becoming.* New York: Freeman.

Prigogine, I. & I. Stengers (1984) *Order out of Chaos.* New York: Bantham Books.

Sol, H.G. (1982) *Simulation in information systems development.* Groningen: Rijksuniversiteit Groningen.

Tennekens, H. (1990a) *Dan leef ik liever in onzekerheid.* Bloemendaal: Aramith.

Tennekens, H. (Ed.) (1990b) *De vlinder van Lorenz. De verrassende dynamica van chaos.* Bloemendaal: Aramith.

Verhulst, F. (1990) De historische route naar chaos. In Tennekens, H. *De vlinder van Lorenz.* De verrassende dynamica van chaos. Bloemendaal: Aramith Uitgevers.