Sustainable Decision Making
Final report
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1 SUMMARY

This report describes the project 'Sustainable Decision Making´ (in Dutch: Duurzaam Beslissen, contracted to DuBes). The Dubes project has been a search for the solutions that are required to make the abstract concept sustainable development operational for applications in the built environment. This search started 2 years ago, after the completion of a study to the Dutch National Packages Sustainable Building, currently the most important policy instruments in the Netherlands aimed at sustainable development in the building sector. This study showed that, although the packages are powerful tools for promoting and implementing sustainable development, they offer limited perspective for sustainable development at the middle- and longer term. This especially holds true if the packages are viewed in the context of ambitious goals such as 'factor 20' (Tjallingii, 1999[1]).

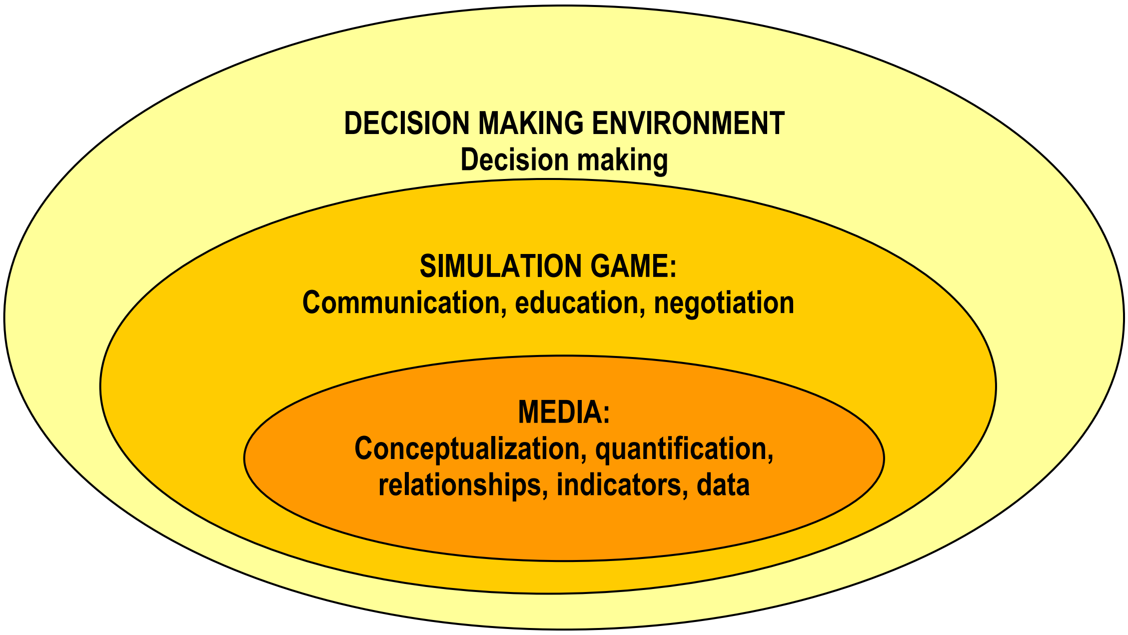
The Ministry of Housing, Spatial Planning and the Environment (VROM) recognized the limited effective life span of the packages and the need for new alternative approaches in the future. The question was: which approach? The Dubes project, which was engineered at the Delft Interfaculty Research Centre 'The Ecological City', seemed a promising solution and the Ministry decided to support this project financially. The essence of the Dubes project was the integration of the decision making process with impact assessment models. The Dubes–project subsequently was adopted by the Delft Cluster[2], and several more partners were involved in the project.

The results of the Dubes project are innovative and meet the expectations. In essence, the result of the project is a *philosophy* about how to deal with sustainable development in the built environment. In this philosophy, actors, decisions processes and impacts of decisions are conceptualized, related to another and made transparent. This philosophy served as a conceptual basis for two operational results:

- First, a dynamic and innovative computer model: MEDIA (Modeling Environment for Design Impact Assessment). In this model several concepts from different disciplines, such as policy sciences, spatial planning & design and environmental impact assessment are combined. The model is no goal in itself, but served as means of conceptualizing, formalizing, describing and testing of existing or newly developed concepts and ideas. MEDIA also functioned as a catalyst in the development of new concepts and ideas.
- Second, a simulation game. In this simulation game, participants are asked to develop a first set of requirements for the sustainable urban renewal of a particular neighborhood. This can be either an existing neighborhood, or a fictional neighborhood. Participants represent the various organizations and their interests that are involved in urban renewal projects. MEDIA is used to support the simulation game.

The relationship between MEDIA, simulation and practice is presented in fig. 1.1.

Figure 1.1: Relationship between MEDIA, simulation game and decision making environment



MEDIA integrates concepts of decision making models, design models and environmental impact assessment models. The simulation game provides a complex policy environment in which actors can experiment with making sustainable decisions, supported by MEDIA. The simulation game also has educational purposes. It creates awareness of the complexity of sustainable decision making from both a managerial and a sustainability point of view, and relates this to the goals and preferences of the participants.
It is the combination of model (substantive quality design) and simulation game (process design) that provides most of the added value of the Dubes project. Observations from the simulation game provide feedback for MEDIA and vice versa. This combination has been tested successfully in practice twice.
A major drawback of the present result is the lack of quantitative data for supporting decision making. Although working with such data has been conceptually implemented in MEDIA, the actual inventory of the necessary data is a project in itself, and therefore falls outside the scope of the Dubes project. The mainly positive responses from the scientific, public and market sectors, however, show there is an enormous potential for the combined approach developed in this project. Certainly in the Netherlands, where the public debate about interactive and participative policy making is vibrant, there seems to be an still vacant niche for approaches such as these. In order to reach its full potential, further research and development will be needed.

2 INTRODUCTION

2.1 Motivation and problem definition

The days that designers and policy makers could focus on finding technical solutions for technical design challenges are past. Decision-makers, irrespective of their work field, must take notice of an increasing number of aspects. These may be of a primarily technical nature, for example in the aircraft industry, where demands and regulations regarding noise, emissions, safety and fuel economy have to be incorporated into airplane designs. In addition to technical issues, the societal context is also becoming more and more complex. An example of this are high speed rail infrastructures, where societal problems relating to track choice are often more difficult to overcome than the many technical problems.
In addition to these technical and societal issues, there is a growing awareness regarding sustainable development issues, which further complicates large projects. Sustainable development is one of those magical concepts that everyone is in favor of (Hajer, 1995[3]). In the urban environment, with its major impact on many sustainability issues, it proves difficult to translate this concept into practical approaches. In the Netherlands and Europe there is a obvious need for such approaches, to take on the challenges posed by major urban (re)development projects in the years to come. Especially the post-war peripheral residential neighborhoods are of poor quality, and are afflicted by a combination of physical and socio-economic problems (European Commission, 1996:6[4]). For example, Europe has eighty thousand blocks of flats, in need of refurbishment (Eriksson and Dekker, 2000[5]).

Looking more closely at the problem of implementing sustainable development principles in large projects, three major categories of complexities can be distinguished: complexity related to substantive quality, policy complexity and design complexity. These will be shortly described below.

Complexity related to substantive quality
Sustainable development and its derivative for the built environment, sustainable building, are concepts that are difficult to define unequivocally (Dryzek, 1997[6], Hajer, 1992[7], Roe, 1998[8]). These concepts represent various values such as 'quality of life' and 'safety', but also ecological values such as 'ecosystem quality' or 'emissions'. These different values sometimes prove difficult to unite. For example, a windmill park can be perceived as a source of sustainable energy or as a blot on the landscape. Questions related to these values cannot be answered univocally and give sustainable development its equivocal character. This equivocal nature manifests itself on philosophical, political and operational levels.

Policy complexity

Large design challenges in the built environment involve a network of actors, who strive to achieve their ambitions and protect their interests. For example, in the design stage it will involve municipal services for building, housing, traffic and the environment, housing associations, project developers, residents, interMEDIAry organizations, water and energy providers, water boards, construction companies, architects and town planners. Each of these organizations and professionals make decisions at various moments based on their own preferences and interests (Bremer and Kok, 2000[9], Van Bueren and Priemus, 2002[10]).
This process is determined by the perceptions and value systems of the actors involved, causing them to make competing assumptions about problems and solutions, means and ends, cause and effect. From the actor network perspective, there is no single correct view to policy problems and their solutions. Decisions are made in a complex process of negotiation between actors.
The production of a design specification or a program of requirements is therefore a much politicized process. The dynamics of political events, such as disputes within a council or board, the resignation of an executive member of the local council, or elections, can often cause a restructuring process to progress by fits and starts (Teisman, 1995[11]). A matter that seems, at a given moment, to have been resolved may subsequently come up for discussion again.

Design complexity

Urban systems are extremely complicated and consist of many interdependent physical and social variables, such as the number of homes and roads and also the behavior of the residents in their homes and neighborhoods (Tjallingii, 1996[12]). Because decisions are often interdependent, and decision options may influence the values of multiple variables relevant for sustainable development, the effects of decisions are often difficult to predict. This makes it difficult to make a design for sustainable restructuring. For example, in a urban redevelopment project, increasing the housing differentiation may influence not only on the social structure of the neighborhood but also matters such as the mobility of the residents, energy consumption and the quantity of household waste produced.

The three complexities described above must be addressed simultaneously in any integrated and effective approach aimed at sustainable urban (re)development. The procedural rationality, typical of most model-based approaches, one does not suffice for such complex problems. The same holds true for approaches that are primarily aimed at reaching consensus among the actors involved.
Urban (re)development, and large building projects in general, are design challenges where the trend towards increasing complexity is clearly visible. Cities as living space and organizational units are already among the most complex man made systems (Müller, 2002[13]), providing the interface for a multitude of economic, social and ecological functions. Decision makers in the area of urban planning & renewal and large building projects with ambitions regarding sustainable development therefore cannot ignore this increasing complexity. In order to realize technically and functionally sound projects that are acceptable to the actors involved and also comply

with the principles of sustainable development, it is necessary that policy makers, designers and sustainable development experts work together. Co-operation between these actors can be enhanced by tools that make design and decision making processes more transparent (process) and offer insight in the environmental impacts of decisions (substantive quality).

Currently, there are no integrated tools that address these complexities simultaneously. Many tools are developed in a process-oriented setting, such as the Dutch National Packages Sustainable Building (SBR, 1996[14], 1998[15]; CROW, 1999[16]; Nationaal Dubo Centrum, 1999[17]). Other tools, such as life cycle assessment (LCA) or material flow analysis (MFA), are aimed primarily at substantive quality.
The lack of truly integrated tools is the primary motivation for the Dubes project. It is unlikely that without such tools ambitious goals such as factor 20 (Weterings & Opschoor,1992[18]; UNCED, 1992[19]; Weiszäcker, Lovins & Lovins, 1997[20]) are within reach.

2.2 Goal

The goal of the Dubes project is to develop tools that integrate sustainable development principles into the decision-making process of large building assignments. In the original proposal the goal was defined as follows:

The development of an approach in which substantive quality aspects are related to relevant moments in the decision-making process and by which a significant contrition is made to a decrease of the environmental impacts of the built environment with a factor 20.

2.3 Structure of this report

Chapter 3 gives an overview of the somewhat unconventional development-process which resulted in this report and the other products of the Dubes project. Strictly speaking, this chapter isn't necessary, but it may provide more context and understanding for the choices that have been made in the project.
Before any approach or tools can be developed, the underlying causes of complexity must be understood and analyzed. This is done in chapter 4, in which we elaborate three complicating factors of large building assignments: policy complexity, the equivocal character of sustainable development, and design complexity.
In chapter 5 the conceptual foundations that where used or developed for this project are presented. These foundations are our solutions to the complicating factors described in chapter 4.
In chapter 6 the conceptual model and software tool MEDIA is presented. In this chapter, the analysis of complexity is used to derive the functional requirements that have guided the development of MEDIA. We then discuss the specific manner in which the conceptual foundations have been implemented in MEDIA. The model is illustrated using a small case study and screenshots of the relevant functions

The second main result of the project, the simulation game, is discussed in chapter 7. This simulation game provides a complex policy environment in which actors can experiment with making sustainable decisions, supported by MEDIA.
The report is concluded by drawing conclusions (chapter 9) and formulating directions for future research and development (chapter 10). Literature is included in chapter 11.

To increase the readability of the report, text-boxes are used which contain more detailed information. This detailed information is not essential for understanding the report, but provides extra information and context.

3 HISTORY OF THE DUBES PROJECT

3.1 Introduction

The Dubes project has been no 'ordinary' project, with a clearly and unambiguous defined problem definition, goals, research method and projected result. This is a logical consequence of the complexity of the subject, which can be divided into policy complexity, design complexity and the equivocal character of sustainable development. In addition, the project team members all had their own perceptions of these complexities. These are in turn determined by their different professional backgrounds, such as policy sciences, spatial planning, material sciences, environmental sciences, etc. This further enhanced the challenge.

It was during the project that consensus was reached on definitions, conceptual foundations, solutions, research methods, etc. This happened in an interactive, iterative, creative and rather unstructured *process*. This (learning) process is by no means finished and is itself one of the most important results of the project. Because of the unstructured nature of this process, it is difficult to document and report. Nevertheless, an attempt has been made in this report, using documents or results from strategic important stages in the project, such as the proposal and intermediate reports. These strategic stages are discussed and analyzed from the current perspective. The goal of this analysis is not to produce a chronological description, but to share the experiences of the project team members, and thus help the reader in understanding why certain choices were made as they are and the results are what they are.

The following strategic stages will be discussed in this chapter:

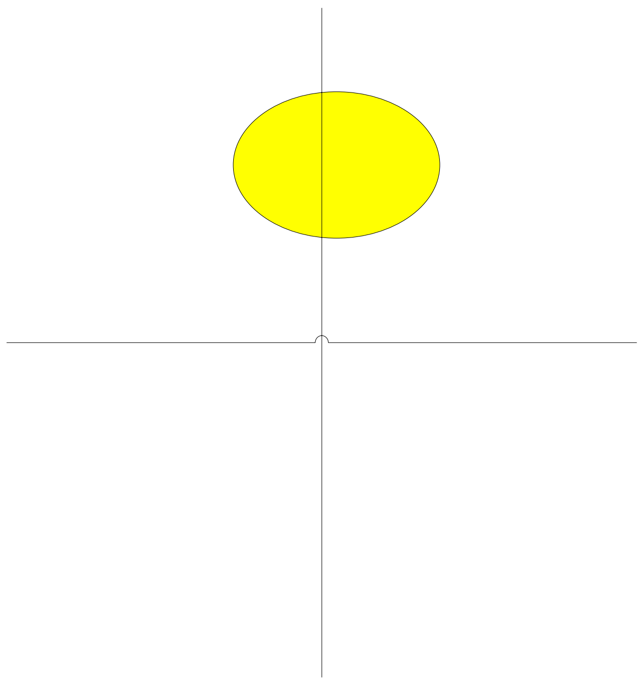
- Project proposal
- Intermediate report 04-2000
- MEDIA-I 05-2000
- Simulation games: test runs, Emmen and Alphen

3.2 Project proposal

In the original proposal, the goals and desired results of the project were defined in abstract terms. For instance, it was stated that 'substantive quality and process should be linked together in an integrated approach', but little was said about how this should be done. With regard to the process component, it was suggested that the phasing of projects (usually 6 phases: initiative, programming, designing, realization, utilization, and redevelopment) as used by building professionals could be a starting point. For the substantive quality-oriented component several possibilities are suggested, such as life cycle management (LCM), life cycle assessment (LCA), the Ecoindicator 99[21]. The impression of the final result that is made by the proposal is some sort of quantitative computer–based model, which is cleverly linked to the traditional decision making process.

In figure 3.1 the perception of the final result, as suggested in the proposal, is presented in a graph. The horizontal axis represents the degree to which the result is suitable for programming or evaluative purposes. Terms that can be associated with programming are: agenda-setting, ambitions, goals, exploration, diverging, qualitative and communication. Evaluative on the other hand stands for testing, checking, quantitative, modeling, data, etc. The vertical axis expresses the degree to which the result is aimed at single or multi-user environments. Single-user environments are associated to more ore less stand-alone approaches, which can be used by experts or consultants. Multi-user environments on the other hand, depend largely on the (active) participation of other actors.

Figure 3.1: View of final result in proposal



3.3 1st intermediate report

The first intermediate report is dated April 2000. The focus of this report is on the conceptualization and formalization of the assignment. Much progress has been made in this area. The original idea of using process phasing as a basis for a method has been rejected and the AIDA-concept (Analysis of Interconnected Decision Areas) has been introduced in return. Also the concept of spatial level has been introduced. As far as components aimed at substantive quality, the emphasis still lies on the use of quantitative models. In figure 3.2 the conceptual picture the project team had at the time of the result is presented. In figure 3.3 the perspective of the final result at this stage is presented graphically.

Figure 3.2: Conceptual model 1st intermediate report

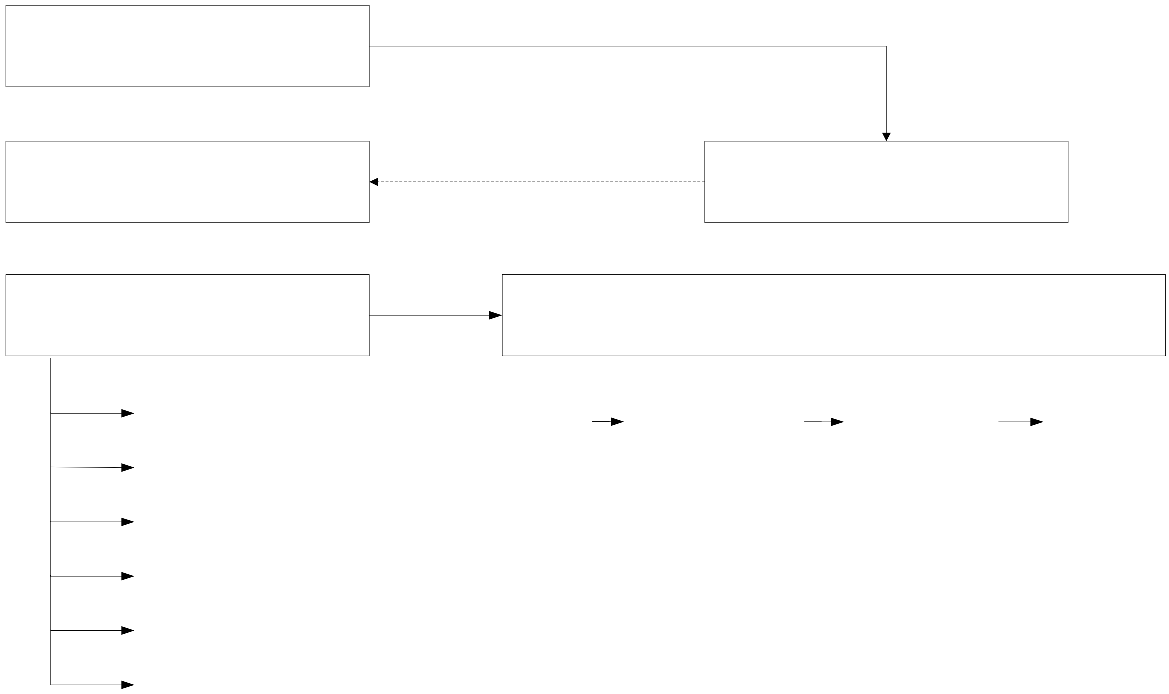
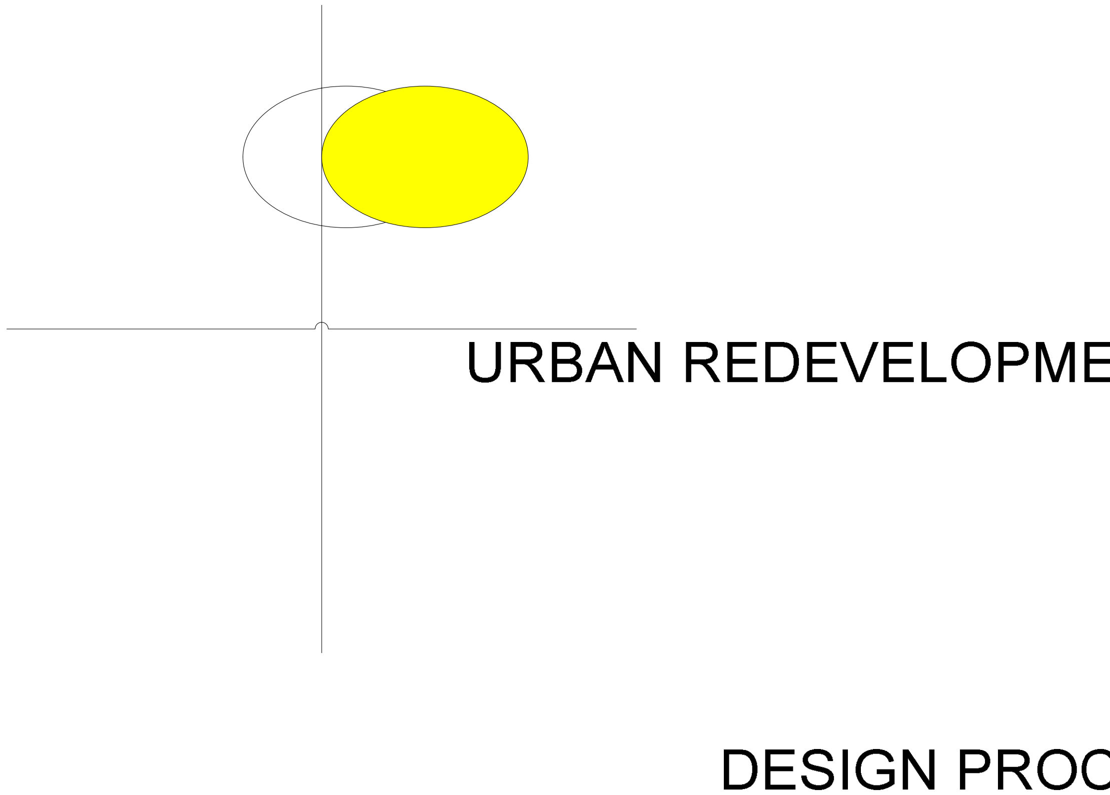


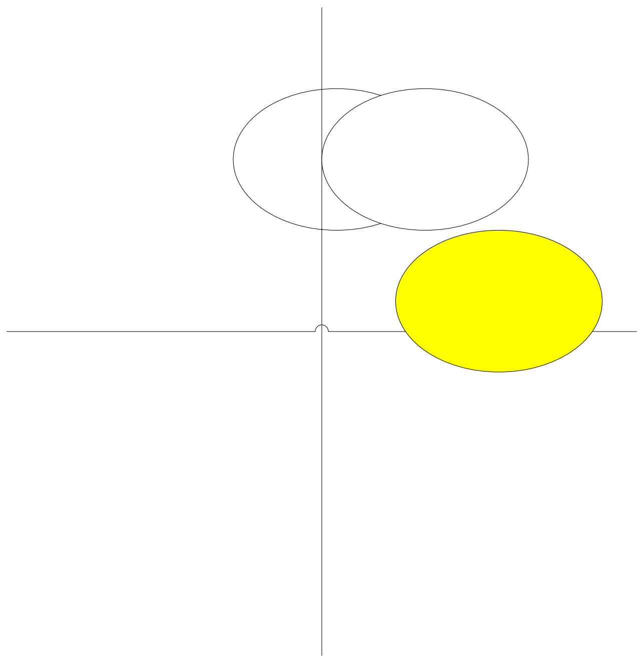
Figure 3.3: View of final result in 1st intermediate report



3.4 MEDIA version 1

In May 2000, the idea of using a computer-model to conceptualize, describe and make the concepts defined in the intermediate report operational was introduced. The introduction of MEDIA further shifted the (virtual) image of the final result to a quantitative sort of decision support system, as is shown if figure 3.4. From the beginning on, MEDIA was designed as a multi-user model.

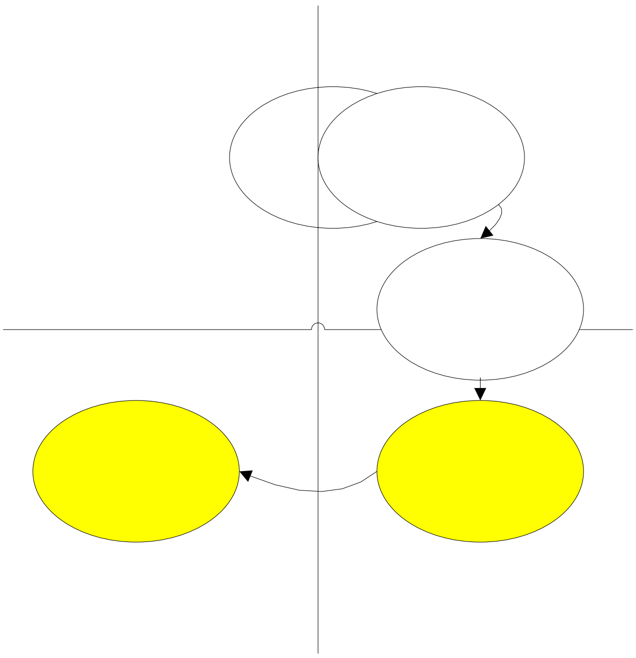
Figure 3.4: View of final result after 1st MEDIA-version



3.5 Simulation games

The idea of using simulation games was introduced in 2001. One of the reasons for this was the complexity of the MEDIA-model and the difficulties resulting from this for practical applications. In the beginning the idea of the simulation games primarily was to shift from a single-user environment to a multi-user environment. The practical problems of integrating enough quantitative data for evaluative purposes were too large to be solved within the scope and budget of this project. This meant that after the actual simulation games were finished, the picture of the final result shifted dramatically to an approach for programming purposes within a multi-user environment (figure 3.5). The added value of the 'evaluative' roots of the final results is that a development towards a more evaluative approach is possible without any major conceptual changes to the approach.

Figure 3.5: View of final result after simulation games



4 DETAILED PROBLEM ANALYSIS

4.1 Introduction

In order to systematically tackle the complex assignment of this project, it is necessary to make a solid analysis of the problem itself and related sub-problems. This analysis is presented in this chapter, in which we argue that the following three types of complexity must be dealt with in order to find more sustainable solutions for design challenges in urban (re)development:

1. The equivocal character of sustainable development.
2. Policy complexity.
3. Design complexity.

Although other ways of categorizing and analyzing the many subtopics related to sustainable development exist, in our opinion this broad division in three types of complexity does not exclude any of the relevant subtopics.

The three major complexities will be discussed in the next sections, resulting in conclusions in section 4.5.

4.2 The equivocal character of sustainable development

Sustainable development and its derivative for the built environment, sustainable building, are concepts that are difficult to define. The most cited definition of sustainable development is the one found in the Brundtland report: *a development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (WCED, 1987[22]). This definition was succeeded by principle 3 of the Rio declaration on Environment and development (UN, 1992[48]): *to equitably meet developmental and environmental needs of present and future generation*. Both these definitions leave ample room for interpretation. When are present needs met? What exactly are the needs of future generations? How can we be sure we are not compromising their abilities? These questions address undefined, uncertain, subjective and therefore debatable variables and give sustainable development its equivocal character. This equivocal nature manifests itself on different levels of policy making. On the philosophical level, the debate focuses, for example, on the interaction between environmental, economic and social issues. There are two mainstream opposing views on this topic. The first is often referred to as 'weak' sustainability (representing an anthropocentric view), and is based on the assumption that the reductions in finite and non-renewable environmental capital caused by human interventions can be compensated through extensive substitution with human capital. This view is most clearly stated by the Brundtland report and the (World Bank, 1992[23]). Principle 4 of the Rio Declaration (integration principle), expanded in Agenda's 21 chapter 8 (Quarrie, 1992[24]), calling governments to "review the status of the planning and management system and, where appropriate, modify

and strengthen procedures so as to facilitate the integrated consideration of social, economic and environmental issues" confirmed the view that economic and social issues are of the same significance to sustainability as environmental issues.
The opposing view, 'strong sustainability', (representing an ecocentric view) is based on the thought that our existence on earth is ultimately based on biophysics, not economics. Consequently it argues that (bio) physical environmental issues are critical and that goals regarding sustainability should therefore be defined in environmental terms. This ecological view of sustainability is shared among others by (Georgescu-Roegen, 1971[25]; Daly, 1973[26], 1974[27], 1977[28]; Ayres, 1996[29]; Welford, 1997[30]).
Other authors acknowledge the arguments put forward by the supporters of 'strong' sustainability, but stress that socioeconomic equity is a critical element in reaching sustainability (Daily & Ehrlich, 1995[31]), arguing that the global cooperation necessary for sustainable development can only be achieved by narrowing of the gap between rich and poor countries. In box 4.1 a number of frequently used definitions are presented. The dichotomy anthropocentric – ecocentric is well known. What's essential and relevant for this project is that supporters of these opposing views will time and time again confront one another with conflicting arguments, models and methods.
On the policy level, there are other complicating factors. First of all, the number of (alleged) sustainability issues, such as energy, natural resources, biodiversity, land use, materials, emissions, livability and cultural heritage is very large. Second, there is no consensus on the way in which, and the extent to which, these issues are indeed tied in with sustainable development. This is partly because these specific issues themselves are not well-defined. Finally, even if all the issues and their exact significance to sustainable development could be established, there is the problem of their relative importance. On the operational level, which has to do with actual tools and methods, there are many practical problems related to availability of suitable models and data.

All in all it is fair to say that sustainable development is a concept that should be further defined and negotiated in a political context. This however doesn't solve the problem, but only moves it to the arena of policy-making, negotiation and decision making, which, as we shall see in section 4.3, introduces several new obstacles in return.

BOX 4.1: Some definitions of sustainable development[32].

- "requires meeting the basic needs of all people and extending opportunities for economic and social advancement. Finally, the term also implies the capacity of development projects to endure organizationally and financially. A development initiative is considered sustainable if, in addition to protecting the environment and creating opportunity, it is able to carry out activities and generate its own financial resources after donor contributions have run out." *Bread for the World*, Background Paper No. 129, Washington, DC, March 1993.

- "improves the quality of human life while living within the carrying capacity of supporting ecosystems." International Union for the Conservation of Nature and Natural Resources (IUCN), World Conservation Union, United Nation Environment Program (UNEP), and World Wide Fund for Nature (WWF), *Caring for the Earth*, pp. 10, IUCN/UNEP/WWF, Gland, Switzerland, 1991.

- "uses natural renewable resources in a manner that does not eliminate or degrade them or otherwise demise their renewable usefulness for future generations while maintaining effectively constant or non-declining stocks of natural resources such as soil, groundwater, and biomass." World Resources Institute, Dimensions of sustainable development, *World Resources 1992-93: A Guide to the Global Environment*, pp. 2, Oxford University Press, New York, 1992.

- "maximizes the net benefits of economic development, subject to maintaining the services and quality of natural resources." R. Goodland and G. Ledec, Neoclassical economics and principles of sustainable development, *Ecological Modeling* 38 (1987): 36.

- "is based on the premise that current decisions should not impair the prospects for maintaining or improving future living standards. This implies that our economic systems should be managed so that we live off the dividend of our resources, maintaining and improving the asset base." R. Repetto, *World Enough and Time*, pp. 15-16, Yale University Press, New Haven, CT, 1986.

- " is taken to mean a positive rate of change in the quality of life of people, based on a system that permits this positive rate of change to be maintained indefinitely." L. M. Eisgruber, Sustainable development, ethics, and the Endangered Species Act, *Choices*, Third Quarter 1993, pp. 4-8.

- " is development without growth --- a physically steady-state economy that may continue to develop greater capacity to satisfy human wants by increasing the efficiency of resource use, but not by increasing resource throughput." H. E. Daly, Steady state economics: concepts, questions, and politics, *Ecological Economics* 6 (1992): 333-338.

- " is the search and the carrying out of rational strategies that allow society to manage, in equilibrium and perpetuity, its interaction with the natural system (biotic/abiotic) such that society, as a whole, benefits and the natural system keeps a level that permits its recuperation." E. Gutierrez-Espeleta, Indicadores de sostenibilidad: instrumentos para la evaluacion de las politicas nacionales", unpublished paper presented at *50th Anniversity Conference of the Economic Sciences Faculty* sponsored by the University of Costa Rica, San Jose, Costa Rica, Nov. 19, 1993.

4.3 Policy complexity

Can definitional issues be resolved in the policy arena? Not easily. Large design challenges in the built environment, such as urban (re)development, are typified by a complex network of actors with different interests and expertise (Spaans, 2001[33], van der Waals, 2001[34]). Typical actors for a urban redevelopment project are municipal services for building, housing, traffic and the environment, housing associations, project developers, residents, intermediary organizations, water and energy providers, water boards, construction companies, architects and town planners. All these actors strive to achieve their ambitions and protect their interests. They will therefore make decisions at various moments based on their own preferences and interests (Bremer and Kok, 2000, Van Bueren and Priemus, 2002. This process is not governed by objective rationality, but determined by the perceptions, value systems and knowledge of the actors involved.
This actor network perspective on policy problems stands opposed to more traditional views, which more or less assume that objective information leads to objective decisions. In reality it is observed that, based on the exact same information, different actors reach different conclusions and decisions. This is not so much because the facts of the matter are inconsistent (though often they are), but more because the actors involved (policy makers, policy analysts and other stakeholders) make competing assumptions about problems and solutions, means and ends, cause and effect. From the actor network perspective, there is no single correct view to policy problems and their solutions. Decisions are made in a complex process of negotiation between actors. Ideally, in such an interaction process the different views are exchanged and tradeoffs are made. In practice, the interaction is not perfect and the outcome sub-optimal in terms of both substantive quality and (public) support. The solution to this problem is sought in process management (De Bruijn and Ten Heuvelhof, 2000[35]): by facilitating the interaction, better results can be achieved. Participatory approaches of impact assessment en project appraisal (Monnikhof, 2001[36]), based on the actor network perspective, seem promising.

So is good process management the solution to the problems posed by sustainable development? Certainly the significance of different sustainable development issues and their relationships can be made more transparent. This in turn makes weighting of separate issues en deliberate negotiations easier. It still remains a complex process however and still doesn't address the actual subject: the complex (re)design challenges that are posed by urban (re)development projects. Actors involved in an urban (re)development project must be able to connect sustainable development to many different design choices in a way that makes a reasonable assessment possible. This introduces the third main hurdle that has to be taken: design complexity.

4.4 Design complexity

The third main complicating factor for urban (re)development has to do with the large number of design parameters that come into play at large building projects. There are typically hundreds of decisions, each with two or more alternative options. These decisions and decision options may have different spatial levels and are often interrelated. Also the stage in which the decision is made may differ. The choice for certain options in the beginning of a design process can seriously limit the number of available options in other decision areas further on in the process. In addition, each decision option can have effect on the values of multiple variables relevant for sustainable development. Finally, it is often observed that these variables themselves are linked by laws of nature.

Unfortunately, urban (re)development is an example of where this complexity has resulted in a tendency towards academic and professional specialization. For many of the separate (clusters of) decision areas mono-disciplinary approaches may exist, road construction and road planning for example both have to do with roads, yet are two separated disciplines. Also there are many approaches that try to integrate one specific sustainability issue into decision making. Especially with respect to energy use this is obvious. These mono-disciplinary approaches, whilst scientifically valid, lack an overall picture of the problem in a wider societal context. At best they sub-optimize a certain decision option or sustainability issue. On the other hand, more pragmatic and holistic approaches are often not transparent and for that reason not acceptable for generic use. Others have described this as the dilemma of the choice between scientific disciplinary rigor and practical relevance (Schon, 1978).

What is needed, is a balance between integration on one hand and scientific validity and precision on the other. This balance can only be achieved by coordinated discussion between specialists about technical issues, much like the normative discussion that is needed in the policy arena.

4.5 Conclusions

Together, the equivocal nature of sustainable development, policy complexity and design complexity constitute a formidable barrier for an integrated and effective approach aimed at sustainable urban (re)development. At this moment, current practice in the Netherlands has not crossed this barrier. Most approaches have been developed with the focus on scientific validity, communicative aspects or the practical use as a design tool. This is illustrated with a number of examples from Dutch current practice.

A good example of an approach developed from the scientific perspective is the Life Cycle Assessment method (LCA). This method is applied as such for individual building products and also serves as a basis for more aggregated tools such as Ecoquantum and Greencalc. Although LCA seems a promising tool and has the aura of scientific validity, it is often observed that the application in public policy processes is problematic (Bras-Klapwijk, R.M., 1999[37]), mainly due to the limited current possibilities of multi-actor involvement. Other shortcomings of LCA and similar approaches, such as Material Flow Analysis, are the limited scope with respect to sustainable development issues and the difficult to interpret and communicate results. Example of approaches where consensus and process prevailed over substantive quality, are the National Packages Sustainable Building (SBR 1996, 1998; CROW 1999) which, although widely accepted in the Netherlands, have no scientific foundation and offer little insight in the actual progress that they accomplish (Van Bueren, 2000[38]), thus increasing the risk of 'negotiated nonsense'. Attempts to develop more integrated design tools are also being made, such as the DCBA-method[39]. Because of the large amount of presumptions and limited scientific validity methods like this suffer from a lack of acceptance.

An ideal approach would be one in which ambitions regarding sustainable development and related models are negotiated on a project-basis and in interaction with all the actors involved. Furthermore, ambitions and models should somehow be linked to the complete design challenge in question and not just too separate design questions. Finally, the (lack off) scientific validity of the models used should at least be made transparent.

The main conclusion that can be derived from this analysis is that procedural rationality typical of most models-based approaches alone does not suffice for complex problems such as urban (re)development. This has been recognized by other authors. Moldan and Billharz, 1997[40] explicitly mention the need to address inter-linkages through integrated approaches using inter-linked sets of indicators and that the existence of socio-ecological linkages highlights the limitations of the usual procedures for generating and aggregating indicators. Lombardi, 1998[41] states that the evaluation of urban sustainability needs an understanding of all the interdependencies between aspects and the effect that action in one aspect might have in others. She stresses the current lack of adequate infrastructures towards a common understanding of urban sustainability and the needs for a systematic and pluralistic approach and postulates a multi-modal thinking approach for establishing an integrated, meaningful and holistic framework for guiding the evaluation of urban sustainability in planning. Other projects, schemes and initiatives that recognize these complexities are Bequest, Sureuro and Crisp (see also box 4.3). The Dubes project can be seen in line with international research projects like these.

The main consequence for this project is that conceptual solutions must be developed and implemented for each of the three complexities described in this chapter. Attempts to develop an approach which is not conceptually sound will increase the chance of failure of this project. Equal attention must be given to process design (ability to support early stages of projects, interactivity, actor participation, agenda creation) and substantive quality (impact assessment models and related issues such as variables, data, etcetera).

Box 4.2 : Wicked concepts

Looking at the complexities described earlier in chapter 4, it can be observed that integrating the principles of sustainable development in decision making processes regarding urban (re)development is a problem which can not be described or solved univocally. This equivocal character has been amply described by (Van Bueren, 1999[42], 2001[43]). Common terms for such problems are wicked (Rittel and Webber, 1973[44], Roe, 1998[45]), essentially contested (Connolly, 1978[46]), political (De Graaf and Hoppe, 1989[47]) or unstructured. Other examples of wicked problems are health care, drug use and international terrorism. These problems have the following characteristics in common[43].

- They cannot be isolated from their context.
- They consist of a large number of components, which are highly differentiated and which are interdependent. As a result, causal relations are unclear.
- The components of the problem are also wicked; they also consist of many, interdependent components.
- Conflicting values are present between the various components.
- Each problem is unique.
- Each solution has irreversible effects.

Within this equivocal setting a large number of interpretations, models, methods and tools for analyzing and appraising sustainability applied to urban (re)development have been developed. The Rio declaration (UN, 1992)[48], requiring that 'environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it", further encouraged the development of approaches for analyzing and appraising sustainability (George C, 2001[49]). By definition, these approaches differ, although there seems to be some sort of consensus regarding the major issues such as global warming and ozone depletion. The fact remains that we are confronted with a multitude of approaches, that differ with regard to goal and scope, geographical and temporal scale, degree of quantification and aggregation, intervention point in cause-effect chain and decision making process, degree of stakeholder participation, etcetera.

In this box a number of other current projects and schemes aimed at sustainable development are described

Box 4.3 : Other projects aimed at sustainable development in the built environment

CRISP

"CRISP aims to develop and validate harmonized criteria and relevant and efficient indicators to measure the sustainability of construction projects particularly within the urban built environment. Through the range of indicators which will be dealt with, the project will contribute to improve the quality of life in urban communities and to promote sustainable development assessed in economic, architecture, environmental, social and cultural terms. Challenges which will be considered through the indicators are for instance linked to the preservation of natural resources, air quality, noise, health and safety, waste, economic competitiveness, employment, deterioration of infrastructure, urban sustainability, environmental loads of construction, socio-cultural aspects etc. Other impacts include also better co-ordination of the development of sustainability indicators for construction and cities, improved consensus on the indicators available and on the criteria of their use, better understanding and application of these indicators by relevant end-users such as planners, developers, designers, standardization bodies, authorities, contractors and materials producers. These end-users will benefit greatly from an authoritative, relevant and agreed source of information on indicators. It will enable them to develop more appropriate performance targets, tools and standards in order to improve the level of sustainability of the built environment."

SUREURO (Sustainable Refurbishment Europe)
"Seven representative European companies - managing some 212 000 apartments - teamed up with a number of research bodies and industrial construction firms to launch the Sureuro (Sustainable refurbishment in Europe) consortium under the key action The City of Tomorrow. The aim is to develop innovative approaches in terms of energy savings, sustainable management and the quality of life of the residents of apartment buildings of this kind.
All the new concepts will be developed in close cooperation with the property management companies which initiated the project and which will, in turn, involve residents' associations and the local authorities responsible for low-cost housing and the urban environment. The solutions proposed are currently being put to the practical test as part of a refurbishment project involving some 13 000 apartments. On the basis of these tests, which will serve both to demonstrate and to validate solutions, technically and economically, Sureuro will propose a set of refurbishment models and tools collected in a computerized database."

Most basic is the inventory of tools. These inventories often include a very broad range of tools without a clear definition of tools. The focus in Sureuro is on knowledge transfer between the participating partners

BEQUEST (Building Environmental Quality Evaluation for Sustainability through Time)
"The E.C. program of policy and action in relation to the environment and sustainable development of 1992 clearly identified improvement of the urban environment as a priority field of action, particularly in terms of reconciling the conflicting political, social and economic demands of modern commerce and transport with the desire to provide a good quality environment. The current situation is characterized by differences in terminology, approach and understanding between differing cultures, professions and most importantly, between those working at the scale of the city or urban district and those working at the scale of individual buildings. This project expands the embryonic BEQUEST network to form an effective multi-disciplinary, trans-European and cross cultural network for urban sustainability. The action makes extensive use of I.T, communications through existing networks and the Internet, as networking, consultation and dissemination are key to the project's success. The knowledge and experience of a wide range of actors from both the demand and supply sides of the construction and development industrial sectors is to be brought to bear on the problem through regular dialogue using a variety of means, including an iterative cycle of multi-disciplinary, interactive workshops and electronic questionnaires with rapid follow up via the Internet.
The primary outputs include:

- an effective multi-professional, international, interactive built-environment quality evaluation and sustainability networked community,
- a directory of environmental assessment techniques and methods currently in use and

emerging in the built environment sector, across the E.U.,
- a directory of professional advisors in the field,
- a procurement protocol for sustainable urban development."

Bequest offers a framework for classification of assessment tools to be able to communicate clearly with tool is best to be used in a particular situation (Deakin et al. 2001).

ANNEX 31

Annex 31 concerns energy related impact of buildings. For this project a questionnaire was held for the collection and representation of internationally available interactive tools and instruments supporting decision-making in the planning process by the application of criteria relevant to energy and environment (IEA-BCS Annex 31 2002).

The Green Building Challenge

The Green Building Challenge aims to develop an internationally accepted generic framework for a building environmental assessment tool, among others to compare existing building environmental assessment methods and to facilitate comparisons of the environmental performance of buildings (Cole and Larsson 2000).

5 CONCEPTUAL FOUNDATIONS

5.1 Introduction

In chapter 4 of this report it is argued that policy complexity, the equivocal nature of sustainable development and design complexity are the three main obstacles in reaching sustainable development in urban (re)development. Solutions must be found for each of these obstacles. The conceptual foundations of the solutions chosen in this project are described in this chapter. These three obstacles are addressed separately in the Dubes-approach, taking the requirements presented in chapter 4 into account.

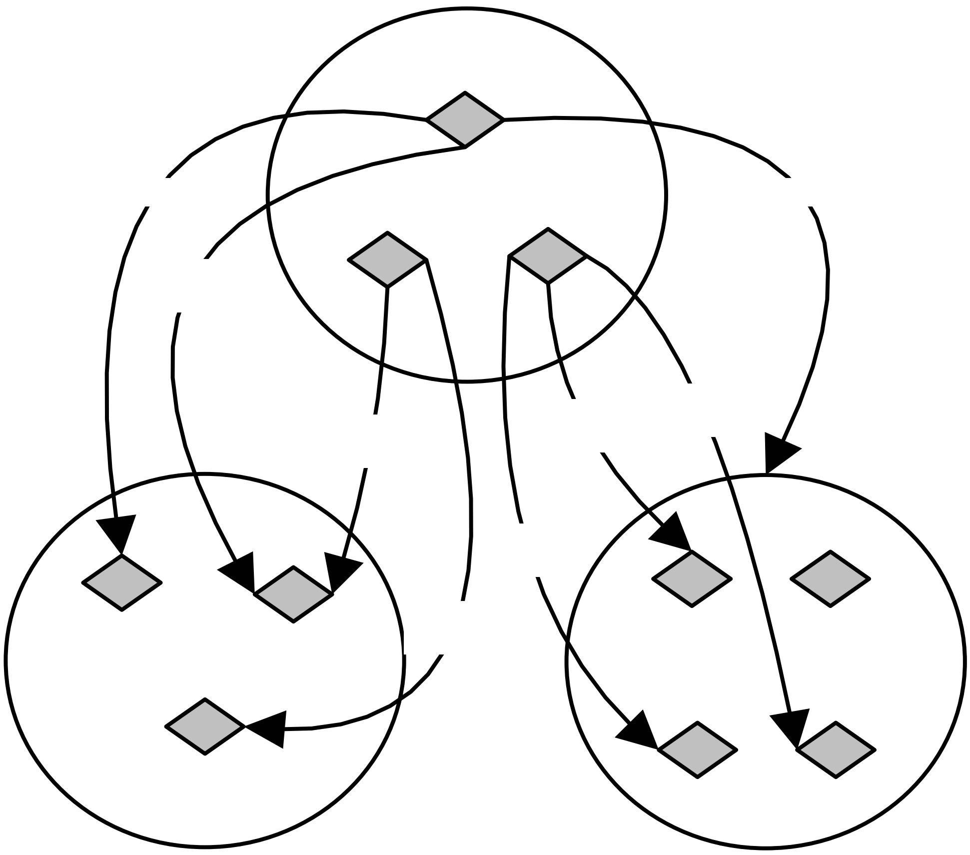
The order in which these conceptual foundations are addressed in this section is reversed, compared to chapter 3. The reason for this is that the fundamental framework of the approach developed in this project is based on concepts originally developed for design applications.

5.2 Addressing design complexity

As mentioned earlier in section 4.4, large building challenges, such as urban (re)development are characterized by a large number of design variables. For describing and formalizing decisions and the relations between decisions the concept "Analysis of interconnected decision areas" (AIDA) has been used as a basis (Morgan, J.R., 1971[50]). AIDA is a technique that makes large design challenges transparent and manageable. Design challenges are described as a set of decisions areas, each with at least two decision options. Decision options within the same decision areas by definition exclude one another. Relations between decision areas and decision options can be formalized, creating transparency and insight in the direct and indirect consequences of one specific decision or a comprehensive set of decisions (scenario). Relations exist between decision options of different decision areas in the form of exclusions. For example, the choice for integral elevation to prepare a building site for urbanization, excludes the option to give green areas a ecological function later on. Furthermore, relations between options and decision areas can be distinguished as preclusions, for instance if it is decided to keep a quarter free from cars, al the decision areas related to parking are not relevant anymore.
For pragmatic reasons (manageability) decision areas have been grouped according to spatial level: region, city, quarter, block, building and room. Decision process stages (e.g.: initiative, programming, design, construction, maintenance) run right through the spatial levels and decision areas, and currently are not used as a structuring principle. Each decision option can have multiple variables attributed to it. These impacts can be purely descriptive variables (for instance the amount of m^2 surface water resulting from choosing a pond) as well as complex functions of different variables (indicators). The topic of variables and indicators will be further discussed in section 5.3. In figure 5.1 the basic AIDA-structure as designed for this

project is presented. In this example three typical decision areas that may occur during urban (re)development are presented.

Figure 5.1: Analysis of interconnected decision areas (AIDA)



In figure 5.1 three typical decision areas relating to urban (re)development and their options are presented as an example. Two types of relations exist: exclusions between options of different decision areas and preclusions between a decision option and other decision area(s). These relationships can be definite, probable or possible.

Based on several case-studies, currently over 200 decision areas have been distinguished for a typical urban redevelopment case. This large number introduced the need for a higher level of organization then decision areas. For this purpose the concept 'Theme' has been introduced. Themes are categories of decision areas related to the same topic (e.g.: water management, energy).

AIDA provides the backbone for MEDIA, which is described in further detail in chapter 6. It also structures the simulation game which is presented in chapter 7.

Exclusion (defini

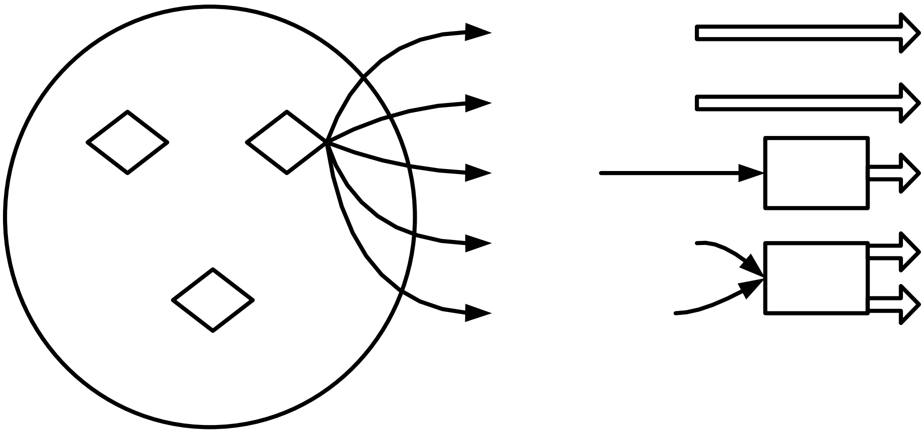
5.3 Addressing the equivocal character of sustainable development

The problem of the equivocal nature of sustainable development is hard, if not impossible, to solve conceptually. Any attempt to develop a generic set of indicators and calculation models still can be regarded as just one more interpretation of this concept. No matter how sincere the intentions of the authors of such a generic set, numerous normative choices would still have to be made. If these choices themselves are not involved somehow in the decision making process, chances are that the outcome is not acceptable for all the actors involved.

One of the starting points of the Dubes project is that the equivocal character of sustainable development is addressed in a transparent and non-normative manner. This is achieved by applying three principles.
First Dubes and its derivates (MEDIA and the simulation game) are not conceptually based on any single sustainability approach, but structured in such a way that numerous approaches can be facilitated. These approaches need not be in any way methodically compatible, consistent or complementary.
Second, there is no preferred (default) sustainability approach incorporated in Dubes: users can decide for themselves which approach is applicable in their case and have the possibility to apply their own approach.
Third, on a more operational level, models (MEDIA) developed in Dubes are designed in such a way that all kinds of data are facilitated, varying from simple quantitative and qualitative variables (indicators) to variables which are calculated by more or less complicated functions. Preferably, variables attributed directly to decision areas are purely descriptive (non-normative) and all normative elements are incorporated in separate methods (functions).

While this open non-normative structure may seem indecisive, inconclusive or even evasive, we feel that the benefits outweigh the deficits. The benefits being that no approaches are precluded, no approaches are forced upon actors and dialogue between actors is facilitated. The deficits are that no easy and quick answers are provided. In the Dubes project, sustainable development is regarded more as a learning process then as a straight line to some utopist stationary (defined) situation. In figure 5.2 the structure of Dubes with respect to variables, indicators, calculation models (functions) and data is presented.

Figure 5.2: Flexible multi-model structure



In this figure as an example the variables associated with the option 'integral elevation' have been displayed. Some variables, such as 'm change in groundwater level' are directly relevant for certain aspects of sustainable development (in this case desiccation). Other variables must first be processed in a model, before meaningful indicators can be derived, for instance the amount of sand can be translated to indicators using Life Cycle Assessment methods.

Since there is often confusion regarding the terminology surrounding indicators, in the following box the terminology used in this report and in the Dubes project is briefly described, based on [Moldan B. and Billharz S., 1997].

BOX 5.1: Terminology regarding variables, indicators, data and models

- Operational representations regarding the state of a specific attribute (quality, characteristic, property) of a system are called variables (Gallopin, G.C. 2000[51]).
- Indicators are variables that are particularly relevant and meaningful to policy and decision making.
- Indicators may be more or less normative (as opposed to descriptive). In normative indicators, the process of interpretation and evaluation is (partly) embedded in the indicator itself. Descriptive indicators leave this process to the decision maker.
- Indicators can be defined as an individual variable, as a function of a variable or as a function of two or more variables. These functions may vary from simple functions (e.g. a ratio) to complex simulation models
- Data are observations (qualitative) or measurements (quantitative) of the values of the variables at different times, locations, populations, or a combination of these.
- Values of indicators may be observed or measured directly at the appropriate level of aggregation required for decision-making. If this is not so, they may also be derived

from primary data that are analyzed and processed to establish the values of more aggregated variables which are used as indicators: in the latter case, indicators are variables representing more or less complicated functions of the primary data

- A proxy can be defined as a variable assumed to be correlated (or otherwise linked) to some attribute which itself is not observable or measurable.
- Indicators can adopt various states: threshold, standard, norm, target, reference value, benchmark
- Indicators can be qualitative (nominal) variables, rank (ordinal) variables or a quantitative variables. Qualitative indicators can be translated into quantitative notation.
- The systems that indicators are related to can vary greatly. System boundaries may be based on different grounds: regional, temporal, product- or service life cycle, environmental compartments/MEDIA, sectoral, goals, administrative mandate. Also the hierarchical level may vary. Different systems and levels usually have their own specific indicators.

Various authors have proposed requirements that indicators should meet. In [Moldan B. and Billharz S., 1997] the most universal requirements are listed:

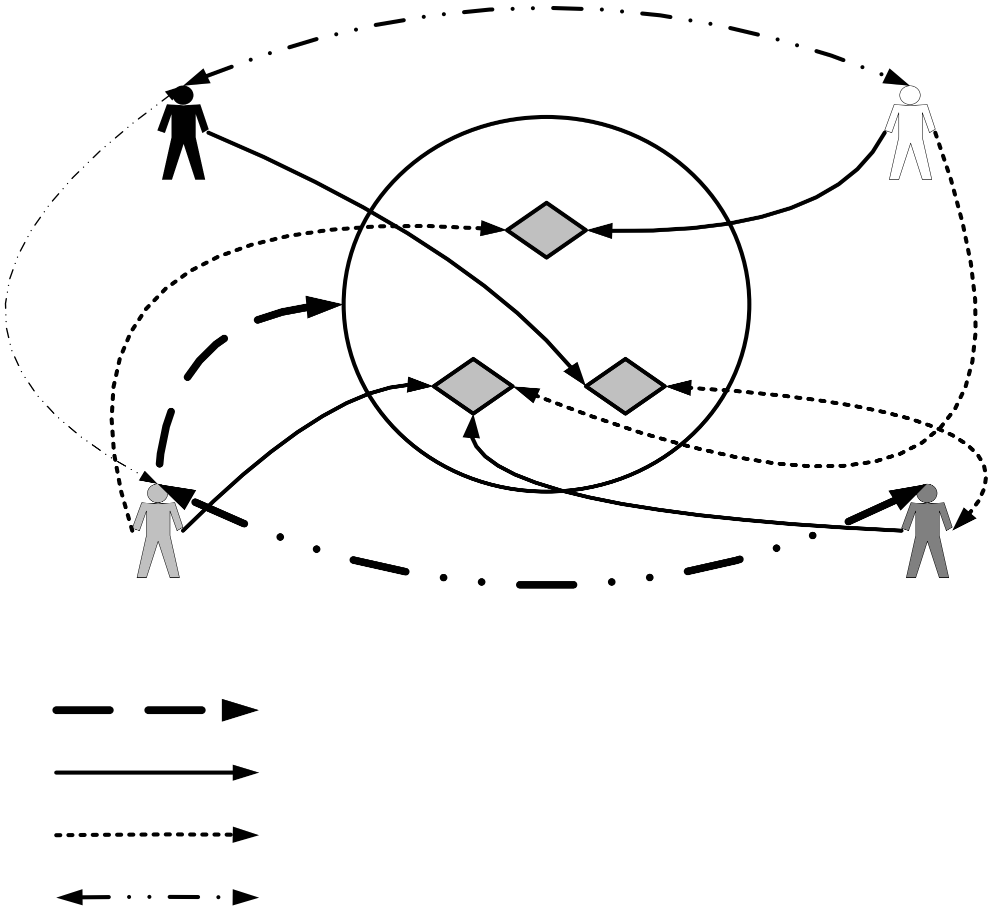
1. The values of indicators must be measurable or observable.
2. Data must be either readily available or obtainable.
3. The methodology for data gathering, data processing and construction of indicators must be clear, transparent and standardized.
4. Means for building and monitoring the indicators should be available. This includes financial, human en technical capacities.
5. Indicators or sets of indicators should be cost-effective.
6. Political acceptability at the appropriate level must be encouraged.
7. Participation of and support by the public in the use of indicators is highly desirable

5.4 Addressing policy complexity

Choices, whether they concern sustainability issues or other criteria, represent many different, potentially conflicting, values. Also the different options of a decision must compete for the attention and resources (budget) of the decision makers. Decision making ultimately remains a process of setting priorities, weighting and of course choosing. The decision maker decides which options are in their best interest. The result of the process of prioritization, weighting and choosing depends on several factors, such as the value system of the actors involved, the goals and ambitions of these actors, the specific (formal) role of actors in the decision making process and the interaction between different actors that occurs surrounding the problem at stake (networks).
These aspects are the main study-object of dynamic actor network analysis, which leads the analyst to think in terms of actors who all have their own problem perception. By making these perceptions explicit in a qualitative, conceptual language and then perform different types of comparative analysis, the analyst sharpens her insight not only in the policy situation at hand, but also in her own reasoning (analyst as *reflective practitioner*). The representations of actor perceptions may also serve as (organizational) memory and as a basis for discussion amongst analysts and/or actors.
To actually 'grasp' the policy complexity that is typical of large building assignments, case specific detailed research and analysis is required. It would be presumptuous to think that a model could replace such an analysis. It is however possible to model some of the less intricate relationships, the purpose of which is to at least make the process more transparent. It also makes the use of queries possible. The following elements related to policy complexity have been included in the Dubes-approach: actors and their preferences and aversions concerning decision options, the decision power of each actor, the interrelationships between actors and finally the ambitions of actors regarding sustainable development issues.

In figure 5.3 this in presented graphically with an example.

Figure 5.3: **Dynamic actor analysis elements**



In this figure the decision area 'function of green areas', is presented as an example. For this decision area the municipality is the only actor with decision power. For other decision areas, the decision power may be shared. If applicable, the preferences and aversions of the actors regarding decision options can be defined. Finally, the degree to which actors have access to other actors (expressed as the degree to which they can influence the decision) can be defined.

For an urban (re)development case, typical actors are municipalities, regional authorities, project developers, financiers, communities, housing corporations, environmental organizations and housing owners.

The elements shown in figure 5.3 are implemented in both the model and simulation game. The simulation game in itself can also be regarded as a more subtle and realistic way of integrating actors and their networks into the approach. This is described in detail in the chapter 7.

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6 MEDIA INTERFACE

6.1 Introduction

The conceptual software prototype MEDIA is based on the concepts described in the previous chapter. In this chapter the MEDIA-model is described that was used for the second case study for the municipality Alphen a/d Rijn. In this version the improvements resulting from the first case study in Emmerhout-Noord were implemented.
Meanwhile, newer versions have been developed and many suggestions for further improvements have been made. However, these adaptations have not been validated or tested in practice yet. For this reason, this particular version of MEDIA is reported.

In section 6.2 the functional requirements that emerged during the development of MEDIA are summarized. The conceptual foundations described in chapter 5 and their translations to model components are presented in section 6.3. In section 6.4, screenshots of MEDIA are presented and discussed. In section 6.5 the experiences of the practical work done with MEDIA is reported.

6.2 Functional requirements

The requirements for a model that addresses all the complexities described in chapter 4 are described in this section. Not all the requirements where drawn up in advance, but rather the result of an iterative trial and error process.

Eventually the following, mostly conceptual, requirements have been identified:

- The decision making process itself should be reflected in the primary structure of the model, using the AIDA concept, since it is through decisions that actors, design and impacts are linked together. Model structures based on other principles, such as sustainability themes, spatial level, or design process stage are less suitable as a basis for a truly integrated approach.
- The model should adequately represent the policy complexity that is typical of urban (re)development and large building projects. This implicates that functional demands of actors should be an important driving force of the model: what do the inhabitants, municipalities, project developers and other actors want? What are their ambitions, preferences and aversions? What are the relationships between all the different actors? All these aspects should be explicitly integrated in the model.
- Relationships between decisions should be included in the model, since certain decisions can seriously limit the decision space of other decisions.
- Knowledge related to substantive quality and insights regarding the consequences of decisions, such as design knowledge (what is technically feasible), legal issues (what is allowed), financial data (what are the costs) and scientific data about the

impacts on sustainability issues should somehow be linked to the relevant decision options.

- The model should not be normative with regard to sustainable development, but must be able to handle different interpretations of this concept. This means that there should be room for different types of variables, indicators, data, and functions (models). This enables different actors to use their own models, or models that closely resemble their view of sustainable development.
- The model should help the users focus on the most relevant issues only, since not all decisions made in a design process are equally important. The model should remind the users of all the decisions, but should also facilitate prioritization and selection of the most important decisions areas. On the other hand the model must also be systematic to avoid the possibility of overlooking critical issues.
- The model must be able to function in a dynamic environment, such as a simulation game.
- Finally the model should be transparent. The decision process itself should be made transparent to the users and participants in that process.

The present prototype version of MEDIA would seem to meet the most of these requirements, although sometimes simple linguistic tricks were needed.

6.3 Implementation of concepts in MEDIA

6.3.1 Implementation of the AIDA-concept

The AIDA-concept has been translated to MEDIA, without any major conceptual changes. Added to the concept is that the weight of relationships can be specified more precisely: definite, probable and possible.
Based on several case-studies, currently over 200 decision areas have been distinguished for a typical urban redevelopment case. This large number introduced the need for a higher level of organization then decision areas, for this purpose the concept 'Theme' has been implemented in MEDIA. Themes are categories of decision areas related to the same topic (e.g.: water management, energy). Some examples of decision areas and options are presented in figure 5.1.

By organizing and structuring assignments, using the AIDA-concept, many analytical possibilities are created. An important feature is the possibility of integrated analysis, since all decisions are linked.

6.3.2 Implementation of open multi-model structure

One of the requirements of MEDIA is that the equivocal character of sustainable development is represented adequately. This is achieved by applying three principles. First, MEDIA is not based on any single sustainability approach, but structured in such a way that numerous approaches can be linked to it. These approaches need not be in any way methodically compatible, consistent or complementary. Second, there is no preferred (default) sustainability approach incorporated in MEDIA: users can

decide for themselves which approach is applicable in their case and have the possibility to apply their own approach. Finally, on a more operational level, MEDIA is able to handle different types of variables, indicators, data and models. While this open non-normative structure of MEDIA may seem indecisive, inconclusive or even evasive, we feel that the benefits outweigh the deficits. The benefits being that no approaches are precluded, no approaches are forced upon actors and dialogue between actors is facilitated. The deficits are that no default preprogrammed answers are provided.
In combination with the AIDA-functionality of MEDIA, the multi-model structure makes it possible to perform sophisticated (semi)quantitative analysis, aimed at single decisions or comprehensive scenarios. For this it is necessary that all the required variables and their values (data) and models are implemented in MEDIA. Certainly if the ambition is to assess comprehensive scenarios with respect to multiple variables this is a major endeavor, one that may be hindered by limited data availability and lack of sufficient models (at the appropriate level of aggregation), especially if case specific (non-generic) decision areas and decision options are involved.

6.3.3 Implementation of dynamic actor analysis elements

The concept actor network analysis is made operational in MEDIA in the following way:

- Each separate actor can be described as an object in the model.
- The influence of each actor on each separate decision can be formalized in a (semi) quantitative manner.
- The preferred and non-preferred options for each decision can be formalized in a semi-quantitative way.
- The relations between actors can be formalized semi-quantitatively.
- The goals (ambitions) of actors regarding sustainability (and other) issues can be formalized using the concept of indicators described earlier in this paper.
- The model facilitates balloting techniques.

The combination of AIDA, the multi-model structure and dynamic network analysis elements opens up new realms of analytical possibilities. All sorts of queries can be imagined, such as: find the optimum scenario between actors A en B, find the scenario in which indicator I is minimized or maximized, find the optimum scenario between actor A and indicator I, find discrepancies between ambitions and preferences of actor A, etcetera, etcetera.

As mentioned before, in order for this type of queries to work, decisions and their relationships, variables and their values, actors and their relationships and so on, must be fully implemented in MEDIA.

6.3.4 Summary of MEDIA-components

Below, a short overview is presented of the components, implemented in MEDIA:

Themes.
Themes are clusters of decision fields, such as energy, green space and physical infrastructure. The prototype of MEDIA contains the various themes (about 30) that are important to design tasks in the urban environment. These themes were defined by the members of the Dubes project team, taking account of formulations as they are frequently used in practice. Examples of themes are green space, waste, mobility, facilities and social safety. Themes are grouped according to spatial level.

Decision areas
A decision field is the general designation for all kinds of decisions that have to be made in a design task, for example on provisions for waste collection and parking. With each decision field, one can choose from several options. Examples of decision fields under the theme of mobility at neighborhood level are: the structure and frequency of public transport, the infrastructure for non-motorized transport, the type of access to and from the neighborhood, the parking standard and the location of parking facilities. The MEDIA prototype contains an overview of a large number of decision fields (about 150) that may be involved in a design task.

Decision options
Options are the alternatives from which one can choose in each decision field. For example, parking facilities may be centralized or decentralized, above ground or underground, nearby or at a distance. The MEDIA prototype contains on average three to six options for each decision area.

Relationships between options
Options from different decision fields may be mutually exclusive or they may actually imply one another. For example, the choice for a certain form of energy infrastructure partly depends on the housing density and the type of dwellings. For a large number of options, the MEDIA prototype indicates whether they are interrelated and, if so, how.

Variables
Options have various effects, for example on costs and on sustainability. These are called variables. For example, the creation of parking facilities has an effect on the use of materials, on the possibilities for rainwater infiltration, on the soil balance, on car use (and therefore on the use of fossil fuels and the emission of CO_2 and other substances), on social safety, on the accessibility of a neighborhood or street, and so on and so forth. The MEDIA prototype only contains variables to a limited extent, usually qualitative in nature. The calculation of variables is the goal of new versions of MEDIA.

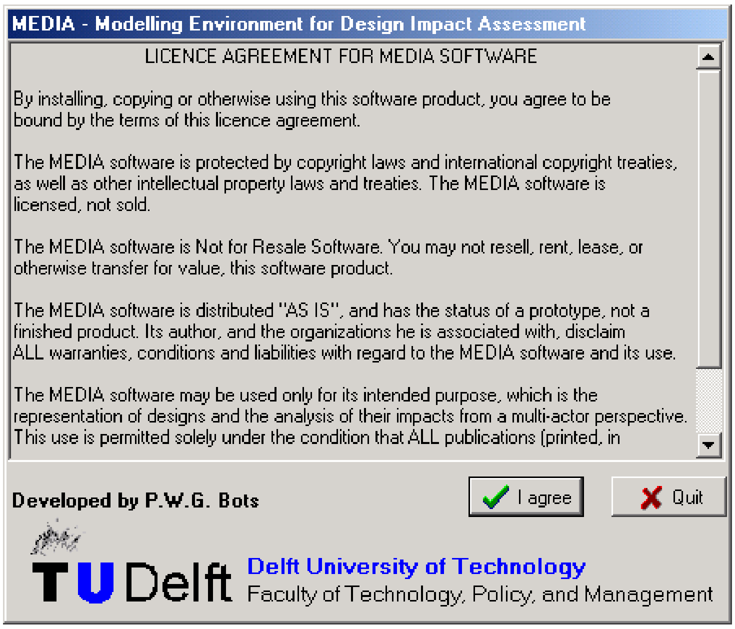
Methods
Various methods exist to picture the effects of options, such as life cycle analysis (LCA) and life cycle costing (LCC) methods. The MEDIA prototype offers the possibility to refer to these methods and, if applicable, to link these to MEDIA. However, in this respect too, MEDIA is still in need of further development.

Actors and their preferences
For every decision, certain actors are involved. MEDIA offers the possibility to indicate which actors are involved in the decision fields. In addition, actors often have a preference for certain options. MEDIA also offers the possibility to indicate the preferences of the various actors.

With the aforementioned structural elements, the Dubes model offers those involved in a design task an insight into the choices, the interdependencies between the choices, and the parties who are involved in these.

6.4 The MEDIA interface

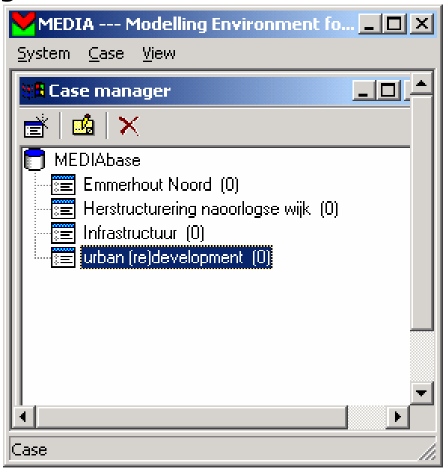
The MEDIA software model was developed by P.W.G. Bots of the Delft University of Technology. It consists of a Microsoft Acces™ database (Mediabase) in which all the information regarding decision areas, actors, variables, etcetera is stored, and an interface to access this database (MEDIA). This interface is currently programmed in Inprice Delphi™. In the following sections, the functionality of MEDIA will be discussed, using screenshots of the different software menus.



6.4.1 Case-manager

The first menu is the case manager (figure 6.1). In this menu cases (projects) can be selected, created or deleted. A case is a defined project or assignment, for instance an urban redevelopment project of a specific quarter. Since MEDIA is a multi-user program, the case manager also shows the number of individuals that have logged in to work on a specific case.

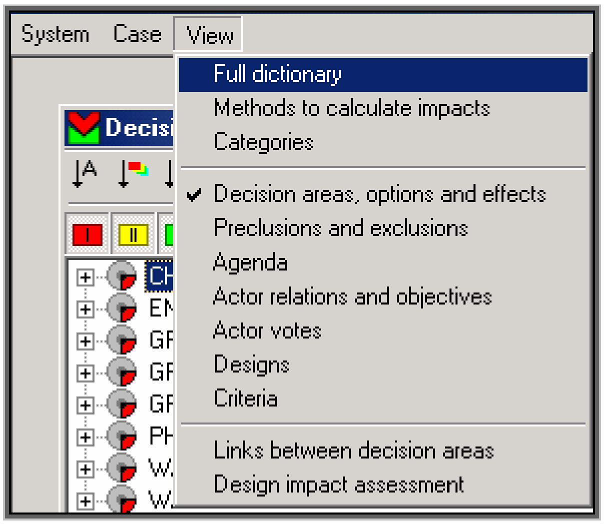
Figure 6.1: Case manager



6.4.2 Main menu

After a case has been chosen or added in the case manager, a number of submenu's can be chosen from the main menu when the roll-down menu 'view' is selected (see detail in figure 6.2).

Figure 6.2: Main menu



The following submenus are available:

- Full dictionary
- Methods to calculate impacts
- Categories
- Decision areas, options and effects
- Preclusions and exclusions
- Agenda
- Actor relationships and objectives
- Actor votes
- Designs
- Criteria
- Links between decision areas
- Design impact assessment

All these submenus will be briefly described in the following sub-sections.

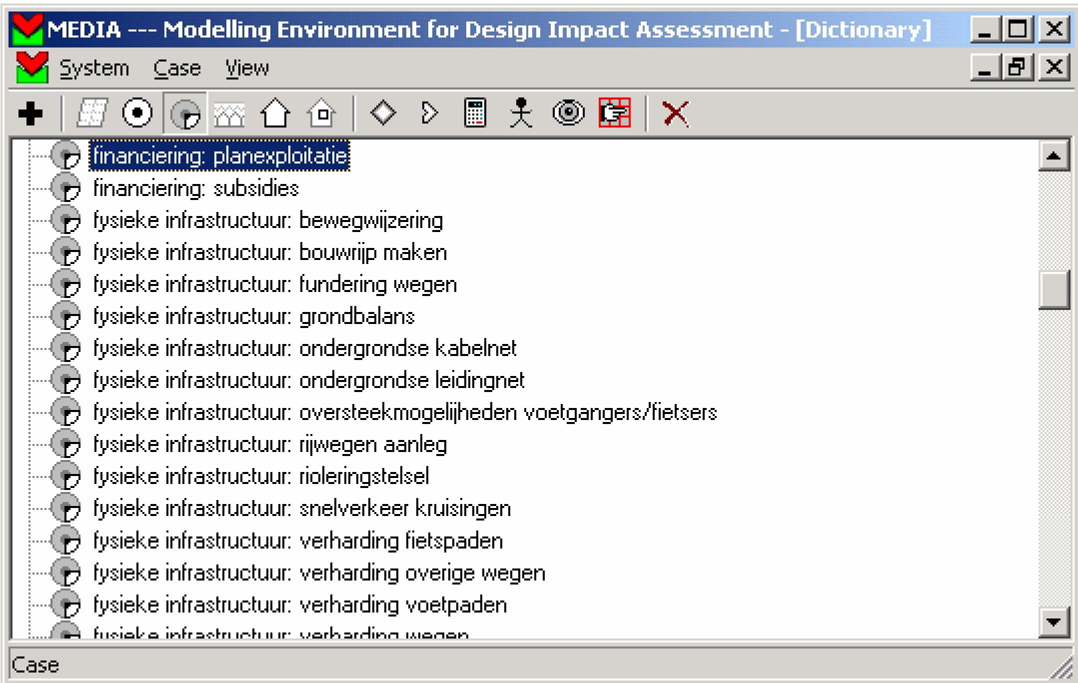
6.4.3 Full Dictionary

The dictionary is the most basic input-menu of MEDIA (figure 6.3). All objects of the model can be created or edited through this menu. Some other menus may also have limited input-functionality; objects defined in these other menus are automatically added to the dictionary. The dictionary is generic and not case specific, so objects added in one case can also be used in other cases.

The following objects can be added through the dictionary menu, by clicking ✚:

- Decision areas (at different spatial levels: region, city, quarter, block, building, room and also at different life cycle stage (indicated with colors): design, realization, utilization and demolition).
- Decision options.
- Variables (impacts).
- Functions or methods (not implemented).
- Actors.
- Visions (not implemented).
- Policy frame (not implemented).

Figure 6.3: Dictionary

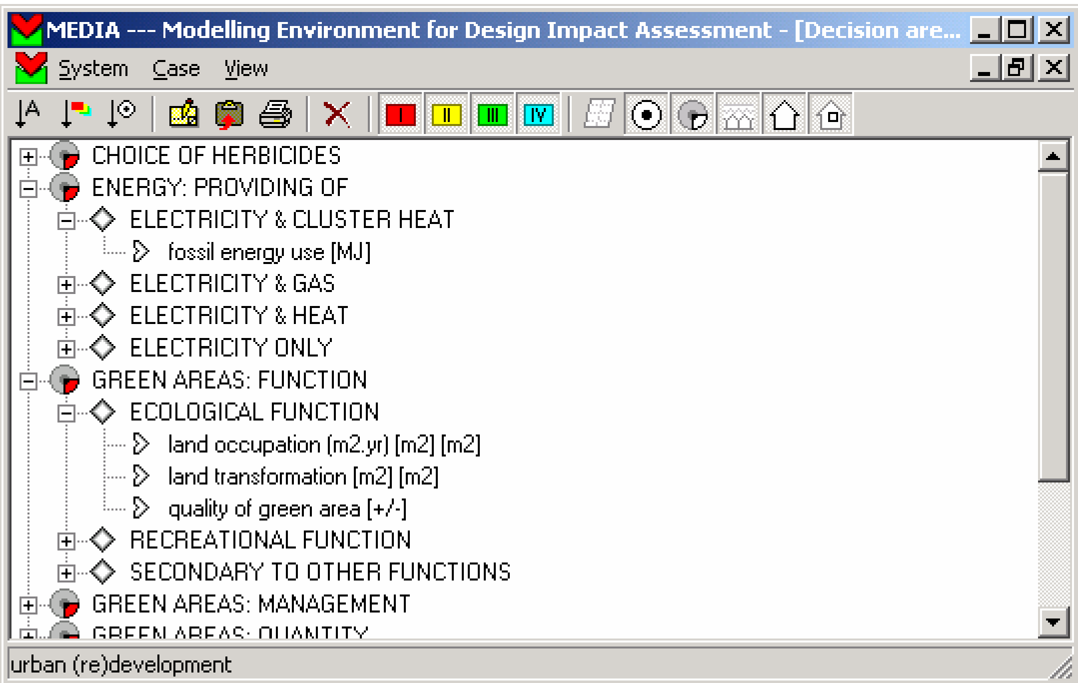


6.4.4 Decision areas, options and their effects

This is one of the most fundamental menus. It displays decision areas, options and variables in a hierarchical structure (figure 6.4). In this menu these objects can also be added by using the insert-key.
Besides basic sorting, reporting and print functions, decision areas can be added on several spatial levels: region, city, quarter, block, building, room. If a decision area is created a submenu pops up, asking the user to define the stage of the life cycle in which the decision area is relevant (the decision is made). There are 4 possible life cycle stages: design (red), construction (yellow), utilization (green) and demolition (blue). Decision areas are colored according to the life cycle stage.
When working on a case and adding and editing decision areas and options, the following rules must be observed:

- Decision areas must relate to logical and understandable decisions or coherent sets of decisions.
- The naming of decision areas must reflect the topic in a short, clear and unambiguous way.
- Decision options should exclude one another.
- Variables should be defined as descriptive as possible and at the appropriate level of aggregation.

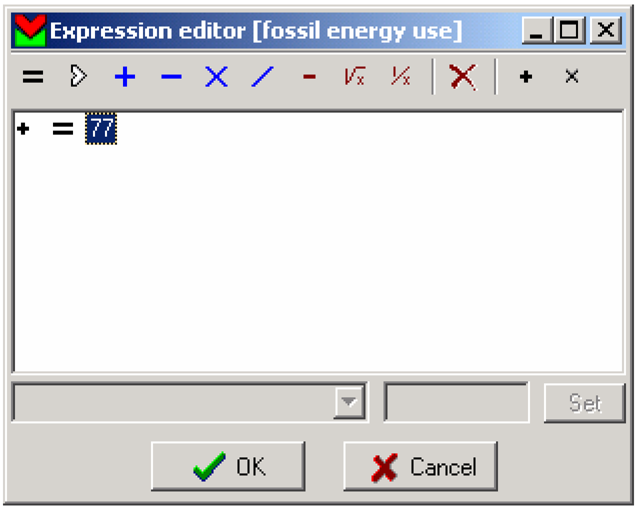
Figure 6.4: Decision areas, options and their effects



6.4.5 Expression editor

The expression editor, presented in figure 6.5 is a window which pops up when variables are double-clicked in the 'Decision areas, options and their effects' menu (section 6.4.4). Its main function is to add the value of the variable in question for the specific decision option. Furthermore simple mathematical functions can be attributed to variables. Variables can be made interdependent this way. An example is that the amount of dwellings in a quarter can be used as a multiplier for the impacts of sewage water processing. In practice, this function is hardly used, since it makes the model less transparent. In addition, the functions of the expression editor can conceptually also be executed by methods (section 6.4.13).

Figure 6.5: Expression editor

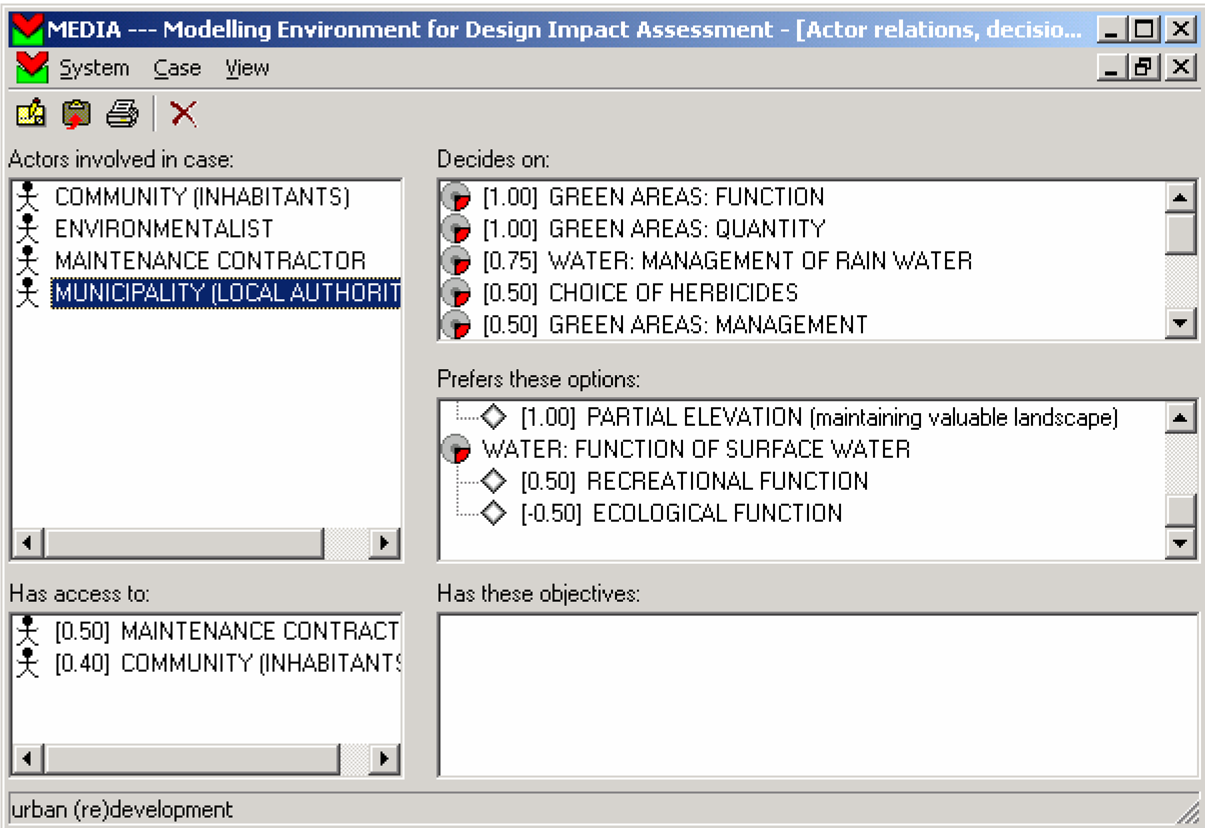


6.4.6 Actor relations, preferences and objectives

This menu, shown in figure 6.6, enables the user to define the relations between actors and decision areas and options. The following relations are possible:

- The decision power of an actor regarding the defined decision areas. The weight of the decision power can vary between 0 (no decision power) and 1.00 (total decision power). This means that 2 or more actors can share the decision power between them.
- The preferences of an actor for the defined decision options of each decision area. The weight of the preference can vary between -1.00 (absolute aversion) and 1.00 (absolute preference). It is also possible to leave this relationship blank, so it is not required to define a preference value for each option.
- The relationship between actors (access) can also be defined. Again the weight of this relationship can be defined, it can vary between 0.00 (no access) and 1.00 (total control over the actor).
- The last relationship that can be defined is the objective of the actor regarding specific goals. Theoretically and ideally, these objectives should be defined in terms of certain variables/indicators or functions of these, that are of significant importance for the project and have the appropriate level of aggregation. Because there are presently no values of variables defined in MEDIA, this function has not yet been utilized.

Figure 6.6: Actor relations, preferences and objectives

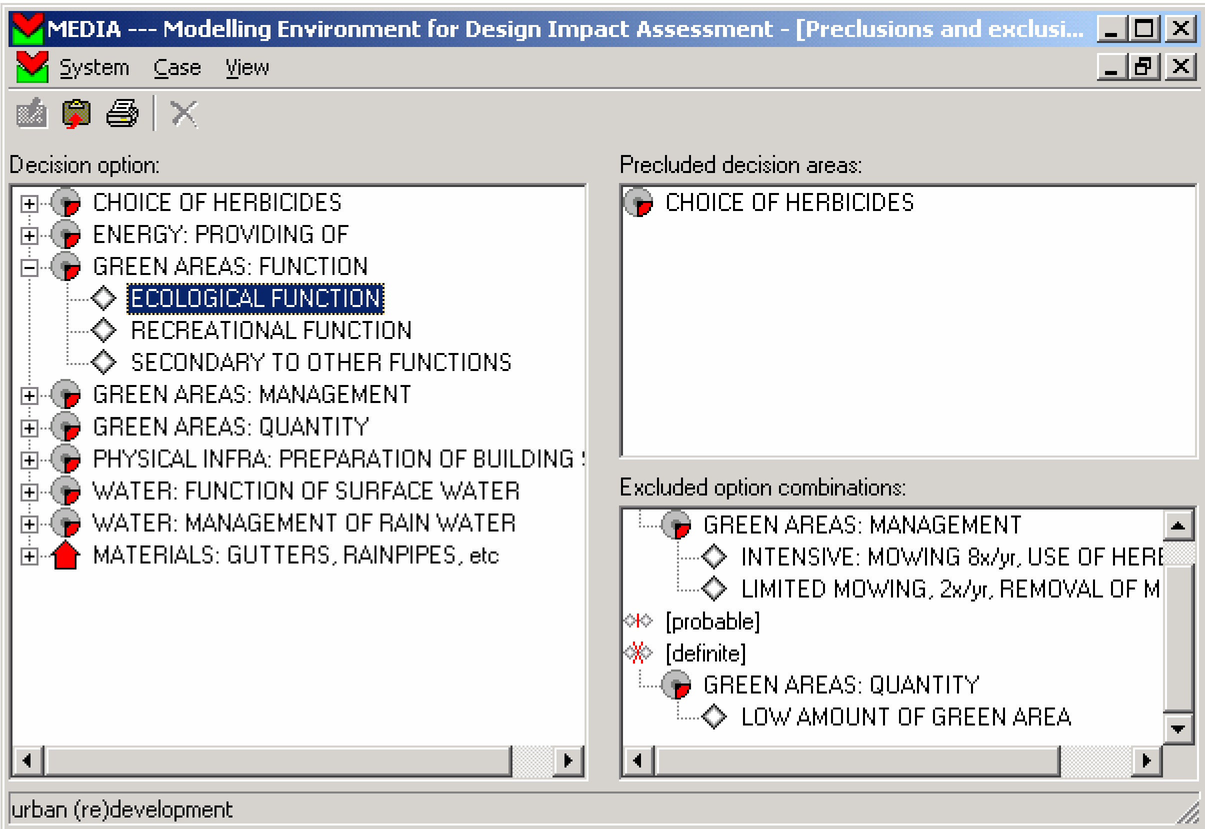


6.4.7 Decision areas, options and their pre- and exclusions

The Decision areas, options and their pre- and exclusions menu (figure 6.7) is one of the conceptually more important menus. In this menu the relationships between options on the one hand and decision areas or options on the other can be defined. The following relationships are possible:

- A specific decision option can preclude one or more other decision areas.
- Specific decision options can exclude one or more decision options in other decision areas. The weight of this exclusion can be defined as definite, probable or possible.

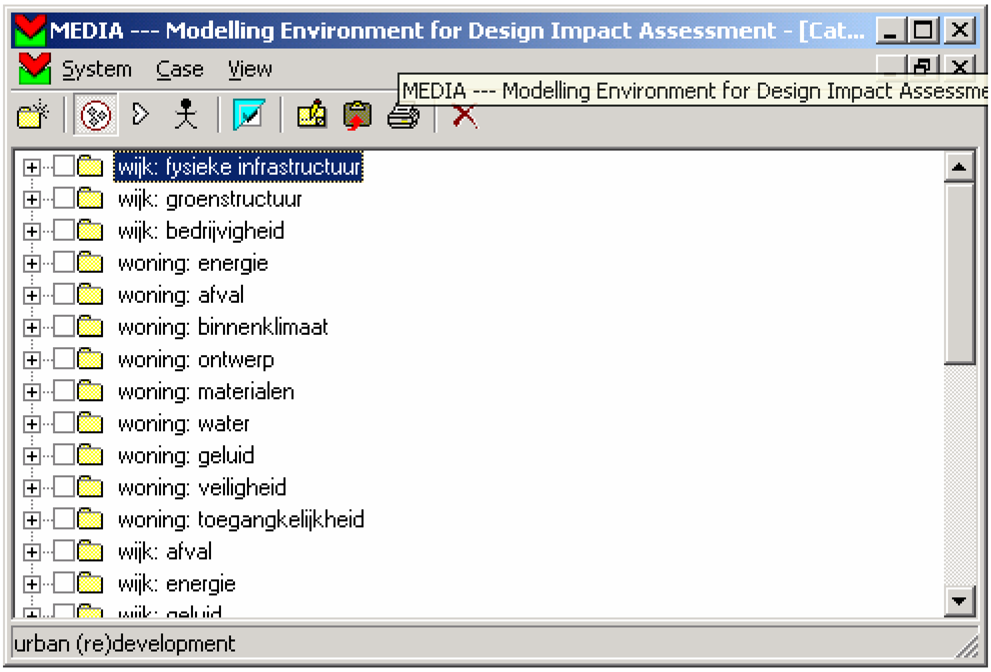
Figure 6.7: Decision areas, options and their pre- and exclusions



6.4.8 Category browser

The category browser, shown in figure 6.8, has no specific function, other then to categorize decision areas in a limited number of coherent categories of decision areas. Currently these categories are based on the specific topics or themes the decision areas are aimed at (e.g. water management, energy, mobility). Other categorizations are possible. Furthermore, the categories are used in the agenda function, which is described in section 6.3.8.

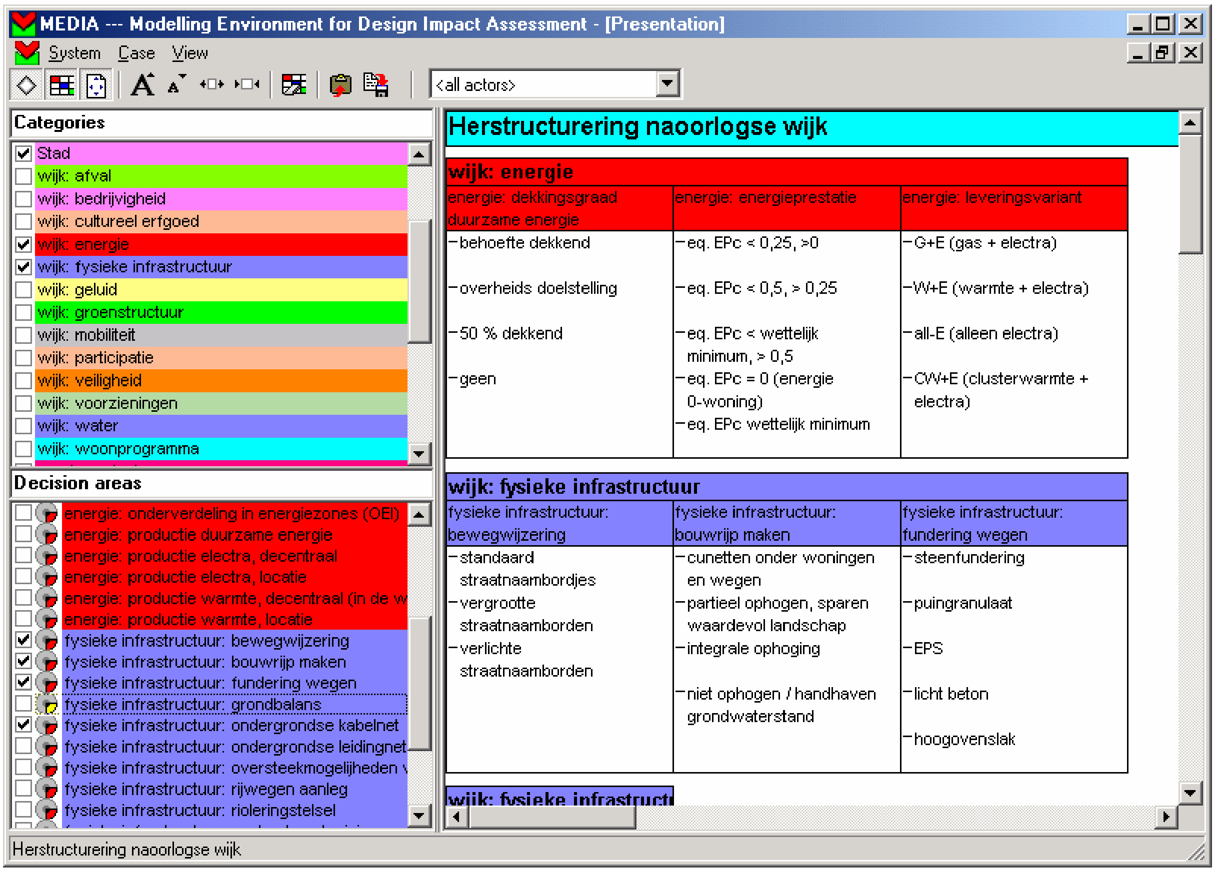
Figure 6.8: Category browser



6.4.9 Agenda

The agenda function, presented in figure 6.9, is developed for use in the simulation game. It is basically a function which enables the players in the simulation game to focus their attention on the most relevant categories and decision areas. The agenda works as follows: first the categories that are assumed to be relevant are selected in the top left menu. Consequently, the decision areas in this category appear in the down left menu. These can also be individually selected, which makes the decision areas and options visible in a table on the right side of the screen. If required, more information about a decision area can be displayed in a fact sheet, which pops up if a decision area is double clicked in the down left menu. In this fact sheet, information about the decision area self is showed, as well as the relationship with other areas and options (pre- and exclusions). Finally, the fact sheet displays information about the variables that are directly affected by the decision area.

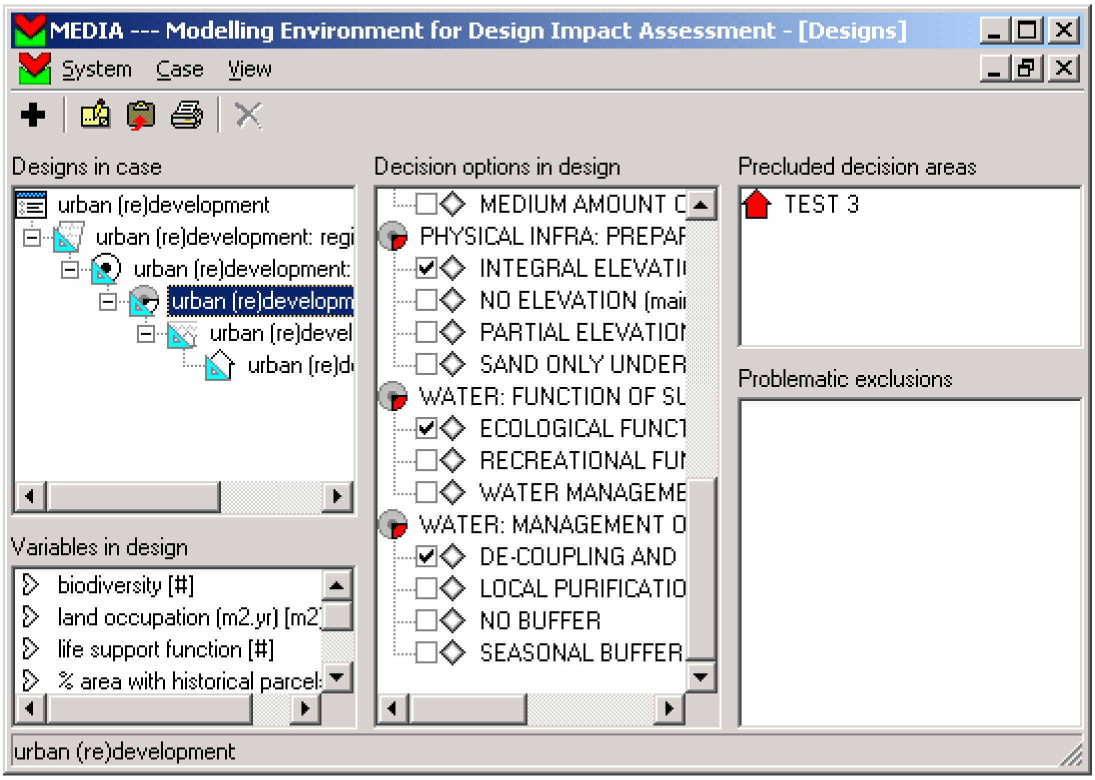
Figure 6.9: Agenda



6.4.10 Designs

The design function is a menu in which the generic decision areas and options are aggregated into an actual design (figure 6.10). A design is based on the spatial levels that have been distinguished earlier (region, city, quarter, block, and building). A design is constructed top down: first the options are selected for the higher spatial levels, followed by the lower spatial levels.

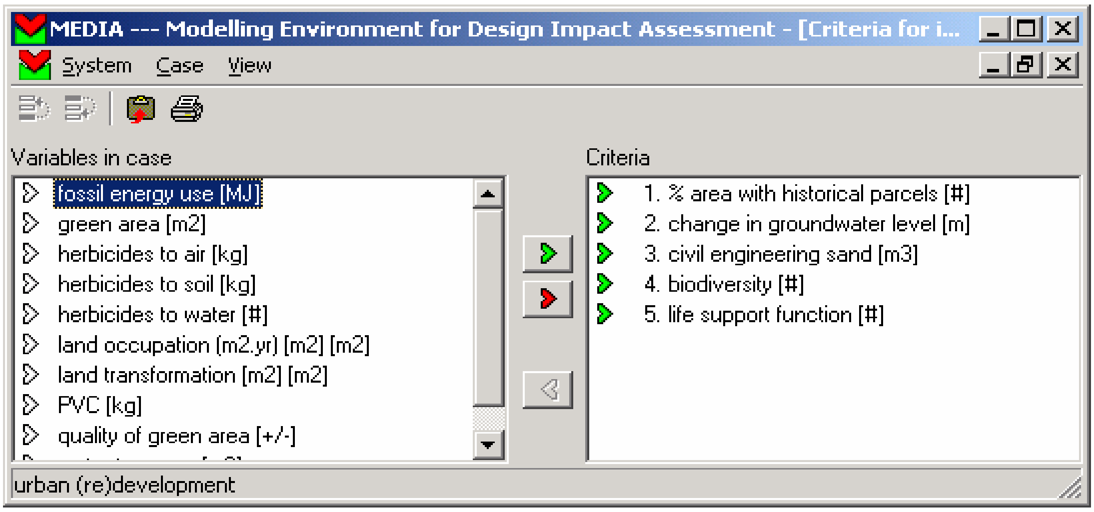
Figure 6.10: Designs



6.4.11 Criteria for impact assessment

In this menu, presented in figure 6.11, the variables are selected that are relevant for the actual impact assessment. Not all variables need to be relevant for a specific situation.

Figure 6.11: Criteria for impact assessment

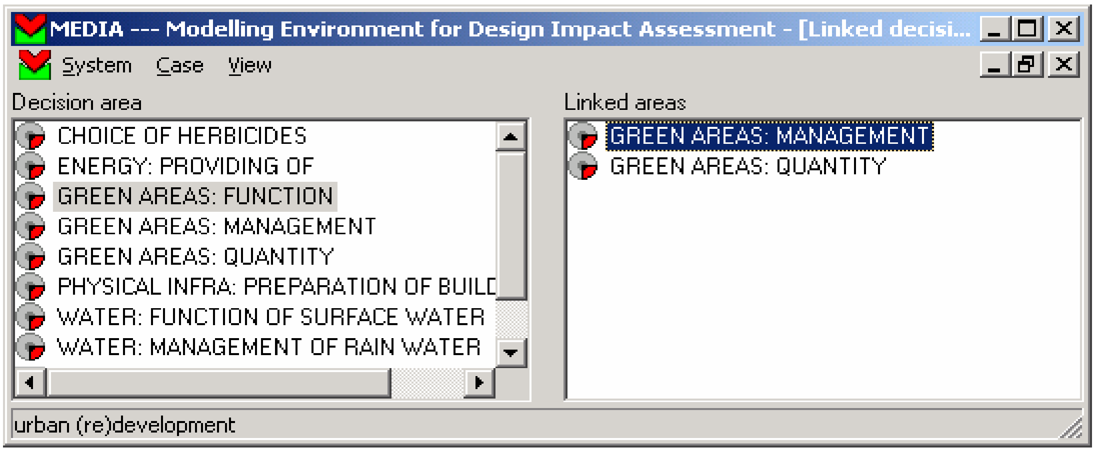


Since there are little data currently available in MEDIA, this menu has so far not been used in practice.

6.4.12 Linked decision areas

The linked area menu (figure 6.12) is primarily a visual menu, which allows the user to get a quick view of the degree to which the decision areas and options in a specific case are interlinked.

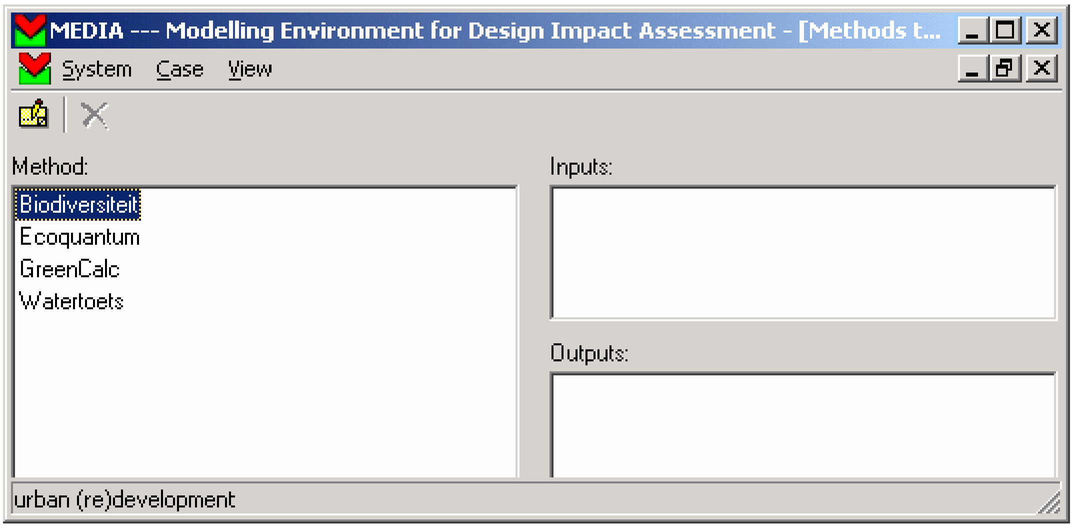
Figure 6.12: Linked decision areas



6.4.13 Methods for impact assessment

Methods are functions which perform certain, sometimes complex, calculations, using the variables of decision options as input. Currently this function is not operational, because of the lack of actual data (values of variables). For illustrative purposes, this menu is shown in figure 6.13.

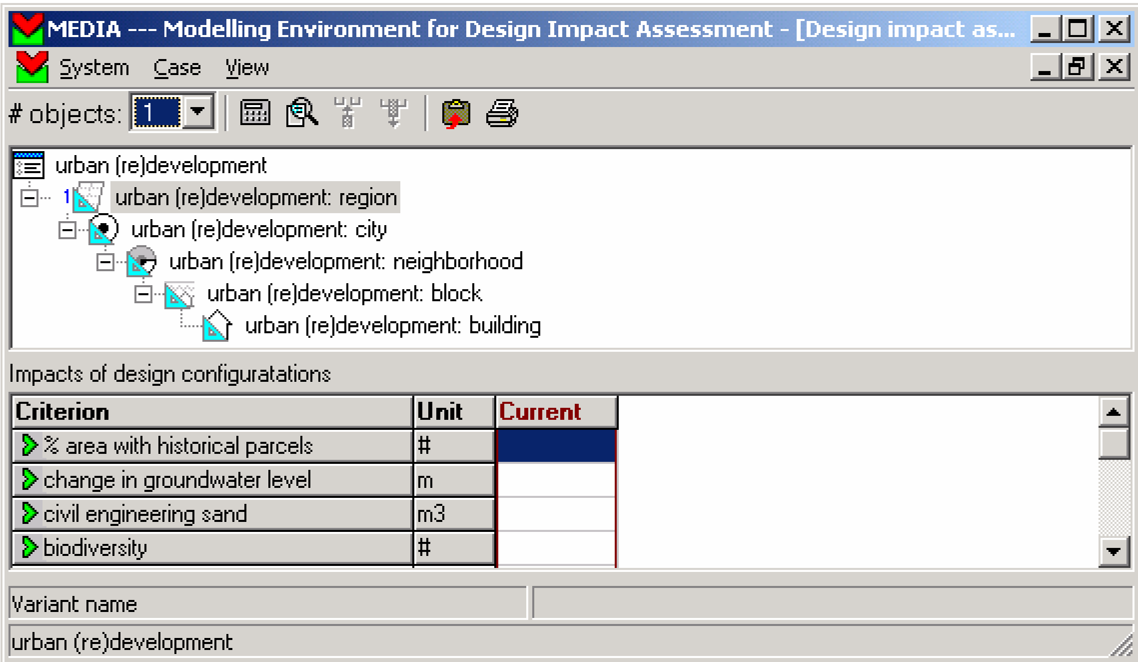
Figure 6.13: Methods for impact assessment



6.4.14 Design impact assessment

In this menu (figure 6.14), the criteria that are selected in the 'criteria for impact assessment' are calculated for the design which has been defined in the design menu. When several alternative designs have been defined, the impact table functions as a Goeller Scorecard (Miser & Quade[52], 1988, p386), showing the rank order of alternative designs for each criterion as a color range.

Figure 6.14: Design impact assessment



6.5 Practical experiences with MEDIA

6.5.1 Introduction

The database of MEDIA (MEDIAbase) is filled using actual cases. There is no generic database, which facilitates all sorts of projects or decision areas in the built environment. Different sorts of cases can be handled, such as the redevelopment of an old quarter, the development of a newly built quarter and the realization of a new rail infrastructure[i].

So far an urban redevelopment case has been worked out in detail. In section 6.5.2, the explicit and implicit rules that were used in constructing this case-study in MEDIA are presented and discussed. In 6.5.3 a summary is presented of the actual modeling efforts. In 6.5.4 the experiences of the project team members and simulation game participants with the rules are discussed. In 6.5.5 a short description is presented regarding the attempts to model an infrastructure case.

6.5.2 Rules

In the sections describing MEDIA, some of the more explicit rules to be applied when working with MEDIA have already been presented. However, in the practical work done on MEDIA, more (implicit) rules can be distinguished. The following set of instructions has been used in the work on the MEDIA-database:

1. Decision options should preferably be defined as discrete and concrete (physical) options.
2. Decision areas must have a significant probable impact on sustainability impacts to be included in MEDIA (only the most important and relevant decision areas).
3. For each decision area at least the most common decision options must be included.
4. Options must be mutually excluding.
5. Decision areas and –options must be defined at the appropriate (spatial) level. In practice this means the lowest spatial level possible.
6. Variables must be defined as descriptive as possible (as opposed to normative).
7. Professional terminology should be used in defining decision areas, -options and variables should, preferably the terminology of the most important decision-maker.
8. Relationships (exclusions and preclusions) must be determined by decision options.
9. Decision areas should not be directly aimed at certain sustainability issues.

It is observed that if the rules are applied incorrectly, inconsistent decision areas and-options, etcetera are produced. However if certain rules are consistently broken, this

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[i] Conceptually, the application of MEDIA is not limited to design challenges in the built environment. In theory, all sorts of policy problems can be handled.

might indicate that the rule is either wrong or impractical, or that it should be redefined at a higher order of organization.

6.5.3 Experiences of project-team members with rules.

1. Decision options should be discrete and concrete

This rule turned out to be very difficult to comply to. Among the project-team members there was a tendency to formulate more abstract decision areas. An example is related to public safety. Although physical decision areas, such as public lighting, presence of 'dead spots' and public visibility ultimately determine public safety, there was a need for a more abstract decision areas 'public safety' with decision options 'high priority' and 'average priority'. The reason for the need for such decision areas is probably that they are more in line with the early (programming) stages of projects. During these early stages, discussions are more about ambitions and goals then they are about the physical solutions (concrete options) for achieving them.

Although it is no problem to define such programming decision areas in MEDIA, there are a number of complications. Firstly there is a possible overlap between programming decision areas and the corresponding physical ones. In itself this is no problem. With the use of preclusions and exclusions this overlap can actually add to the functionality of MEDIA. By analyzing the relationships between programming decision areas and physical ones it becomes possible to get a quick picture of what physical measures are related to a certain ambition or goal. Typically programming type of decision options have relatively a lot of such relationships.

There is however a problem with respect to programming decision-areas and the use of variables. If the same variables are attributed to both programming options and physical options, double counting will be the result. This can be avoided by A) not attributing variables to programming options or B) using specific and different types of variables for programming- and physical decision options. Option B has some advantages. It is imaginable that for programming type decision options, less precise variables are used (e.g. estimates by a panel of experts), whilst for physical decision options more exact and physically determined variables are used (e.g. physical measurements). With these different types of variables, it would be possible to have information regarding decision options available much earlier in a project. In the beginning of a project this information would be based on estimated data, which could be replaced by more exact measurements as the projects progresses.

2. Decision areas must have a significant impact

This rule was applied with some flexibility. Sometimes decision areas have been formulated, of which the significance of the impact was not obvious. As more information became available, some of these decision areas were deleted later on. This way, the chance of omitting a decision area that does have a significant impact, is decreased. In addition, it is methodically not inconsistent to include some decision areas with insignificant impacts. It only decreases the manageability of the database somewhat.

Since the assessment of what is significant and what is not, is based on both the expert judgment of the specialist using MEDIA as the participants in a simulation game, the procedure described above assures the fact that all decision areas, considered as important, are included.

3. The most common decision options must be included
This rule apparently posed no problems to the project team members. An average level of expertise regarding decision options seems to be sufficient.

4. Options must be mutually excluding
This rule forces the user of MEDIA to define decision areas correctly and at the appropriate spatial level. For the project-team members this rule caused no problems, as there was enough time to redefine decision areas that did not comply with this rule.

5. Decision areas and –options must be defined at the appropriate level
This rule turned out to be more problematic then anticipated. For some decision areas (e.g.: some of the energy-related decision areas), there was a tendency to define the decision area and its options at too high a spatial level. Although this does not necessarily lead to inconsistent decision areas (where for instance the options are not mutually excluding), it makes the case less realistic and precise. This rule therefore deserves more attention in future cases. This tendency is also related with the tendency toward programming decision areas described earlier.

6. Variables must be defined as descriptive as possible
No completeness has been achieved in this area. No methodological problems have been encountered with respect to this rule. In most cases it is possible to define purely descriptive variables. However was a tendency to define more aggregated variables, which also is related to the tendency to define programming decision areas. As long as it is made clear for which type of decision area a variable is valid, this is not a problem.
Another problem related to variables is that it is not always clear which variables of a certain decision options are relevant for (aspects of) sustainable development. This may result in incompleteness regarding variables. To avoid this, variables should ideally be defined by, or in conjunction with, experts in the relevant decision areas and impact assessment experts.

7. Professional terminology should be used
This rule posed slight problems. The suitable professional terminology was not always known to the project –team members. Also some decision areas did not have concurrent terminology, because they were not used as such in practice. Altogether these are minor problems, that can easily be corrected as more cases are modeled and more simulation games are played.

8. Relationships must be determined by decision options
It was not possible to deviate from this rule, since MEDIA simply won't allow this. However with respect to relationships in general, the use of exclusions and preclusions alone was perceived to be a somewhat negative approach. The use of positive relationships was proposed in response. Positive relationships could possibly be related to scenario's (visions), for instance all the decision options that have a positive influence on the impacts of a certain low-mobility scenario. Other sorts of relationships related to other objects then scenarios are also imaginable.

6.5.4 Experiences of project-team members and simulation game participants.

Since not all rules are applicable to the participants of the simulation game, only the relevant rules will be discussed.

1. Decision options should be discrete and concrete
Is was observed during the simulations exercises that participants found it difficult to apply this rule stringently. Some of the proposed decision areas could be regarded as programming decision areas (see also section 6.5.3), but there also was a tendency towards non-discrete options. This usually was the result of defining a decision area at the wrong spatial level, and is therefore discussed further under rule 5. Furthermore a lot of the decision areas proposed by the game participants are related to organizational aspects (e.g. financing, management of green areas) aspects or social topics (e.g. participation, social cohesion). Although these type of decision areas may also be influenced by the physical space in a quarter (and vice versa), the effects are also primarily non-physical. Naturally, this doesn't imply that such decision areas are not relevant for sustainable development. The importance attached to these type of decision areas by game participants, was not reflected in the decision areas, included in the original MEDIA-database constructed by the project team members. This was caused because social and organizational aspects originally fell outside the scope of the Dubes project (not for methodological or principal reasons, but for pragmatic managerial reasons). Based on the experiences of the simulation games, the scope of the project was expanded to these issues.

4. Options must be mutually excluding
Relatively a lot of decision areas defined by simulation game participants contained options that were not mutually excluding. An example is the decision area 'traffic safety in quarter' with options such as 'traffic lights', '30 km zones' and 'narrowing of roads'. These options are not mutually excluding. The reason why such decision areas are defined is that not enough consideration was given to the spatial level of a decision area. For instance the issue of traffic safety should not be defined at the spatial level 'quarter', but at a lower spatial level. As is discussed under rule 5, the correct selection of the spatial level is not always self-explanatory.

5. Decision areas and –options must be defined at the appropriate (spatial) level
Under rule 4 it is already put forward that participants often make mistakes regarding the spatial level of a decision area. This is not the 'fault' of the participants alone. Since the spatial levels incorporated in MEDIA are aimed mostly at the 'living' functions, it is sometimes difficult to define decision areas which are about other functions, such as traffic safety, infrastructure or water management. This issue should be given attention in future development of MEDIA.

6.5.5 Urban redevelopment of a typical Dutch post-war quarter

Sustainable urban redevelopment was one of the primary motivations for developing the model and the simulation game. Therefore this type of assignment has been the focal point in the work performed with MEDIA. More specifically, MEDIA has been used to model the redevelopment of a typical post-war Dutch quarter, with relatively a lot of high-rise apartment buildings.

Categories, decision areas and options
The result of this exercise are as follows: Altogether about 200 decision areas have been distinguished, typically with 3 or 4 decision options (sometimes less or more). Most decision areas relate to the quarter and building-level. The spatial level 'block' is used little, whilst the 'city' and 'room' levels are not used at all. The decision areas are categorized into 30 categories. These figures are summarized in table 6.1.

Table 6.1: Overview of categories and decision areas in an urban redevelopment case

Spatial level	Categories of decision areas	Number of decision areas in category
Region	-	-
City	-	-
Quarter	physical infrastructure functional program water facilities mobility energy green areas security/safety participation waste cultural heritage commercial activity funding & finance noise	16 16 11 10 10 9 8 7 7 6 4 4 2 1
Block	functional program	5

	mobility social safety management cultural heritage	4 3 2 1
Building	materials design energy interior climate admission water infra noise security waste cultural heritage	26 20 6 5 3 3 3 3 2 2 1
Room	-	-

In defining the decision fields, we used the expert knowledge of the members of the DuBes project team, summaries of checklists, and other summaries of decisions with regard to sustainability. Examples of the latter are the Nationale Pakketten Duurzaam Bouwen voor Woningbouw (SBR, Rotterdam 1996), Utiliteitsbouw (SBR, Rotterdam 1998), Grond-, Weg en Waterbouw (CROW, Ede 1999) and Stedenbouw (Nationaal Dubo Centrum, Utrecht 1999), KODUP (Kosten Duurzame Uitbreidingsplannen, VNG, Den Haag 1997[53]) and the DCBA-kwartet (BOOM, Delft 2000). Documentation for existing design tasks have also been used, such as those for the restructuring of Emmerhout-Noord and the Noord-Brabant sand embankment case.

Variables

In addition to defining categories, decision areas and options, variables have been attributed to most of the decision options. This has not been done consistently for all options however, since the aim of this exercise was primarily to see whether this could be done. In the current database, about 150 types of variables have been defined. There is however a lot of redundancy between variables, because of the experimental nature of the 'variable exercise'.

Preclusions and exclusions

More consistency and completeness was achieved in the definition of preclusions and exclusions. A total of 438 of preclusions and exclusions have been distinguished, mostly exclusions.

Actors and their relationships

Not a lot of effort has been put in this area, because of the very case-specific character of this relationship.

In appendix 1, a print-out of the urban redevelopment case has been included (in Dutch).

6.5.6 Linear infrastructure

The Dubes project is part of the Delft Cluster. This program is primarily aimed at infrastructural projects. For this reason, an attempt has been made to apply MEDIA on infrastructural projects, such as road and rail networks.
Based on several reports on sustainable development in relation to infrastructure (CUR, 1999[54], CROW, 1999) a number of decision areas and –options have been identified. The most important observations are presented below:

- Decision areas regarding materials, constructions and to a certain degree designs could be modeled in MEDIA without problems.
- It proved to be rather difficult to define generic decision areas and options for decisions regarding spatial aspects of a plan, since a lot of such decisions have strong location-specific elements (e.g. geography, soil, hydrology, type of area)[ii]. Naturally this would be possible in an actual case (project).
- Decision areas regarding the functions of infrastructure are entirely dependant of the situation. Therefore these kinds of decisions can not be modeled in the current version of MEDIA.
- Many of the variables associated with decision options are also dependant on the location (e.g. the impacts of a road trough an urban area are entirely different compared to the impacts of the same road in a nature reservation).

The general impression of the infrastructure-exercise is that, for application in infrastructural projects, the current version of MEDIA lacks geographical components, such as maps and charts. An overview of the decision areas and options defined for infrastructural projects is presented in the next box.

[ii] The same observation is, to a lesser degree, valid for the urban redevelopment case.

Box 6.1: Infrastructure case

- ① aantasting archeologische waarden
  - ◆ beperken
  - ◆ geen aandacht
  - ◆ vermijden
- ① aantasting cult.historische waarden
  - ◆ beperken
  - ◆ geen aandacht
  - ◆ vermijden
- ① aantasting geomorfologie
  - ◆ beperken
  - ◆ geen aandacht
  - ◆ vermijden
- ① aantasting schaalniveau landschap
  - ◆ beperken
  - ◆ geen aandacht
  - ◆ vermijden
- ① autosnelweg: aantal rijstroken
  - ◆ 2 x 2
  - ◆ 2 x 3
  - ◆ 2 x 4
- ① autoweg: aantal rijstroken
  - ◆ 1 x 2
  - ◆ 2 x 2
- ① bodemtype
  - ◆ klei
  - ◆ veen
  - ◆ zand
- ① geluidsbelasting
  - ◆ hoog
  - ◆ laag
  - ◆ middel
- ① spoor: aantal sporen
  - ◆ 4 sporen
  - ◆ dubbelspoor
  - ◆ enkelspoor
- ① wijze van aanleg
  - ◆ cut & cover
  - ◆ geboord
  - ◆ op dijk
  - ◆ op maaiveld
  - ◆ Verdiept
- ① afschot weg
  - ◆ dakprofiel
  - ◆ op 1 oor
  - ◆ tonrond
- ① afwatering weg
  - ◆ afvoer naar grondwater via Wadi
  - ◆ afvoer naar opp.water via helofytenfilters
  - ◆ afvoer naar riool
  - ◆ infiltratie in berm
  - ◆ infiltratie via 'lekke' sloten
  - ◆ infiltratrie naar grondwater via const.
  - ◆ oppervlakteverzameling
- ① beperking aant archeologische waarden
  - ◆ archeologisch veldonderzoek
  - ◆ opgraving en conservering archeologische vondsten
  - ◆ vermijden van ingravingen
  - ◆ waarderend archeologisch onderzoek
- ① oversteekmog.heden groot wild
  - ◆ geen oversteekmogelijkheid
- ① bermbeheer
  - ◆ ecologisch bermbeheer
  - ◆ traditioneel bermbeheer
- ① berminrichting: helling talud
- ① berminrichting: versteviging
- ① bodembeschermende maatregelen
  - ◆ afdekfolie
  - ◆ bentoniet scherm
  - ◆ drainage systeem
  - ◆ verhoogde aanleg
- ① energie uit wegdek
  - ◆ geen energie uit wegdek
  - ◆ warmtepomp warmte/koude opslag
- ① fundering autoweg
  - ◆ gestabiliseerd zandbed
  - ◆ steenfundering
  - ◆ zandbed
- ① fundering snelweg
  - ◆ AGRAC
  - ◆ AVI-slak
  - ◆ gestabiliseerd zandbed
  - ◆ puingranulaat
  - ◆ steenfundering
  - ◆ zandbed
- ① geleiderail
  - ◆ houten rail
  - ◆ kunsstof rail
  - ◆ staal duplex
  - ◆ staal gealuminiseerd
  - ◆ staal poedercoating
  - ◆ verzinkt staal (traditioneel)
- ① geluidswallen/schermen
  - ◆ aarden wal
  - ◆ scherm aluminium
  - ◆ scherm beton
  - ◆ scherm beton + PV-paneel
  - ◆ scherm hout
- ① gladheidbestrijding
  - ◆ beperkt strooien (monitoren)
  - ◆ traditioneel
  - ◆ wegverwarming
- ① onderhoud provinciale weg, 10jr
  - ◆ frezen 100mm, STAB, micro
  - ◆ frezen 100mm, STAB, ZOAB
  - ◆ frezen 200mm, CB, ZOAB
  - ◆ frezen 275mm, STAB, STAB, micro
  - ◆ frezen 40mm, remix, SMA
- ① onderhoud provinciale weg, 20jr
  - ◆ frezen 100mm, STAB, micropave
  - ◆ frezen 100mm, STAB, ZOAB
  - ◆ frezen 200mm, CB, ZOAB
  - ◆ frezen 275mm, STAB, STAB, micro
  - ◆ frezen 40mm, remix, SMA
- ① onderhoud provinciale weg, 40jr
  - ◆ frezen 100mm, STAB, micropave
  - ◆ frezen 100mm, STAB, ZOAB
  - ◆ frezen 200mm, CB, ZOAB
  - ◆ frezen 275mm, STAB, STAB, micro
  - ◆ frezen 40mm, remix, SMA
- ① oversteekmogelijkheden kleine fauna
  - ◆ geen
  - ◆ wildtunnel
- ① type toplaag wegdek
  - ◆ beton
  - ◆ dubbellaags ZOAB
  - ◆ klinkers
  - ◆ microdeklaag
  - ◆ SMA
  - ◆ ZOAB
- ① veiligheid 'ontsporen'
- ① verlichting
  - ◆ energiezuinige verlichting
  - ◆ geen
- ① wegconstructie snelweg
  - ◆ asfaltconstructie
  - ◆ cementbeton constructie

6.6 Conclusions regarding MEDIA

- We have succeeded on a conceptual level to integrate solutions for dealing with policy complexity, the equivocal character of sustainable development and design complexity in large building projects in MEDIA.
- Both the use of physical decision areas as the use of goal setting or programming decision areas has turned out to be both possible and useful, the first type representing a bottom up approach and the second a top down approach.
- The main potential advantages of using MEDIA are its multiple integrative qualities. MEDIA integrates: different sustainability issues, different spatial levels in design challenges, different solutions for decision areas, different stages in design processes, different actor preferences en ambitions
- MEDIA is suitable mainly for generic decisions on different spatial levels. Decisions that are very site specific or that are mainly about spatial aspects of a plan are not supported adequately (yet?)
- For making quantitative assessments MEDIA is dependant on adequate quantitative data. A lot of data that currently is available isn't directly suitable for use in MEDIA. Also data about decisions on higher spatial levels is often lacking. Some data may also be suitable, but not available for propriety reasons. The actual 'filling' of MEDIA with data is therefore one of the main areas of attention for the future.
- Even without actual quantitative data regarding certain variables, MEDIA has proven to be useful, by making decision making, design processes and the possible impacts more transparent.
- The use of MEDIA in simulation games has resulted in a shift towards a more communicative character of the tool, as opposed to an analytical / evaluative character.
- So far we see two main applications for MEDIA in the future: a supportive tool in simulation games and an analytical tool to be used by researchers
- MEDIA is susceptible for strategic (mis)use by actors, should these have disproportionate advantages regarding knowledge, decision power, etc.
- MEDIA supports agenda-setting, by which it identifies the information requirements of the actors. This means that discussions can be focused on the most relevant issues.
- The use of MEDIA in a simulation game has proven to be feasible. However currently there are not enough constraints (e.g. financial, space) built into MEDIA.

7 THE DUBES SIMULATION GAME

7.1 Introduction

The Sustainable Decision Making Project concerns the promotion of sustainable development in large building assignments projects. In cooperation with TNO Bouw (TNO Building and Construction Research) and PRC Bouwcentrum, the TU Delft has developed a DuBes method that assists the parties involved to reduce the complexity of sustainable design tasks to manageable proportions. This method is assisted by a computer model - MEDIA - and the DuBes simulation game. The simulation game revolves around the restructuring of an existing or fictional post-1945 residential neighborhood. The respective municipalities and housing associations of Emmen and Alphen aan den Rijn in the Netherlands were the first to gain experience of the DuBes method by participating in the DuBes simulation game. The evaluations show that the participants have formed a positive opinion of the process and the pertinent results (Aarninkhof, 2002[55]; van Bueren, 2002[56]).

7.2 The complexity of sustainable restructuring

Sustainable development is one of those magical concepts that everyone is in favor of (Hajer, 1995). However, as soon as sustainable development has to be realized, it proves difficult to put the concept into practice. In the urban environment, too, where there are many opportunities for the promotion of sustainability, it proves no simple matter to translate these opportunities into sustainable benefits.
In themselves, the lessons for a sustainable built environment are clear. In sustainable development, the entire life cycle of a construction project should be taken into consideration. Management, maintenance, the demolition of houses and flats (if applicable) and the recycling of materials are important stages in the sustainable design of a neighborhood or the residential unit (Hendriks, 2001[57]). In addition to the time dimension, the spatial dimension is important. The urban environment consists of various spatial levels of scale, such as the neighborhood, the building block and the home, each of which can make a contribution to sustainability (Duijvestein, 1990[58]). Integration and optimization of the design in terms of the various dimensions is a precondition for a sustainable design. On the other hand, a third structural element of a sustainable plan consists of the people who design, realize and use the plan: the actors (Tjallingii, 1996). Technology can be seen as a fourth factor important to the realization of sustainable development (Weaver et al., 2000[59]).

However, in practice it proves difficult to apply these lessons for sustainable building. In Europe, these lessons will need to be applied in future years primarily to the restructuring of existing urban areas. In particular, the peripheral residential neighborhoods that were built in the years following the Second World War are of poor quality and are afflicted by a combination of physical and socio-economic problems (European Commission, 1996:6). For example, Europe has eighty thousand blocks of flats that are in dire need of refurbishment (Eriksson and Dekker, 2000). The making of a sustainable design for the restructuring of such neighborhoods is a very complex task, due to 1) the complexity of the urban system, 2) the political and administrative complexity and 3) the complexity of the concept of sustainable development.

The complexity of the urban system
Urban systems are extremely complicated and consist of many interdependent physical and social variables, such as the number of homes and roads and also the behavior of the residents in their homes and neighborhoods (Tjallingii, 1996). It is difficult to make a design for sustainable restructuring because the effects of changes are difficult to predict. For example, in a restructuring project an increase in the housing differentiation may have an influence not only on the social structure of the neighborhood but also on such matters as the movement behavior of the residents, energy consumption and the quantity of household waste produced.

The political and administrative complexity
Numerous parties, with diverse interests and various forms of expertise, are involved in a restructuring project (Spaans, 2000, Van der Waals, 2001). For example, in the design stage it will involve municipal services for building, housing, traffic and the environment, housing associations, project developers, residents, intermediary organizations, water and energy providers, water boards, construction companies, architects and town planners. Each of these organizations and professionals make decisions at various moments based on their own preferences and interests (Bremer and Kok, 2000, Van Bueren and Priemus, 2002). The production of a design specification or a program of requirements takes place in a very politicized environment. The dynamics of political events, such as disputes within a council or board, the resignation of an executive member of the local council, or elections, can often cause a restructuring process to progress by fits and starts (Teisman, 1995). A matter that seems, at a given moment, to have been resolved may subsequently come up for discussion again.

Complexity of the concept of sustainable development
If all the parties involved wish to realize a sustainable restructuring project, the trick is to bring together the rationality of the design process, the making of design choices for the restructuring of the urban system, political and administrative rationality, and the acquisition of sufficient political and public support. Another problem here, however, is that the concept of 'sustainability' is far from unambiguous (Dryzek, 1997, Hajer, 1992, Roe, 1998). The concept of sustainability is a flag that various values rally behind: such values as 'quality of life' and 'safety', but also environmental values such as energy efficiency or emissions. These different values sometimes prove difficult to unite. For example, extensive insulation measures can negatively influence the indoor climate of a home, or a windmill parks can be perceived as a source of sustainable energy or as a blot on the landscape.

7.3 The management of sustainable restructuring: The DuBes philosophy

The management of a neighborhood restructuring process is difficult because it is frequently unclear what sustainability precisely conveys to the various parties involved or how sustainability can be achieved. It is very important to have a good interaction between residents, experts and administrators over the broad range of decisions concerning sustainability (Conte and Monno, 2001[60]). However, because of the differences in knowledge, interests and values it is difficult to bring about and manage a constructive dialogue between the numerous parties. Consultation meetings, for example, are often characterized by a fairly one-sided and superficial venting of wishes and standpoints at a time when the plans have already reached an advanced stage (Mayer, 1997[61]).

In what way is it possible to get an orienting dialogue about sustainable restructuring at a very early stage between all those involved? Such a process must be open to differing perspectives on sustainability. It must be able to put new ideas and technologies on the local agenda, produce useful results for a program of requirements and be robust enough for the political and social decision-making process.

The DuBes Sustainable Decision Making Project takes this vision as its basis to focus on giving practical assistance in the taking of sustainable decisions regarding a (re)construction project. The DuBes method is based on the following objectives:

Assistance in the early stage
The DuBes method and tools are primarily applicable at an early stage of restructuring, in particular for drawing up a sustainable program of requirements.

Interactive and participatory
The DuBes method and tools are appropriate for bringing about the debate and cooperation between parties involved who have varying degrees of expertise, types of expertise, responsibilities, views on sustainability and interests.

Agenda creation and selection
In the DuBes method and simulation game, decision fields and options are put on the agenda and subsequently processed into various strategies for a sustainable program of requirements. The parties involved draw up a common agenda that gives an overview of all the relevant subjects, ideas, wishes and choices that have come up. In this, they are helped by an agenda example from DuBes; this acts as a frame of reference.

Learning and experimenting
In the DuBes simulation game, the parties involved learn how to use the DuBes method. The same procedures and tools can also be used for a real restructuring project. Managers of a restructuring project can therefore familiarize themselves with

the method in a safe environment and try it out, before applying the method and tools in their own way in a real project.

7.4 MEDIA, a decision-making model

The DuBes model helps those involved in a (re)construction project - such as managers, contractors, financiers, interest groups and future residents - to gain an insight into the various considerations, choices and opportunities for sustainability in a restructuring project. The model aims primarily at assisting in the making of sustainable decisions. A prototype of the DuBes-Model was constructed in the MEDIA computer program. This stands for Modeling Environment for Design Impact Assessment. The model is based on AIDA (Analysis for Interrelated Decision Areas) design principles (Morgan, 1971). This model consists of the following components.

Themes.
Themes are clusters of decision fields, such as energy, green space and physical infrastructure. The prototype of MEDIA contains the various themes (about 30) that are important to design tasks in the urban environment. These themes were defined by the members of the DuBes project team, taking account of formulations as they are frequently used in practice. Examples of themes are green space, waste, mobility, facilities and social safety. The themes are grouped according to three levels of spatial scale: the neighborhood, the block and the home.

Decision fields.
A decision field is the general designation for all kinds of decisions that have to be made in a design task, for example on provisions for waste collection and parking. With each decision field, one can choose from several options. Examples of decision fields under the theme of mobility at neighborhood level are: the structure and frequency of public transport, the infrastructure for non-motorized transport, the type of access to and from the neighborhood, the parking standard and the location of parking facilities. The MEDIA prototype contains an overview of a large number of decision fields (about 150) that may be involved in a design task.

Options.
Options are the alternatives from which one can choose in each decision field. For example, parking facilities may be centralized or decentralized, above ground or underground, nearby or at a distance. The MEDIA prototype contains three to six options for each decision field.

Effects of options.
Options have various effects, for example on costs and on sustainability. For example, the creation of parking facilities has an effect on the use of materials, on the possibilities for rainwater infiltration, on the soil balance, on car use (and therefore on the use of fossil fuels and the emission of CO_2 and other substances), on social

safety, on the accessibility of a neighborhood or street, and so on and so forth. The MEDIA prototype only contains effects to a limited extent, usually qualitative in nature. The calculation of effects is the goal of new versions of MEDIA.

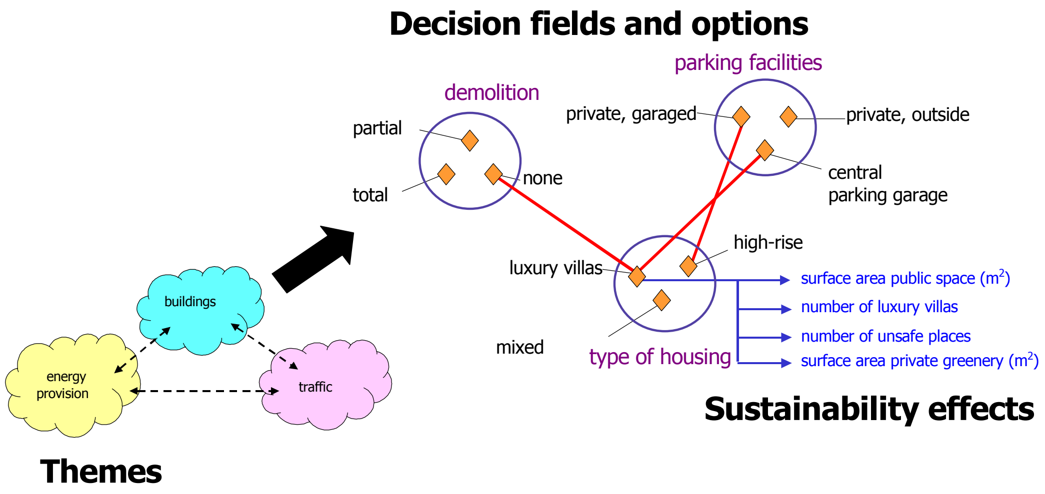
Methods.
Various methods exist to picture the effects of options, such as life cycle analysis (LCA) and life cycle costing (LCC) methods. The MEDIA prototype offers the possibility to refer to these methods and, if applicable, to link these to MEDIA. However, in this respect too, MEDIA is still in need of further development.

Relationships between options.
Options from different decision fields may be mutually exclusive or they may actually imply one another. For example, the choice for a certain form of energy infrastructure partly depends on the housing density and the type of dwellings. For a large number of options, the MEDIA prototype indicates whether they are interrelated and, if so, how.

Actors and their preferences.
For every decision, certain actors are involved. MEDIA offers the possibility to indicate which actors are involved in the decision fields. In addition, actors often have a preference for certain options. MEDIA also offers the possibility to indicate the preferences of the various actors.

With the aforementioned structural elements, the DuBes model offers those involved in a design task an insight into the choices, the interdependencies between the choices, and the parties who are involved in these. Figure 1 illustrates this relationship. The model also devotes attention to the consequences of the various choices for sustainability.

Figure 7.1: Sustainable decision-making: a connection between decision fields, options, effects and relationships between options.



7.5 The DuBes simulation game

At the same time as the Sustainable Decision Making Model was developed, a simulation game was developed in which the potential users are familiarized with the structure and way of thinking of sustainable decision making. The DuBes simulation game is described below.

7.5.1 Simulation games in general

A simulation game provides a safe environment, based on reality, in which the participants can experiment with decisions and negotiations (Duke 1974[62] & 1980[63]; de Caluwé et al. 1996[64]; de Jong and Mayer 2000[65]; Mastik 2002[66]). The participants in a simulation game play various 'roles' that are derived from existing organizations and individuals. As in reality, the participants make decisions, form coalitions and make compromises based on their own goals and interests. A simulation game can be seen as reality reduced to one day (or a few) in a single room. Processes that take months or years in reality, such as drawing up a program of requirements, can be completed in a few hours in a simulation game. A simulation is not primarily intended as a 'game' but rather as a serious, policy-oriented study, and is therefore also designated as a policy exercise (Toth 1988[67]). Apart from being instructive, participation in a simulation game is simply enjoyable.
In a closed simulation game, the message or learning experience for the participants is pre-built into the game. In that case, the simulation game may be intended to teach the players a certain way of dealing with things, for example in connection with education and training. In an open simulation, the message or learning experience is much less clearly built-in in advance. The players, the designers and the client

discover together, via the simulation game, how 'the system' works or could develop in the future, when the relevant actors demonstrate their own repertoire of actions as much as possible. The simulation game approximates to a complex reality, and the participants are invited to act out their true role as closely as possible. In open simulation games, too, there are game rules, role descriptions and game procedures, but a significant proportion of the interactions is determined by the implicit knowledge and information that the participants bring into the game from reality.

7.5.2 Fictional or real assignment

In its present form, the DuBes simulation game can simulate a fictional neighborhood or a real restructuring assignment. The method and the tools, however, are generic, so that the same simulation can be used, with a little adaptation for other projects, such as new construction projects or the development of a sustainable business park. When the simulation game is played using the fictional restructuring case, one can experiment with the DuBes method without direct interests being involved. In that case, it is primarily an instructive means of exercising and training restructuring managers in the DuBes method, but the concrete results are open-ended. When the simulation game is used for the further development of a real restructuring assignment, the participants in the DuBes simulation achieve useful ideas and results for the real program of requirements. It is important to realize that the real decisions can never be made in the DuBes (game) simulation.

7.5.3 Groenveld

The following describes the simulation game for the fictional neighborhood of Groenveld in the municipality of Dijkhuizen. Groenveld is an average post-1945 residential neighborhood in a medium-sized town in the Netherlands. The neighborhood has a lot of multi-storey subsidized housing, interspersed with family dwellings and concentrated facilities. Figure 7.2 gives an impression of the neighborhood. Like so many neighborhoods of this type, Groenveld has to deal with the problems of vacant dwellings, alienation, poor maintenance, loitering teenagers, vandalism etc. The neighborhood is therefore in urgent need of improvement. Because there is a good chance of getting finance from the Investment Budget for Urban Renewal (Investeringsbudget Stedelijke Vernieuwing, hereinafter abbreviated to ISV), the participants are asked to produce, in one day, a program of requirements for the restructuring of Groenveld. However, there is an important condition attached to eligibility for ISV financing: the plans must make a clear contribution to the sustainability of Groenveld.

Figure 7.2: Impression of the map and the problems of the Groenveld neighborhood.

In preparation for the day, the participants are sent the DuBes file, as it is known, containing the Groenveld scenario. The scenario describes the urban planning history and characteristics of the municipality of Dijkhuizen and the Groenveld neighborhood. It also describes the housing stock and demographics of Groenveld and the neighborhood's problems with respect, for example, to housing, public space, water, energy, safety, traffic and transport. The DuBes file also contains an overview of the roles, the tasks and competencies of each role, and the role distribution. From 20 to 40 people can take part in each simulation. Prior to the simulation game, each participant is allotted a certain role, such as councilor, director of the 'Our House' housing association, director of the 'Welfare' foundation or project leader of the municipal Water, Energy and Environment Service. In addition, the participants are asked to make use of their own knowledge and experience when playing the simulation. Photo 7.1 gives an impression of the game.

Photo 7.1: Impression of the game

The assignment, for all participants in the simulation game, is to jointly draw up a program of requirements for the sustainable redevelopment of the Groenveld neighborhood, Stage I. The municipality of Dijkhuizen and the 'Our House' housing association, which owns a large proportion of the housing in Groenveld, have decided to consult the principal interested parties in drawing up the program of requirements. With a view to obtaining a subsidy, sustainability has to form an explicit component of the program of requirements.

7.5.4 The DuBes tools

The participants have a number of tools to help them achieve this difficult task in a short space of time. The most important tool is the DuBes Table (see Figure 3). This table, in A0 poster format, schematically shows all the themes, decision fields and options from the MEDIA computer program.

Figure 7.2: Section of the DuBes-table

WATER (HOME)	MAINTENANCE (HOME)		DEMOLITION (HOME)		WASTE (HOME)		Cultural Heritage
Rainwater collection system	**Exterior**	**interior**	**method**	**Recycling**	**collection of domestic waste**	**construction & demolition waste**	**buildings**
disconnect and gradually dispose of	Collective	collective	Traditional by demolition contractor	legal minimum	collective collection point	no separation facilities on building site	maintain
traditional	individual (private)	individual (private)	Combination with job-creation schemes	maximum high-quality recycling	per plot	separation into 11 or 7 fractions	do not maintain
retain and purify						recycling on site	

The boxes at the top in a variety of colors show the themes. The themes are arranged by level - neighborhood, block and home. Some themes recur at several levels of spatial scale. The yellow boxes show the decision fields. The white cells show the various options for each decision field.

The DuBes table provides the participants with an overview of the decisions that can be made in the course of a restructuring assignment. This overview is not exhaustive. The aim of the table is to offer the participants a guide for determining the agenda of the program of requirements. They can therefore use the agenda when the discussion falters or runs short of inspiration or expertise, but they must draw up their own agenda in the main. A full version of the Dubes table that was used for Alphen in included in appendix 3.

In two sessions, one in the morning and the other in the afternoon, the participants draw up their own DuBes table for the Groenveld neighborhood or for a real neighborhood. In the morning, the participants are divided into three working groups. These groups work from various angles of approach, such as public space, housing and welfare, to list the themes and decision fields and decide which ones must be included in the program of requirements. As they do this, they can refer to the existing DuBes table and the DuBes advisors for guidance. Before the working groups commence, the participants individually and anonymously prioritize all the decision fields in the DuBes table based on how important they think a theme or decision field is for the program of requirements. An electronic conferencing system is used for this, so that the results of the vote are available to the working groups within a quarter of an hour. The result of the first session, just before lunch, is a DuBes table for each of the three working groups to serve as the basis for the program of requirements.

Process managers
The discussions and negotiations in the working groups are guided by process managers. Process managers are game participants who are instructed by the game leaders, prior to the simulation game, on the best way that they can chair and guide the process within the working groups and planning studios.

DuBes advisors
The process managers and the working groups are supported by DuBes advisors, members of the Sustainable Decision Making project team (DuBes team). The DuBes advisors assist and advise the working groups and register their results as well as possible in the MEDIA computer program.

During the lunch break, the DuBes team takes the three DuBes tables produced by the working groups in the morning session and, aided by MEDIA, processes and combines them into a single, integrated DuBes table. All the themes, decision fields and options that the participants consider important for the neighborhood's program of requirements are now put into order and placed on the agenda in this integrated DuBes table. However, no choices have been made or strategies decided upon as yet.

In Session 2, in the afternoon, the participants are asked to work out strategies for the program of requirements in three planning studios oriented toward different aspects of sustainability, such as the environment, quality of life and feasibility. This is done by choosing, in discussions, from the options that the participants drew up in the morning. The participants are asked to reason out their choices by devoting attention to the various effects of options, including those on sustainability, and the connection with other decisions, for example decisions relating to other themes and at other levels of scale. The chosen options are marked in the table and selected in MEDIA. The planning studios are also guided by the process managers and the DuBes advisors. The MEDIA computer model registers the choices and gives extra information on the consequences of decisions, effects, consistency etc.

At the end of the day, the presentation, analysis and comparison of the three DuBes table's shows on which points the participants agree and on which points the participants have differences of opinion. On some points, the participants will have come to the conclusion that further research is necessary in order to arrive at the right choice. The DuBes tables, together with the arguments for the choices during the group discussions and evaluations, form the basis upon which a sustainable program of requirements is drawn up for the Groenveld neighborhood or a real neighborhood.

Evaluations
At the end of Session 1 and Session 2, the participants answer some questions about the process in their working group or planning studio, and about the result. This is done using the mobile electronic conferencing system. At the end of the simulation game, the process, the result and the simulation game itself are thoroughly evaluated

in a plenary discussion. Afterwards, the participants are asked to fill in an evaluation form about the simulation game itself.

7.6 Practical experiences

Up to now, the DuBes method and simulation game have been used twice in practice. In cooperation with the project bureau Emmen®evisited (a joint venture between the municipality and the 'Stichting Wooncom' housing association), the simulation was used on 22 November 2001 for the Emmerhout-Noord restructuring project in the Emmen municipality. On 11 December 2001, the simulation game was played, using the fictional Groenveld neighborhood, with the employees of the municipality of Alphen aan den Rijn and the 'WonenCentraal' housing association.

Case-studies play an important role in the Dubes project. The primary functions of the case-studies are:
- To test the usefulness and validity of developed concepts and/or methods.
- To generate input for the development of newly developed concepts and/or methods.
- To assist the owner of the case-study in question with their problems.

Dutch summaries of these case studies are included in appendices 4 and 5. The full reports, also in Dutch, are available as appendices I and II.

7.6.1 Emmerhout

The project bureau Emmen®evisited wished to use the simulation as an instructive learning experience and to discover where opportunities for sustainability were to be found. The simulation could possibly help in the formulation of the assignment to the neighborhood development company, a public-private partnership that was to be established at the start of 2002. The parties that were involved in the restructuring of Emmerhout-Noord will also have to cooperate with each other on future restructuring projects. Twenty-eight participants took part in the simulation game in Emmen, drawn from various municipal departments, the Wooncom housing association, the project bureau Emmen®evisited, the Emmerhout neighborhood and tenants' association, the Emmerhout association of neighborhood interest groups, the Drenthe Province, the project developer Rabo-Vastgoed, the Essent energy company, the WMD water company, the Drenthe College (a school), Novem (an interMEDIAry organization in the field of energy and the environment) and the advisory bureau PRC-Bouwcentrum. Although the existing decisions and plans for Emmerhout-Noord were used as a starting point, the participants were free to make suggestions that did not correspond to these.

7.6.2 Alphen aan den Rijn

In Alphen aan den Rijn, the 'Planetenbuurt' neighborhood is eligible for ISV subsidy; plans are being made for it and are already being implemented in part. In this project, the municipality of Alphen aan den Rijn and the 'WonenCentraal' housing association cooperate intensively and run the project organization together. They try to create a livable and sustainable neighborhood by means of an integrated approach. The Welfare service recently started to take part in the project organization, but has as yet no experience with a project of this nature. The DuBes simulation game offered the various organizations, departments and individuals who need to cooperate with each other in current and future restructuring projects a good opportunity to experiment, in a safe and pleasant environment, with the substantive quality and process of sustainable restructuring.

7.7 Results and outcomes

In both simulations, in Emmen and Alphen, the participants are generally satisfied with how the day went. They thought the simulation a good and enjoyable way of thinking about the sustainable restructuring of their residential neighborhoods with a large number of parties.

It is a pleasant way of establishing objectives quickly.

This way is good for forming an idea, in a short time, of the problems involved and the matters you want to resolve.

As a consequence of the differing aims and intentions, the results and experiences of Emmen and Alphen also differ in some respects. The results and the experiences of the participants, based on verbal and written evaluations, are discussed below.

7.7.1 Learning experiences of the participants concerning 'the substantive quality'

The simulation participants in Emmen are of the opinion that the method is suitable for getting a good overview of the problems and possibilities raised by a restructuring project. According to them, the method is particularly useful at a very early stage of the planning process. They therefore feel it is a pity that the method was not used at an earlier stage for Emmerhout-Noord.
Despite the rather advanced stage of events, the simulation produced some ideas for Emmerhout-Noord. In particular, the municipal Spatial Planning and Housing Service, the Emmen®evisited project bureau and the Wooncom housing association have gained some useful ideas during the simulation on the themes of water and mobility. These included some very practical and simple ideas, such as having rain barrels by the houses, and also more all-embracing ideas such as the recognizability of the infrastructure in the neighborhood and the choice of non-motorized transport as the main form of transport in the neighborhood. Something that experts and project leaders found surprising was the fact that residents and neighborhood organizations

put the theme of 'indoor climate' high on the sustainability agenda (see for example point 5, 'humidity regulation' in table 1). The participants in the simulation in Emmen indicated, moreover, that some ideas that came up in the simulation are also useful for neighborhoods that are being restructured in Emmen and for which decision-making is not at such an advanced stage.

Unlike in Emmen, the simulation game for the municipality of Alphen was not aimed at the generation of ideas imMEDIAtely applicable to an existing restructuring project. The learning experiences with respect to sustainability therefore lie at another abstraction level: the development of various visions of sustainability. If we compare the simulations in Emmen and in Alphen, a clear distinction is apparent as regards the essential themes that came up in the simulation games. It is apparent from Table 2 that the participants in Emmen also discussed themes related to construction techniques, while in Alphen attention was primarily devoted to the social aspects of sustainability, and safety in particular. This can partly be explained by the fact that the participants in Alphen are mainly expert in the field of urban planning and housing, and to a lesser extent in matters of construction and the environment. The participants in Alphen were rather surprised by the great attention that was being devoted in the simulation game to social aspects of sustainability and safety because these have not been major considerations for them until now.

Table 7.1: The 10 most important themes and decision fields as prioritized during the simulations in Emmerhout-N and the municipality Alphen.

No.	Theme/decision field (n= 25)	av. (stdv)
Emmen		
1	Energy consumption of the dwellings (Energy performance coefficient)	8.36 (1.55)
2	Safety in the neighborhood (surroundings, social, traffic, lighting etc.)	8.27 (1.37)
3	Green structure (function, quality, quantity, management etc.)	8.16 (1.8)
4	Sun orientation in building	8.12 (1.07)
5	Humidity regulation in homes	8.04 (1.69)
6	Facilities in the neighborhood (recreation, schools, social & cultural activities, religion etc.)	8.00 (1.44)
7	(Rain)water storage	7.96 (1.51)
8	Indoor climate of the home	7.96 (2.03)
9	Light in homes	7.92 (2.08)
10	Non-motorized transport in the neighborhood	7.88 (1.21)
Alphen aan den Rijn		
1	Safety in the neighborhood	8.27 (1.19)
2	Social safety of the home	8.08 (1.41)
3	Participation	8.00 (1.96)
4	Green structure	7.96 (1.54)
5	Safety of one's surroundings	7.85 (1.08)
6	Security of home against breaking and entering	7.83 (1.27)

7	Illumination of public areas	7.77 (1.9)
8	Quality of green structure	7.76 (1.36)
9	Non-motorized transport in the neighborhood	7.65 (1.29)
10	Road crossings for pedestrians and cyclists	7.64 (1.5)

The participants in both Emmen and Alphen indicate that the DuBes method is suitable for developing a good overview of the problems that are involved in a restructuring project, and for gaining new insights from different disciplines.

It is something of an open door, but sustainability encompasses much more than your own frame of reference. This offers you the opportunity to get to know other disciplines in your own field of work.

In the written evaluation, about two thirds of the participants indicated that they had gained a clearer picture of what sustainability can mean and the decisions that need to be made in the restructuring of a post-1945 residential neighborhood, and of the various options for the restructuring of a neighborhood. Over half the participants confirm that new insights and ideas for sustainable restructuring were brought up in the simulation game. Two thirds of the participants expect that the DuBes method will contribute to a more sustainable program of requirements for the restructuring of a neighborhood.

It is apparent from the evaluation of the discussion in the working groups and planning studios (see table 2) that the participants do not really think that aspects of sustainability played a great role during the discussion (see question 6, table 2). However, in this respect the simulation in Emmen scores better than the simulation game in Alphen. It seems that the participants primarily applied a social vision of sustainability during the discussions, but assess sustainability primarily from an environmental perspective in the discussion. In the final evaluation, the participants indicate that they have learned something about sustainability.

7.7.2 Learning experiences of the participants concerning 'the process'

Even more than the essential results, the participants positively assessed the interactive aspect of the simulation (see questions 1-3 in table 2 in particular).

It is good to do this with all the different disciplines. It continues to be instructive. We looked at matters that I would not have looked at otherwise, always from different perspectives.

It helps to map out in a structured way the themes and decision fields that the parties involved find important.

Table 7.2 : Evaluation of the discussions in the working groups and planning studios based on the DuBes table during the game

M = average rising scale from 1-10 (SD = standard deviation)	Emmen (n = 21)		Alphen (n= 25)	
	Session 1 (morning)	Session 2 (afternoon)	Session 1 (morning)	Session 2 (afternoon)
To what extent was it possible to express your opinion in the discussion in your working group / planning studio?	7.88 (1.3)	7.75 (1.48)	7,7 (1,62)	7.7 (1.38)
To what extent does the DuBes table provide a good overview of the discussion?	7.64 (0.76)	7.29 (1.65)	7.7 (1.13)	7.7 (0.93)
To what extent did your opinion also appear in the DuBes table?	7,44 (1.39)	7.05 (1.23)	7,9 (1,28)	7.3 (1.17)
To what extent do you expect the DuBes table will assist in the making of choices?	7.24 (1.51)	6.71 (1.55)	7.2 (1.2)	7.2 (1.38)
To what extent are you satisfied with the way the discussion went in your working group / planning studio?	6.92 (1.02)	7.29 (1.64)	6.5 (1.73)	7 (1.45)
To what extent did aspects of sustainability play a role in the discussion in your working group / planning studio?	7.48 (1.42)	6.81 (1.86)	5.9 (1.83)	5.4 (1.64)
To what extent did interests (e.g. economic, political, personal) play a role in the discussion in your working group / planning studio?	6.04 (2.07)	5.52 (2.11)	5.1 (2.06)	5.8 (1.97)

According to the participants, the two-session structure, in which the problem is first studied from a sectoral angle, followed by 'decisions' being made from an integrated perspective, contributes to a better understanding of the enormous complexity of the problems and the connections that exist between the various problems. In the planning studios, the participants decide which options they prefer without the other options (which are therefore not chosen) vanishing completely. Because each participant can put decision fields or options on the agenda, and these are recorded for all to see in the DuBes table, and because the decision fields remain part of the general discussion and agenda even if other choices are made eventually based on good arguments, the discussion takes a course that is satisfying for the participants.

In particular, the participating residents of Emmen found it illuminating to see how many parties are involved in the refurbishing of their residential neighborhood and what decisions have to be made.

As a citizen/resident, you do not realize in how many areas decisions have to be made.

The participating residents from the municipality of Emmen indicate that they regretted that they were not represented in all the working groups and planning studios. They would also have very much liked to participate in the more 'technical' Spatial Surroundings and Infrastructure working group and in the Environment planning studio. The residents remarked that the simulation organizers should not worry too much that the residents will not understand, and that it is not necessarily a problem if things get too complicated.

It was good to hear the opinions of the experts who were present.

It should be said that the differences in expertise were not just between the residents and the other participants. All the participants had specific expertise in a certain field. Some were of the opinion that the discussion did not go into sufficient depth and that there was an absence of expert knowledge in some areas. Others, on the contrary, were of the opinion that there was a lot of expertise present - perhaps too much - and that the discussion became very complex as a result. Some participants would have liked to learn more about the effects of decisions, both on the environment and on costs. One participant suggested repeating the simulation in a number of stages, so that the effects can be calculated by experts. In that way, it would have been possible to place sustainability more explicitly on the agenda.

7.7.3 Participation

The role-play helped the participants to approach the assignment from the perspective of different interests. In the simulation game for Alphen, the participants did not necessarily play their own role. For example, some municipal officials, or employees of the housing association, had to think themselves into the role of a resident of the neighborhood. During the plenary discussion at the end of the Alphen simulation game, a discussion developed about the participation of various parties in a restructuring process and the possible role of the DuBes method. Participation in the simulation game raised interesting but troublesome questions for the participants from Alphen. Who could, and should, participate in the DuBes exercise in a real situation?

Of course, the DuBes method is not an easy recipe for a participatory or interactive approach to restructuring. However, the experiences in the Emmen municipality do provide a frame of reference.

The DuBes method seems most appropriate when the participants have different interests and sources of knowledge and experience. The participation of interested parties and experts from, for example, the energy company, the water supplier, the water board and the environmental movement is important because these have the necessary expert knowledge and information. This promotes the depth of the discussion. Sometimes, the discussion led to ambitious proposals for which the experts themselves thought that there would be insufficient interest or support. Residents, administrators and experts all seem to be able to get on with the DuBes method. The enthusiasm of the residents in Emmen was remarkable. It is important, however, to draw up a number of rules for all those involved - administrators, private companies and residents - so that the scope of the exercise is clear.

What can be done to follow-up a DuBes simulation? The sustainability strategies that are drawn up can be further elaborated and studied with regard to their feasibility and effects for sustainability. This can form the basis for further decision-making, whether or not based on a DuBes-like setting. It would also be possible to have a number of sessions in which the DuBes method is alternated with research and design, and in which the requirements for sustainability are formulated in increasingly concrete terms and with increasing definition.

Table 7.3: Evaluation of the simulation game

	Alphen ad Rijn	**Emmen**
Scale: disagree (1) – agree (5)	average (stdv) (n=20)	average (stdv) (n=10[iii])
I have gained a clearer picture of the decisions that have to be taken with regard to the restructuring of a post-1945 neighborhood.	3.72 (0.46)	3.42 (1)
I have gained a clearer picture of the various choices (options) for the restructuring of Emmerhout / Groenveld.	3.83 (0.62)	3.33 (0.98)
Some new insights and ideas for sustainable restructuring of Emmerhout / Groenveld have been produced by the simulation.	3.58 (0.51)	3.50 (1.08)
I have gained a clearer picture of what sustainability means in the restructuring of a post-1945 neighborhood.	3.56 (0.51)	3.58 (1.24)
I have a clearer picture of the parties involved in sustainable restructuring of neighborhoods.	3.56 (0.7)	3.17 (1.03)
The simulation game has produced some useful insights that can improve the process of decision-making on future sustainable restructuring of post-1945 neighborhoods.	3.47 (0.77)	3.5 (1.08)
The DuBes method will contribute to a more sustainable program of requirements for Emmerhout / Groenveld.	3.67 (0.49)	3.33 (0.98)
I have personally learned something by participating in the simulation game.	4.05 (0.52)	3.4 (0.97)
I anticipate that I will also be able to use these learning experiences in the practice of my profession.	3.79 (0.71)	3.3 (0.95)
The tools supported the game well.	4.21 (0.81)	3.3 (0.48)
I think that the DuBes method is worth developing further.	4.26 (0.65)	4.6 (0.52)

7.8 Conclusions simulation game

Based on the experiences in Emmen and Alphen, the DuBes project will be continued along a number of paths. Firstly, the MEDIA model will be developed further so that the effects and costs of options and strategies can also be assessed. MEDIA will then be able to make a more prominent contribution to the discussion during the simulation game. Parallel to this, the DuBes simulation game will be played again a number of times for restructuring assignments. The results of the simulation game can serve as input for MEDIA. Secondly, the DuBes method will be applied to other types of construction projects, such as new building projects, the construction and harmonization of infrastructure, and the restructuring of business parks. Thirdly, the DuBes simulation game will be integrated into the educational syllabus of the faculties of Technology, Policy and Management, Civil Engineering and Architecture of the Delft University of Technology. The simulation game will be played with students from all three courses at the same time. In that way, students can learn in the course of their training that sustainable urban development is a task that they can only realize in cooperation with other disciplines and interested parties.

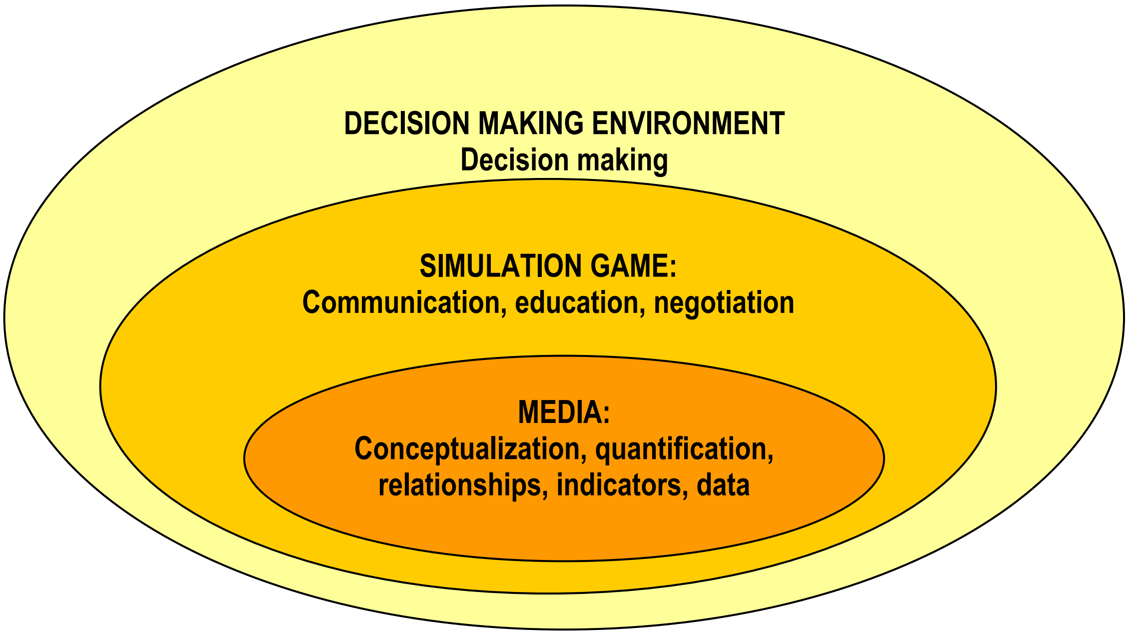
[iii] In Emmen, the participants were given an evaluation form to complete and send off. In Alphen, the participants completed the evaluation imMEDIAtely after the simulation game ended, using the electronic conferencing system. This explains the difference in the response.

8 INTEGRATED CONCLUSIONS

8.1 Integrated conclusions regarding the project result

Currently, truly integrated tools aimed at sustainable development in large building assignments, such as urban (re)development, in which both process quality and substantive quality are addressed, are lacking. In the Dubes project, such an approach has been developed. This approach simultaneously addresses the complexity related to substantive quality, the design complexity and the policy complexity typical of such assignments. The approach in its current form is aimed at the early stages of decision-making processes (initiative and programming).
The approach consists of two main components: the computer-based model MEDIA and a simulation game. In figure 9.1 the relationships between MEDIA, the simulation game and the actual decision making process is presented.

Figure 9.1: Relationship between MEDIA, simulation game and decision making environment



The focus of MEDIA is on the conceptualization and formalization of the problems and solutions surrounding the integration of sustainable development in large building assignments. The model is based on several proven concepts: The AIDA-concept for addressing design complexity and dynamic network analysis principles for addressing policy complexity. The equivocal character of sustainable development is 'solved' by leaving as much room as possible for different views and impact assessment methods.

The simulation game can be regarded as an interface between the (abstract) model and the actual decision making process. It focuses on educating the participants with

regard to the underlying philosophy and terminology of the Dubes project and facilitates motivated discussions and negotiations on the most important issues.
The combination of MEDIA and the simulation game is highly innovative and gives the project its added value: the actual linking of substantive quality and process. In this respect the original goal has been achieved.
There are a number of important constraints however. Although the complexity of integrating sustainable development in large building projects has been made explicit and transparent, it has not been reduced. Therefore the amount of data, needed to make the Dubes-approach fully operational is very large. Within the scope of the current project therefore not all elements of the approach have been completed. This especially holds true for quantitative data (variables and their values) and related impact assessment methods. This implies that the Dubes-approach in general and MEDIA in specific can, for the moment, not be regarded as a fully fledged decision support system. A DSS should generate quantitative data about separate decision options or comprehensive design scenario's. Although the ability to generate quantitative results would indeed increase the possibilities of the Dubes-approach, the simulation games that have been completed clearly show that a conceptual qualitative analysis alone, can play an important role in the early stages of a project, during which there is relatively little need for quantitative data. Such a conceptual analysis also gives direction to quantitative research during the further stages of a project (e.g. design- and realization stages).
The Dubes-approach therefore is integrated in the sense that it is aimed at integrated problems. It helps actors in agenda-setting, prioritization and tool-selection, whilst taking notice of all the relationships that exists between different decision areas, -options and actors. It is not an integrated impact assessment method. This is a deliberate choice, since it isn't possible to develop a generic impact assessment method that meets the needs of all the actors involved in a possible case. However the structure in which data is collected and presented within Dubes in general and MEDIA in specific, doesn't exclude any impact assessment method in particular.

The Dubes-approach, although is has already proven itself to be useful in practice, is far from finished. In chapter 10, recommendations are given for further research in the (near) future.

8.2 Conclusions regarding the research method

The simultaneous development of a conceptual tool (MEDIA) and a process-oriented simulation game has proven to produce innovative and useful results. Without the simulation game, MEDIA would not have developed as it has. The simulation game in return benefited a lot from the sound conceptual basis provided by MEDIA. Which component (MEDIA or exercise) is most important is irrelevant. What is relevant is that both components benefited enormously from each other.

As far as the development of concepts concerned, the use of a prototype software tool (MEDIA) has also proven to be very useful in this project. By using a conceptual software tool for reporting and representing potential useful idea and concepts, researcher are forced to define and describe their ideas transparent, unambiguously and consistent. The tool itself, besides it usefulness for defining and reporting concepts, also serves a testing vehicle. If a concept is not valid, useful or manageable, this will quickly surface if the tool is applied (certainly in combination with a simulation game). Working with a conceptual tool such as MEDIA also generates more ideas and concepts, and it also reveals higher order concepts.

9 FUTURE RESEARCH

9.1 Introduction

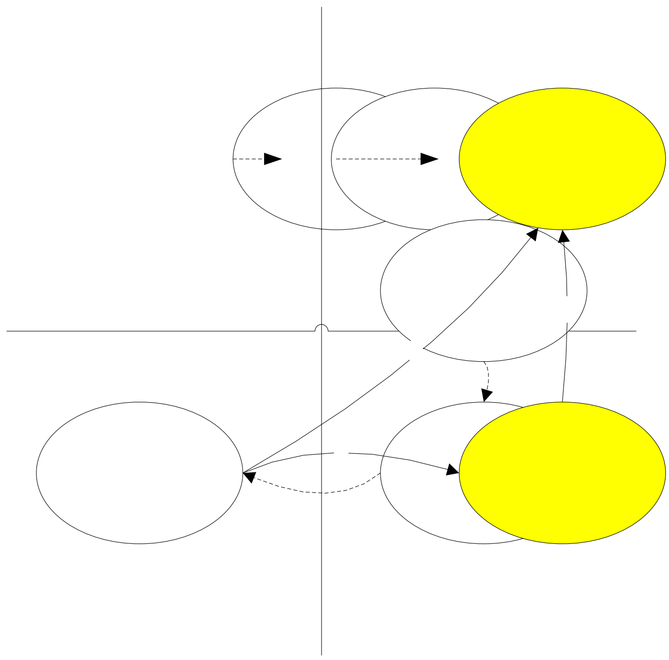
The Dubes project is so versatile, complex and feature-rich that the possibilities for further research are overwhelming. In this chapter it is attempted to bring some order to these possibilities. In the following sections different elements of possible future research are briefly discussed. These are:

- The general development of the Dubes-approach.
- The expansion of the Dubes-approach to other sectors.
- The development of MEDIA.
- The development of the simulation game.
- The use of the Dubes approach for educational purposes and knowledge transfer.

9.2 General development of Dubes-approach

How will the Dubes project evolve in the future?. Theoretically there are three development directions thinkable:

1. Towards a more evaluative approach, but still in a multi-user setting. This implies an increase in the use of (quantitative) indicators, which in turn increases the need for data and calculation methods. It also introduces the need for some sort of visualization of the projects that are tackled, since such a more evaluative approach should also facilitate actual design stages.
2. Towards a more evaluative approach, but within a single-user setting. This would in fact disqualify the whole concept of the simulation game and would require a large amount of validated data and calculation models to somehow (if at all possible) make up for the lack of dynamic multi-actor input. Such a development could theoretically be pursuit directly from the present situation (c), although a more likely path would seem via a multi-user/evaluative approach (a-b).
3. Toward a single-user type of application, but within a single-user setting. This option seems to be the most theoretical one. It also renders the idea of simulation game useless and in addition has no 'hard evidence' to compensate for the lack of actor participation. It is therefore unlikely that such an approach would produce results that are acceptable for all the actors involved.



Naturally, the development in the direction of more evaluative oriented approaches doesn't mean that the present approach, which is suitable for agenda-setting, goal definition and programming applications, looses its value. These kinds of applications might even turn out to be the primary niche for the approach developed in this project. A promising option would be a coherent set of specific approaches, which could be applied during the course of a project (e.g. programming, design and realization).

9.3 Expansion of the Dubes-approach to other sectors

So far the focus of the Dubes approach has been on urban redevelopment. The following sectors seem promising to explore further:

- Infrastructure (roads, railways, waterways).
- Industrial areas.
- Urban development (newly built).

9.4 Development of MEDIA

There are a number of future developments possible:

1. Functional additions to and alterations of MEDIA.
2. Migration of MEDIA to a other software platform.
3. Integration of MEDIA with other models (existing or in development).
4. The implementation of variables and methods.

Programmative

These will be briefly discussed in the following sections. The merits of each possible future development can be assessed separately. An integrated research approach will still be needed, since there are a lot of inter-linkages between these developments.

9.4.1 Functional additions and alterations

The current critical remarks and suggestions with regard to the present functionality of MEDIA, based on the work already done could be further explored. Among these are the implementation of programming type of decision areas, the introduction of 'positive' scenario's or visions, the introduction of project stage as secondary structuring concept, the introduction of other types of spatial levels (less restricted by the 'living' function), enhanced input and editing possibilities, improved design- and impact assessment functions, etcetera.

9.4.2 Migration to other software platform

Currently MEDIA, although multi-user enabled, is not suitable for use over the internet. Migration to a web-based platform would introduce a great deal of new possibilities, such as interactive participation of actors and easy (international) accessibility. In combination with the simulation game, new ways of actor participation are within reach. The inability to use MEDIA is a group decision room-setting could be another reason to migrate to another platform.

9.4.3 Integration with other models and systems

There are a number of models available or being developed, which potentially could enhance the functionality of MEDIA (and vice versa). In future research the possibilities for integrating MEDIA with such models could be explored. Some promising options are GIS-models and virtual design systems (total design).

GIS-models
The current version of MEDIA is not very suitable for visualizing designs. It is also not very precise and user-friendly with regard to the physical modeling of a design. The combination of MEDIA with GIS, although technically complicated, has a lot of potential advantages. Besides the visualization itself, which can be very useful if a project is in its design stage, GIS has lots of advantages related (among others) to data handling, database management and input interface. In the following box, some ideas derived from the attempts to model an infrastructure case, are presented for illustration.

Box 10.1: some ideas regarding the integration of GIS and MEDIA
A few simple ideas on how to integrate geographical elements in MEDIA are described below. These ideas must be regarded as indicative and not as 'official' recommendations. A concept which would solve a lot of the difficulties encountered during the infrastructure exercise would be the 'functional area'. A functional area could be defined as a typical area with more or less homogeneous characteristics, which distinguishes it from other functional areas (e.g. rural area, city centre, industrial area). The second concept which could be helpful is the concept 'object'. Objects are civil engineering elements, such as roads, tunnels, bridges and buildings. Objects also have standard characteristics, depending on their type and size. These characteristics are responsible for most sustainable development-impacts related to materials and constructions. The spatial impacts of objects depend on the functional area they are located in. Objects can be regarded as options of a decision area. In MEDIA, a standard database could be developed, containing the most common functional areas and objects. These could be manipulated in a graphical interface. This way a project can be modeled quickly. With the added benefit that the physical parameters of project can be modeled much more easily and precisely. The development of MEDIA in a way described above can be regarded as integration with a geographical information system (GIS)

9.4.4 Implementation of variables and methods

In the present version of MEDIA, there are only a limited amount of variables and no methods at all implemented (made operational). This is a major focal point for future research. It is important that research in these areas is linked to other possible research topics surrounding MEDIA, to ensure that data and methods are and remain compatible with future developments.
Before such a project is started, it has to be clear for which variables data and methods are required. In the following box a proposal is presented for a comprehensive set of variables that are considered to be representative for a lot of sustainable development issues. More variables are possible, but the amount of variables presented in the box is probably already to large to be integrally implemented.
There are two possible ways to obtain data for variables (see also section 6.5.3). The first possibility is by using a top-down approach, in which values of variables are estimated by, for instance, an expert panel.
The second way is through a bottom up approach, which uses more reliable (physical) measurements of the values of variables. It may also involve the use of

more or less complicated models to calculate meaningful variables (indicators). Most criteria will exist of several sub-criteria, for instance 'ecology' could be broken down to sub-criteria such as 'ecosystem quality' and 'net biomass production'.
These two possible ways of implementing variables are not mutually excluding, but could be fashioned in a complementary manner.

BOX 10.2: Possible variables to implement														
Constraints			Functions					Livability			Flows			
Costs	Time	Space	Living	Working	Recreation	Mobility & transport	Ecology	Safety	Social safety	Participation	Energy	Water	Materials

9.5 Education and knowledge transfer

The DuBes simulation game will be integrated into the educational syllabus of the faculties of Technology, Policy and Management, Civil Engineering and Architecture of the Delft University of Technology. The simulation game will be played with students from all three courses at the same time. In that way, students can learn in the course of their training that sustainable urban development is a task that they can only realize in cooperation with other disciplines and interested parties.

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