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Adaptive **D**ecision **S**upport **S**ystem (**ADSS**) for the Integration of Stormwater Source Control into Sustainable Urban Water Management Strategies

DayWater

DayWater Project

Report 'Review of decision support tools in USWM'
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1 Introduction

1.1 Daywater

Daywater is a Swedish word which basically means 'surface runoff'. Daywater is therefore chosen as title for a European project with the aim to improve Urban Storm Water Management (USWM). The focus of Daywater is on the quantity and quality of storm water in urban areas. In the project Daywater, an Adaptive Decision Support System (ADSS) will be developed in order to support storm water managers by implementing measures which will resort the best effects and suits the way USWM is organised. The ADSS must be helpful to storm water managers. This requires that the ADSS not only provides in scientific knowledge, but also assists in using the knowledge for practical problems. This makes Daywater an ambitious project.

1.2 Architecture of the ADSS

The project Daywater is divided into different work packages (WP's). This report is developed for task 2.1, part of WP2. This WP plays a central role in the architecture of the ADSS by integrating the developed knowledge in the project in the ADSS. The title of task 2.1 is 'Existing bricks and integration'. The task description is: "An initial survey will be conducted in the literature and through end-users of existing decision support tools in USWM in the different European countries, focused on the different phases of decision processes. The opportunity to incorporate existing tools in the ADSS will be assessed. These initial tools will be the basic bricks used to build the first ADSS template to be used in the first testing round (D2.1). Each national partners will be in charge of gathering existing tools in his country, and transmitting to partner #2 (Tauw), who will be in charge of the synthesis of this information, proposing the construction of integrated components from the national bricks and ideas for the formal integration in the ADSS. This task must be achieved within month #6 of the project."

1.3 Setup of the deliverable

This report (Deliverable D2.1 'Review of decision support tools in USWM') describes the first template, in which different DSS tools used in European countries are conceptually integrated. This report starts in chapter 2 with a summary of different concepts out of literature which are useful to compose the ADSS. The focus of the literature study is on the internal and external functioning of a DSS. The insights of the literature study, together with lively discussions with Daywater partners, have served to set up a flow chart of the ADSS. This flow chart is elaborated in chapter 3. Chapter 4 describes different decision tools, gathered by the Daywater partners. These tools are conceptually integrated in the flow chart. The last chapter, chapter 5 contains recommendations for integrating the content of this report into the further development of the ADSS in Daywater.

2 Literature review

2.1 Introduction

The first step in the development of the ADSS is a review of existing literature on Decision Support Systems (DSS). Since an Adaptive DSS has not been developed yet, little literature exists on ADSS. The basic ideas of a DSS though, must also concern the ADSS. The adaptive characteristic can be seen as an extra function of a DSS. In contrast to the limited literature on adaptive DSS, a large amount of literature exists on Decision Support Systems. Only those theoretical insights are studied, which are directly relevant for developing the flow chart of the ADSS.

The focus of the literature review is on the main internal structure, the external functions and the relation between structure and functions of a DSS. In section 2.2 the definition of a DSS is given. Section 2.3 describes the main structure of a DSS, while section 2.4 aims to describe the functions of a DSS. Section 2.5 analysis the relation between structure and functions and section 2.6 will focus on the adaptive characteristic. The last section, section 2.7, summarizes the useful concepts of the literature review for setting up the ADSS.

2.2 What is a decision support tool?

The last years the use of DSS has grown enormously. Partly because of the growing capacity of personal computers, but also because the problems to tackle became more complicated. The aim of a DSS is "to support decision making in complex problems by structuring the information and by analyses and evaluation of the effects of different alternatives" (Sprague and Carlson, 1982). The complexity of problems is related to the uncertainty of the behaviour of the system that causes the problem. The uncertainty exists because of lack of knowledge of the system, or because of structural uncertainties in the system. In USWM there is lack of knowledge on the effects of application of source control measures on a large scale. Structural uncertainty exists for example when the success of source control measures is dependent on the cooperation of stakeholders. Decision making for these problems can be supported by structuring the information needed to get a clearer understanding of the problem. Further on, the DSS can support by modelling the processes which cause the problems, which makes computing of the effects of different solutions or alternatives possible.

The first step in tackling complex problems is a clear *problem definition*. This problem definition must not only describe the problem, but also the elements that cause the problem. These causes can be found into malfunctioning of the water *system* (for example a lack of capacity of the drainage system), or in the *context*. The context contains all kind of events that influence the water system, except technical measures. The context exists of two parts. The first is USWM, defined as the formal organisation of the management of storm water (stakeholders, budget, water policy). The second is *Urban Dynamics*, consisting of all non-formal and indirect influences of the water system, for example other spatial policy fields or political preferences. The Urban Dynamics will be elaborated in WP3.

An important aspect of the problem definition is the 'owner' of the problem. Different stakeholders in USWM have different perceptions of the problem to be solved. An administrator will be sensitive for dissatisfaction of inhabitants because of storm water. A manager is focused on the maintenance of a sound technical water system. A sustainable solution has to satisfy the demands of different stakeholders. Therefore, the ADSS will contain the component '*reflection of the ambition'* that supports the user to determine his perception of the problem.

One of the elements of the definition of a DSS is that it structures information. Therefore, the first template of the ADSS will be described in a *flow chart*, consisting of components and how they are related. The flow chart helps the user to tackle his problem stepwise.

2.3 The structure

The main structure of a DSS consists of three major components: a dialog subsystem, a database subsystem and a model base subsystem. The structure is illustrated in Figure 2.1.

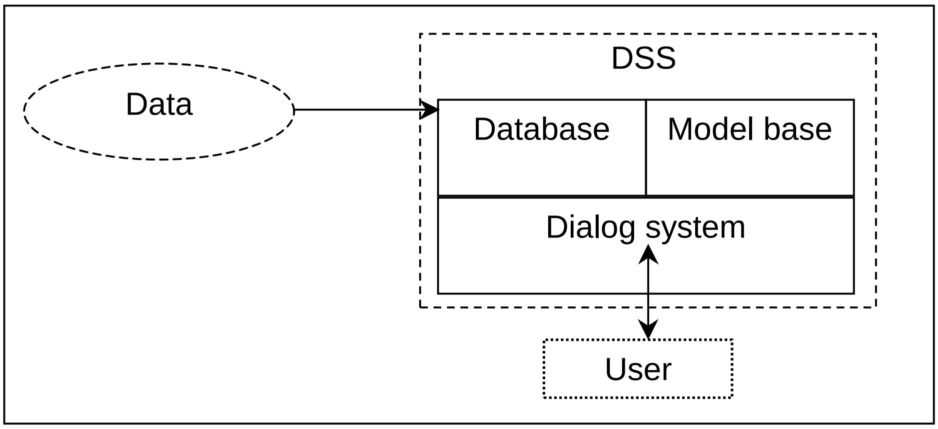

Figure 2.1 General structure of a DSS.

The database contains all kind of data concerning the problem situation. Some of this data can already be present in the DSS, other data should be added to the database by the user. The second component is the model base. The model base is a representation of the real world and contains causal relations that give insight in causes and effects of problems encountered by the decision maker. The model base of the DSS processes the data in the database. The dialog system makes it possible to communicate with the user. The user can give orders to the DSS and the DSS can present results through the dialog system.

The largest part of the content of the ADSS will be described in databases. The core database of the ADSS will consist of all possible measures, since the aim of Daywater is to support the user to decide on the measures to take in USWM. The information gathered and knowledge developed in the different WP's will be inserted into the database in the form of *indicators*. These indicators make it possible to choose the best measures out of the database. The dialog system in the ADSS is the Human Computer Interface (HCI) to be developed in WP2. Most important aim of the HCI is to make the core database in the ADSS accessible for the user by guiding the user through the ADSS. Other aims are a clear presentation of effects of measures and supporting communication with other stakeholders in USWM. The model base is less important for the ADSS. Some models on source and flux will be implemented (WP6), but the use of other models should also be possible.

2.4 The functions

Van Delden (2000) distinguishes five general functions of a DSS. These functions are:

- Management function
- Analysis function
- Communication function
- Education function
- Library function

Management function

The management function is the most important function of a DSS. The results of a DSS can help the user to make decisions to 'manage' the problem. A DSS must guide the user step by step to a solution. The results of the DSS must be accurate enough, so that the decision maker can rely on the results.

Analysis function

The analyses function is one of the strengths of a DSS. It gives insight in a complex problem by structuring the problem and calculating the effects of possible solutions. If accurate modelling is not possible, the DSS can contain guiding principles and illustrations of comparable situations.

Communication function

The presentation of the results of the DSS to the user in figures and tables can support the communication between stakeholders. Also when the user gets clearer insight into the problem, it helps him or her to communicate. Communication is one of the decisive factors of the success of solving a water problem.

Education function

Presentation of the results of the analyses helps in decision making, but also leads to a better understanding of the problem by the user. The DSS can also be employed to educate different stakeholders on USWM.

Library function

The database and the model base contain structured information, which make a library function work. One of the success factors of a DSS is the ease for the user to find relevant information and knowledge.

A DSS always contains all these functions. It depends on the architecture of the DSS which functions prevail. Next view shows the five functions applied to the functioning of the ADSS.

Function	**ADSS**
Management	The user is systematically guided to a solution of the problem by giving insight in the structure of the problem and by evaluating alternatives to solve the problem.
Analysis	The models used in the ADSS are source and flux models. For Urban conceptual models are used in the form of *mental maps*.
Communication	Communication becomes in USWM a more and more important factor. Especially source control measures require communication with other stakeholders.
Education	The ADSS can give storm water managers new insights into the comprehensive character of USWM and the way to cope with the complexity in USWM.
Library	A lot of information and knowledge is classified in database, which will form an extensive library on USWM.

The main functions for the ADSS are the management and the analysis function. The analysis in the ADSS takes place and the user can choose a solution he thinks it is the best. Criteria for this best solution are the costs and effects of the solution and the capacity to implement a solution. In order to determine the capacity to implement the solution, the ADSS will support an analysis of the way USWM is organised. The management function of the ADSS becomes visible in supporting the implementation of measures, after the capacity to implement a solution is analysed. The management function becomes also visible in guiding the user through the instrument (HCI).

2.5 Output of the ADSS

Depending on the problems perceived in USWM, information and knowledge is needed. Figure 2.2 shows four types problems in policy making and the kind of solutions needed to solve each type of problems. This helps to determine which output of the ADSS is necessary in order to be helpful.

		Acceptation by actors involved	
		(Possible) goals and measures are accepted	(Possible) goals and measures are not accepted
Clarity for actors involved	(Possible) goals and measures are clear	Take formal decision 1st Quadrant	**Important activities:** - Activities for gaining support **Less important activities:** - Consistency activities *2nd Quadrant*
	(Possible) goals and measures are not clear	**Important activities:** - Consistency activities **Less important activities:** - Activities for gaining support 3rd Quadrant	**Important activities:** - Consistency activities - Activities for gaining support 4th Quadrant

Figure 2.2 Four types of problems (after Verbeek, 1997).

The *first quadrant* problems can be solved by taking formal decisions, as the goals and measures are clear and accepted by all actors or stakeholders involved. Traditionally, there was a consensus by actors in USWM about how USWM problems should be solved; optimising the system by for instant increasing the capacity of the sewage system. For a long time USWM problems were typified as first quadrant problems. Problems where goals and measures are clear, but acceptation by actors or stakeholders is missing, can be typified as *second quadrant* problems. Here activities for gaining support are needed. A DSS can support in this process identifying the involved actors and their position towards the problem. These problems can also be supported by use of the DSS as a communication tool. Simulation and analysis of the impact of USWM measures encourage discussion on these measures. In order to facilitate the discussion, the assumptions, models and data used in the DSS have to be accepted by all the involved actors.

In the *third quadrant,* the problem is not the acceptation of goals and measures, but the clarity for involved actors about what these goals and measures should be. The main function of a DSS for this type of problems would be the library of analysis function. It has to provide insights in complex systems by using all kinds of models, in order to give a better understanding of the water system. The library function makes the existing data and knowledge easily accessible and points out if there are blank spot.

Verbeek points out that policy problems often are *fourth quadrant* problems. This means that both the clarity and the acceptance of goals and measures are missing. In an attempt to solve this kind problems it is important that the DSS supports activities for gaining support as well as activities for gaining knowledge (Van Delden, 2000).

USWM decision making has to deal with fourth quadrant problems. Although the overall objective is clear (a sustainable urban storm water system), it is far from clear what kind of measures have to be taken to reach this objective. What is the durability of source control measures and what are the risks of soil pollution? Because of these uncertainties of measures, a broad consensus about the acceptance of these measures (for example source control measures) is missing. The output of the ADSS should therefore consist of technical data of possible measures, including a description of the measure, the functioning of the measure the effects and the costs. This is the hard information, but not enough to make implementation successful. Therefore, the ADSS has also to support the implementation process of measures, including convincing and involving of stakeholders to support measures. The usefulness of the ADSS for the implementation is however limited, because of the unpredictable character.

2.6 Adaptation

One of the main characteristics of the information system, developed in Daywater, is the A of the ADSS, which stands for adaptive. Adaptive is defined as the quality of the ADSS to adjust the information and knowledge given, according the problems perceived and existing in the real world. The adaptive character is necessary in order to be helpful in 'fourth quadrant' problems. Chuang (1998) defines an ADSS as 'a DSS that is able to automatically or manually modify some aspects of its structure, functionality, or interface to meet different needs in its users'.

On base of Chuang (1998) the next characteristics of an ADSS can be described:

Characteristics	ADSS	Components
1. *Multiple views*	An ADSS should be able to support multiple presentation modes to accommodate the heterogeneity of users. Given a particular user engaged in a particular problem situation, an individually tailored presentation mode should be provided for the user.	Guidelines for implementation
2. *Multiple scenarios*	Like traditional DSS, an ADSS should be able to support the decision maker for performing 'what if' analysis of various scenarios.	Definition of scenarios
3. *Different problem situations*	With the least help from the user, an ADSS should be able to generate various knowledge states for various problem situations within the problem domain and support the decision maker in different problem situations.	Problem definition in terms of system and context.

G. Geldof (2002) has developed valuable insights in the usefulness and organization of adaptive USWM. One of the aims of the ADSS is to support the user reorganizing to adaptive USWM in order to make an overall transition to source control measures a success. These insights will be used in WP3.

2.7 Conclusions

The literature study has resulted in the next definition of the ADSS to be developed in Daywater.

The ADSS contains a web-based model, which supports decision making in USWM in order to find the best suitable measures by adapting to a clear problem definition and accompanying measure, by analyzing the effects of possible measures, by letting the user reflect on his capacity for implementation and by managing the user through guiding principles in implementing chosen measures. It also contains reports, roadmaps, leaflets, research results, etc that can be used by the user to handle storm water in urban area.

According the literature the components needed in the ADSS are:

- Problem definition
- Developing scenarios
- Developing indicators through the WP's
- Reflection of the ambition of the user
- Guiding principles for implementation

The next chapter relates these components into a flow chart.

3 A first template

3.1 Introduction

According to insights out of the literature study and many discussions with partners, a first template of the ADSS is developed in the form of a flow chart. In the flow chart, the different work packages of Daywater are integrated. This makes the mutual dependency of the WP's visible and the contribution of WP's to the ADSS as a whole.

3.2 The flow chart

The flow chart is the backbone of the ADSS. It contains the *components* and the relation between these components. A component is a pre defined basic homogeneous element of the ADSS. The flow chart describes the steps, which need to be taken in USWM in order to define helpful measures. The aim of Daywater is to support USWM to find the best solution for a given water problem based on a balanced weighing of traditional and source control measures. The flow chart of the first template of the ADSS is presented in figure 3.1.

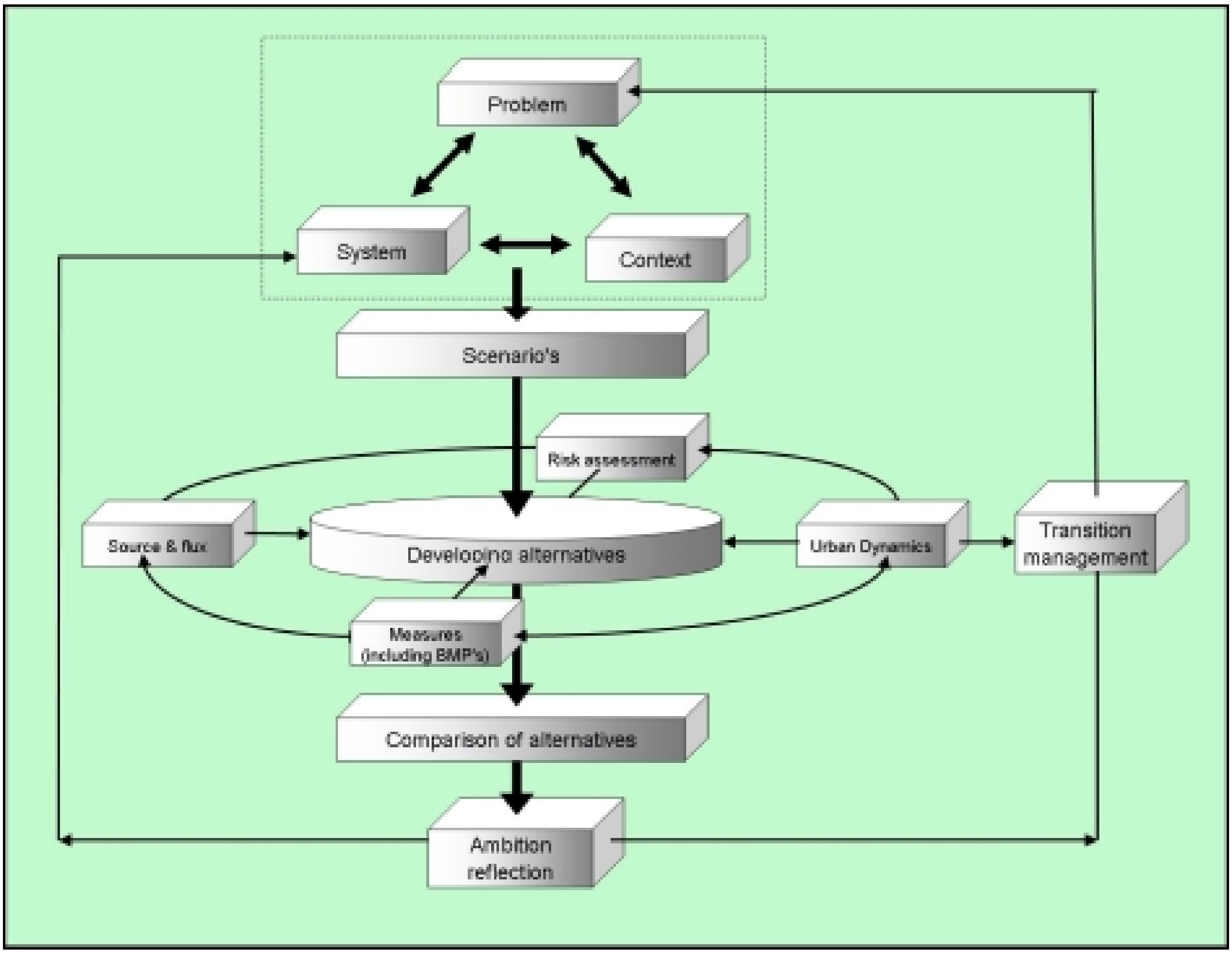

Figure 3.1 Flow chart of the ADSS.

Remarkable of the flow chart is that it has no clear start and end. The idea is that the user by iterating the scheme can find a solution that suits his specific problem situation. In this way, the ADSS can adapt to a helpful solution. On top of the flow chart, a problem must be defined. This is an important step, but often neglected or too fast passed through. A clear problem definition results in helpful solutions at the end. The user defines his problem by a first investigation of the technical water system in order to find physical causes and effects. This enables the user to sharpen the problem definition. In addition, context related matters can sharpen the problem definition. Context related matters for example are the historical background, the perception of the problem by other stakeholders then the storm water manager, etc. The system and context provide in boundary conditions and the first evaluation of *indicators.* An indicator is what the user marks as important characteristics of the problem definition.

Next, scenarios are stated which give direction in a vast amount of possible solutions of the problem. At a first round, the user might skip this component, in order to set up directly alternatives to gain insight in possible outcomes. After defining a scenario, the user can select different measures solving the problem. The indicators of these measures are developed in the WP's Urban Dynamics, Risk Assessment, BMP's and Source & Flux. The indicators help the user to compare and decide on the measures to implement.

The comparison of measures has a static character. The implementation of measures is dynamic. Therefore, the user has to reflect on his ambition. Does he or she want to make the effort, needed for implementation of the measure? The efforts can be quite different, regarding different possible measures. Great efforts are needed when a *transition* of USWM has to take place, in order to implement measures. A transition of USWM means that the organisation of USWM must structurally change, because the present organisation of USWM is insufficient to implement specific measures, for example when extensive cooperation is required with social stakeholders. If this is the case, the user has to redefine his problem definition in terms of transition management. The user can also choose to develop new alternatives, starting with a refined definition of the water system.

In section 3.4, the components of the flow chart will be elaborated.

3.3 Components of the ADSS

3.3.1 Problem description

Einstein once stated, "You cannot solve the problem with the same kind of thinking that has created the problem." This learns not only to focus on the problem itself, but also to develop a helicopter view on the problem. The problem definition must contain technical or physical data concerning the problem, but also the framework in which the problem exists. For example, the way USWM is organised, or political, historical or cultural processes.

To assist the storm water manager in solving the problem, the ADSS must 'know' what the problem is, in order to guide the user through the ADSS and to come up with a helpful solution. Posing the who, where, when and why questions, the problem of the user can be found out. The why question clarifies the answers, which leads in the end to the pre-defined problems in the ADSS. Table 3.1 illustrates this.

Table 3.1 Defining the problem.

What is the problem?	**Water on street situations**	Why?
How?	To reduce water on street	– because inhabitants

	situations?	complain – because risk of health / dangerous situations – because of damage on infrastructure
Who?	inhabitants	– Inhabitants are bothered – inhabitants have damage on houses
When?	extreme rainfall situations	
Where?	lowest geographic places	
What?	prevents water on street situations?	

One of the tasks in WP2 will be to work out these questions into a tree. This tree helps the user to come up to pre-defined problem definitions. The main problem in USWM is clear, storm water causing trouble or even dangerous situations. The causes of this problem and thus the possible solutions can be very complicated to find and depend on the perception of the problem owner. Some examples:

- The malfunctioning of the water system as a whole.
- The maximum effect of the control-approach of the water system is reached.
- Straightforward and inexpensive technical solutions with short-term effects prevail on sustainable solutions, which ask for structural changes.
- Stakeholders do not like to change to a new type of measures, because of uncertainty.
- The lack of knowledge for implementing source control measures.
- Laws on USWM make it hard to change to a source-control approach
- Restricted budget for USWM
- Formal attitude of water partners, which make cooperation impossible
- The unwillingness of the storm water manager to communicate with inhabitants
- The way USWM is organised.
- Etc.

The problems, the ADSS has to answer, will be brought forward by the Core End Users (CEU). The definition of underlying causes of problems should come from the partners interacting with the CEU. The CEU have received a questionnaire, developed in WP3, to come up with their problems on USWM. The results of the survey will be analysed in WP7 resulting in a characterisation of CEU-sites, including the way USWM is planned. WP3 will use the results for the analysis of Urban Dynamics.

Indicators

Next to formulating the problem, the user has to define indicators, which express what matters to the storm water manager. Later on, these indicators play a role in formulating criteria to decide on different alternatives.

3.3.2 System and Context

The next step in the ADSS is to research causes by analysis of the system in which the problem exists and its context. The *system* is the coherence of water streams in natural structures or in man-made infrastructures. The water system exists of: rain water, surface water, groundwater plus the soil and banks together with storm water, drinking and sewage water in the drinking or sewage system. The *context* is each event that influences the water system, so it stands for the environment in which the water system is situated. Examples of processes or events in the context are:

- Physical planning for urban area's
- The legal framework for USWM or other activities influencing the system.
- The stakeholders
- Economic structure

The component 'Context' will be filled with information form the problem description regarding the real or structural causes, the component 'System' will contain the symptoms or the effects of the problem with which the storm water managers are directly confronted. The information in 'System' will be used to find technical source control solutions, the information in 'Context' will be used to determine if the technical solution fits in its environment: geographic conditions, the budget, the legal framework, etc. This information is necessary in order to make source control measures work. The context itself consists of two parts. The first part is USWM, or the formal organisation of the management of storm water. The second part is Urban Dynamics, concerning all kinds of events which possibly can influence the water system.

The division in system and context is important, because it makes clear that both finding technical solutions for solving water problems and the implementation of technical and other measures (e.g. influencing behaviour of stakeholders) in a complex environment is important. The information gathered in the component context is also useful for derivation of guiding principles for implementation of measures.

3.3.3 Scenarios

Before zooming in on setting up alternatives to solve defined problems, the formulating of scenarios is needed. Scenarios are developed as directions in which solutions can be found. Scenarios can be seen as a kind of boundary conditions for developing alternatives. The aim of formulating scenarios is to get clear the possibilities of the user for implementing source control measures. Scenarios can be derived when a first description of the system is known, which takes place in the first step: problem description.

Examples of scenarios are:

- According the current policy on USWM
- Low costs
- Strong control
- Optimal harmony with other policy fields
- Short time effects with a minimum of uncertainty
- Source based measures
- Fit in with political situation
- Maximum use of effort inhabitants or other stakeholders
- Percentage of reduction of surface run-off.

3.3.4 Alternatives

After the scenarios are chosen, alternatives will be deducted. These alternatives consist of measures, combined with all kind of indicators, summarized in the core database of the ADSS. The indicators are elaborated in the Urban Dynamics, Risk assessment, BMP's and Source & flux modelling.

Table 3.2 Core database of the ADSS.

Measures (WP5)	Scenario1 Cost	Scenario2 Infiltration	…	WP3 Communication needed?	WP4 Pollution oils?	WP6 Outflow?
BMP 1						
BMP 2						
end of pipe1						
end of pipe1						

3.3.5 Urban Dynamics

The Urban Dynamics concern the processes in the context, which are relevant for implementing certain measures (see D3.1). In the core database the Urban Dynamics are described in indicators, which is static. The dynamic character of Urban Dynamics becomes clear in the definition of the problem and in the implementation of measures. The structuring of all kind of possible influences of Urban Dynamics on the water system will be elaborated in D3.1.

3.3.6 Risk assessment

Risk becomes a more and more important factor in decision making. The level of risk of certain BMP's is one of the indicators for choosing between alternatives. Risk assessment not only concerns the technical risks, but also the risk perception. Risk and the risk perception must be in balance for safe situations. How this must be realised in USWM, will be worked out in WP4.

3.3.7 Measures (including BMP's)

The component measures is a database with all kinds of BMP's and standard solutions. The description of the measures must contain technical, ecological, social, financial, legal and organisational indicators. This will be worked out in WP5.

3.3.8 Source & Flux models

In the component source and flux models, the functioning of separated technical water measures and of the technical system can be analysed. By this the effectiveness of measures can become clear. To make this analysis possible, some models will be integrated into the ADSS. However, to make the ADSS widely applicable it should be always possible to use own methods or models to analyse measures. WP6 has the aim to develop de source & flux analysis in the ADSS.

3.3.9 Comparison of alternatives

The alternatives will be evaluated on criteria in a multi criteria analysis. These criteria will be based on the indicators, important to the decision maker (user). Also the indicators given in the component problem definition will be used. As a result of this component, a ranking of alternatives will appear. These alternatives serve for input in the next step, the reflection of ambition.

3.3.10 Reflection of ambition

Deriving alternatives to solve water problems is not enough. The storm water manager has to reflect on the way USWM is organised in order to determine if he is able to execute proposed alternatives. Some important questions to ask in this component are:

- How to cope with the uncertainty of the alternative?

- Is the organisation ready for implementing the alternative?
- Does the alternative solve the core problem, or does it tackle symptoms?

Only when the storm water has reflected on the possibilities and goals of USWM, the ADSS can support in formulating practicable advice.

Three types of USWM can be distinguished: basic, functional and contextual. These types are worked out in D3.1. The different types of USWS determine the possibilities the storm water manager has to execute alternatives. The possibilities stretch out from end-of-pipe to source control measures. The ADSS must help the user to give information on the best suitable measure for a specific situation. End-of-pipe measures will fit in the basic and partly in the functional type, source control measures partly in the functional and in the contextual type.

3.4 Feedback loops

When it becomes clear that the alternatives cannot be implemented, because of the attitude of the storm water manager, two basic choices can be made. The first is searching for another alternative that suits the current attitude. This is done by a feedback to the components system and context, so it is possible to refine the knowledge of system and context in order to come up with a new scenario and new alternatives. The second choice the water manager can make is to change the attitude. This widens the possibilities for the storm water manager to implement source control measures, but also asks for transition management. This last option is the hardest, because transitions are not easy to comply, for example the transition from a control to an interactive attitude. One of the side-effects of the control attitude is that the storm water management is strongly pulled to storm water managers. As a consequence other stakeholders do not feel responsible for the system. Possible appeals on other stakeholders, needed for specific source control measures, will not work. This is one of the factors making a *transition* from the control to the interactive scenario difficult.

When the user chooses for a transition, redefinition of the problem is needed. The difference in previous iterations is that the problem definition will focus now on processes in the context. Some questions are:

– What is the legal framework of the current USWM?

– What is the commitment of stakeholders?

– How to stimulate cooperation between stakeholders?

The measures needed for structural change in USWM have another character then the BMP’s, for example measures that focus on influencing behaviour of stakeholders.

After the reflection on the ambition it is also possible that the alternative fits with the desired attitude of the storm water manager. Then a *roadmap* can be given as a scheme for implementing the desired measures.

3.5 Iteration and shortcuts

After presentation of the components of the flow chart is important to stipulate that the ADSS does not have a clear endpoint, which illustrates clearly how the instrument must function: by guiding the user in finding solution for his water problems. Iterations in the flow chart make solutions become more detailed and adjusted to the possibilities and goals of the storm water manager. The assumption is that users will start with a focus on the functioning of the system and step by step will give attention to context-related processes which can be used to tune the desired technical solution to the way USWM is organised. So in the first stage of use the accent lies on the system and while working to solutions, the accent shifts to processes in the context. Working in loops makes it possible to work from coarse to fine. Each loop will need and give more detailed information and a more precise alternative can be found. While working with the ADSS, the user adapts to the right solution for his problem.

The iterative use of the ADSS requires extensive use. On the other hand it must also be possible to get quick access to information in the ADSS. To make this possible shortcuts have to be implemented.

3.6 Mulit - user

The importance of the perception of the problem for advising effective measures, asks for characterisation of different users of the ADSS. This is also expressed in different discussions with Daywater partners. This makes that different participants in the urban storm water problem can use the DSS, which will stimulate interaction and commitment of the participants towards a final solution. Different users might be presented at different levels of the DSS, with different components available or different parts of the database available. All these levels must be available in the ADSS so interaction between the levels should be possible. This is visualised in Figure 3.2. If and the way this should be implemented it still uncertain and will have to be discussed and worked out in future.

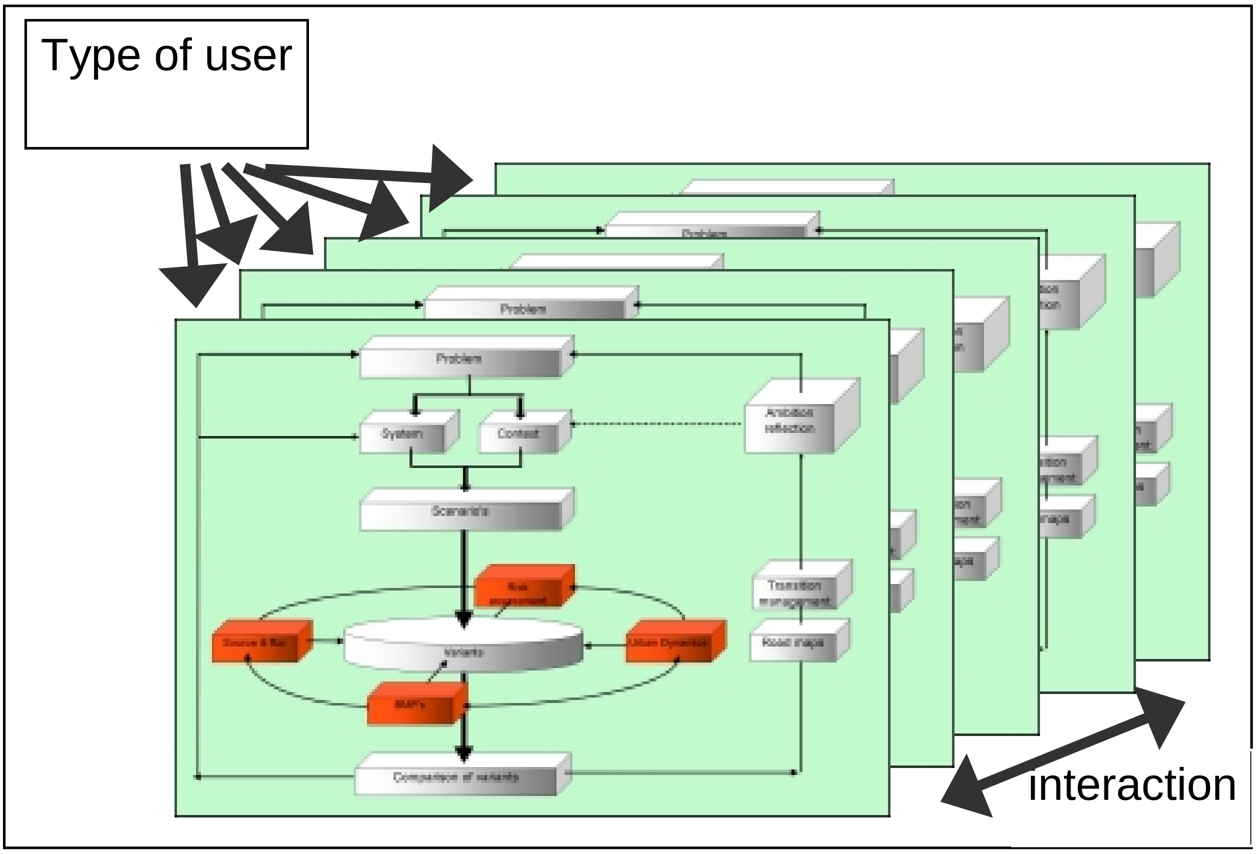

Figure 3.2 Multi-user functionality of the ADSS.

4 Review of existing tools

This chapter gives a short description of the research for existing tools in USWM. First a description of the guidelines and the organisation of the research is given. Then the results of the survey are presented and the tools are classified to the different components of the ADSS.

4.1 Guidelines and organisation

In order to assess the opportunity to incorporate existing tools in the ADSS, it was agreed that each Daywater partner would conduct a survey to the existing tools in his country. These existing decision support tools in urban storm water management (USWM) will be used to build a template ADSS for the first testing round. The guidelines for collecting, structuring and analysing the existing tools are given in appendix 1. The goal was to challenge every partner to think about the relevance and use of the tools in relation to the ADSS in order to produce a limited pre-selected list of 'state of the art' tools.

Tauw also asked to express the ideas on the ADSS in order to use those for constructing the flow chart of the ADSS. This 'I have a dream' description should contain several elements: which function(s) do you think the ADSS should have? What are your ideas on the definitive ADSS regarding the degree of detail, the ability to adapt, etc? What do you think are critical elements in the ADSS that should deserve full attention? What should definitely not be the end product of this project?

Partners had to complete their survey to existing tools before 14 April 2003. In the months April and May 2003 Tauw has synthesised the collected tools and incorporated them in the first template of the ADSS.

4.2 Results of the survey

The answers from the different partners to the request to come up with a selection of 'state of the art' tools in their country are given in a table in section 4.3. The table gives a summary how the model works, what the strengths and weaknesses are and how the tool can be used in the ADSS – Daywater. Table 1 gives an overview of the results.

Table 4.1 Overview of the results.

Partner:	**Tool**
Middlesex University London	SWARD – Sustainability of water systems
	Decision support for the design of retrofit SUDS
	GIS based DSS for sustainable urban drainage
	Development of small Greenfield sites
Technical University of Denmark	4P Hazard and problem identification model
	Wastewater in sewer less settlements (web-based)
Ecole Nationale des Ponts et Chaussées	ELECTRE IS, ELECTRE III – IV, ELECTRE TRI
	SFR
	DELTANOE
	Plando

	Canoe
DHI Hydro inform, a.s.	DSS Czech Republic
Ingenieurgesellschaft Prof. Dr. Sieker. GmbH	STORM

The contribution of partners and therefore the usefulness of the results of the survey were not according to our expectations. Tauw expected that the description of the tool should give enough information to implement the different tools in a first template of the ADSS. The architecture of the flow chart should then be filled in by the different tools. In stead, the description of the tools gave no extra information. It was not clear what the model was doing, what the input, output, of throughput was, or how it could be implemented in the ADSS. The information received is implemented in a table, consisting of the name, the goal, the working, the strengths and weaknesses of the model and the possible contribution to Daywater. In the column ‘contribution to Daywater’ a first possible application of the model for the ADSS is mentioned. A full description of the submitted descriptions of tools can be obtained by Tauw. In appendix 2 a mind map has been set up in which different tools are integrated. The possible integration of these tools takes place in WP2.

4.3 DSS Tools in Europe

Table 4.2 DSS tools in Europe.

Name of the model	**Goal of the model**	***Working of the model***	***Strengths***	***Weaknesses***	***Contribution to Daywater***
Middlesex University London:					
A. SWARD – Sustainability of water systems	Judgement of the sustainability of a certain solution	Multi criteria analyses with aspects considering economics, environment, social and technique.	A lot of aspects are taken into account	• Difficult to compare different criteria • Water manager is not objective	Scenario Risk assessment Comparison of variants
B. Decision support for the design of retrofit SUDS	Gives the best solution for source control measures	Flow chart with a multi criteria analyses	Convenient to use	Some assumptions have to be made	BMP
C. GIS based DSS for sustainable urban drainage	Gives solutions for source control measures given a certain situation	GIS maps with detailed information about ground use and soil type give source control measures	Clear maps as result	Some assumptions have to be made	BMP
D. Development of small Greenfield sites	Selection method for small infiltration sites	Small flowchart	Fast and Convenient to use	Very simplistic	BMP
Technical University of Denmark:					

Name of the model	Goal of the model	*Working of the model*	*Strengths*	*Weaknesses*	*Contribution to Daywater*
4P Hazard and problem identification model	Problem identification / risk assessment when rainwater is reused or discharged	Analyses of the quality of rainwater	Indiscrimination: all potentially present compounds are listed without limitations Screening: Provides overview and assists the user in keeping focus	Inherent properties and environmental data are not available for all pollutants. Data on chemicals used in e.g. building materials, roofs, and roads may be incomplete or inaccessible.	Source & flux BMP Risk assessment
Wastewater in sewer less settlements *'Spildevand i kloaklose bebyggelser'*	To provide a coherent concept for planning and assessing solutions to sustainable handling of wastewater in areas without conventional sewer systems.	A web-based DSS composed of tools to assist users with the following tasks: • on-site analysis • dialogue workshops • technology information tool • Conducting assessments	Users are forced to think in a structured manner. Using the web-media sets a new stage for communicating information to a broad target group, especially when there is a large need for updating information.	Maintaining and updating a web-based DSS requires continuous organisation and funding. The access to the Internet can be a large barrier in some parts of Europe. The DSS is only available in Danish.	Context Urban dynamics
Cereve:					
4.3.1.1 ELECTRE IS	Comparison of different variants based on quantity and quality criteria.	Multi Criteria Analyses	• Easy to use and understand • Can be used in a wide range of problems	Comparison of variants and criteria is not always possible	Comparison of variants
ELECTRE III – IV	Presentation of different variants based	Multi Criteria Analyses	• Easy to use and	Comparison of variants and criteria is not	Comparison of

Name of the model	Goal of the model	*Working of the model*	*Strengths*	*Weaknesses*	*Contribution to Daywater*
	on quantity and quality criteria.		understand • Can be used in a wide range of problems	always possible	variants
ELECTRE TRI	Sorting of different variants based on quantity and quality criteria.	Multi Criteria Analyses	• Easy to use and understand • Can be used in a wide range of problems	Comparison of variants and criteria is not always possible	Comparison of variants
SFR	Helping a decision-maker defining the ranking and the relevant importance (weighting) of the criteria	The user answers various questions about his preferences and does many different rankings of the criteria	Can be used in combination with ELECTRE tools	Comparison of variants and criteria is not always possible	Comparison of variants
DELTANOE	It gives a better application and dissemination of BMP's in USWM.	It does a sorting out of variants to technical possible or impossible or possible under restrictions	• Easy to use • Good visual presentation of the results	It takes into consideration only technical criteria	BMP
Plando	This tool collects and helps in the analysis of information related to retention ponds	It is based on a database containing tables related to catchment occupation, pond description, water quality, ecology and management.	Its capacity in gathering data	The lack of data	BMP
Canoe	Design and analysis of urban water systems (waste and runoff water)	Simulation tool combing the description of a project,	The quality of the hydraulic modelling.	Bugs, the water quality model is not yet	BMP

Name of the model	Goal of the model	*Working of the model*	*Strengths*	*Weaknesses*	*Contribution to Daywater*
		rain data, pipes characteristics library, and hydraulic modelling.		reliable	
Germany					
STORM	Tool for analysing alternative BMP's	Multi reservoir model	Gives fast insights in effect of alternative BMP's in relation to the water system	No information	Useful for BMP analysis and comparison
Czech Republic					
DSS	Development of national water management plans	The user has access to data bases and modelling tools through a graphical / GIS interface	No information	No information	No information
4.3.2 Tauw					
Source control opportunity map	The Source control opportunity map (SOM) indicates the possibilities of disconnecting storm water from combined sewage systems depending on the suitability of the soil and the surrounding. Also the map gives insight in ways of	The SOM is a GIS analysis based on a decision tree and a database. Using the so-called overlay technique the map can be divided into several categories of source control possibilities. These categories vary from infiltration of storm water to surface	The SOM can be applied on different scales in urban storm water management depending on the degree of accuracy of the database. Because the tool is a GIS application, the results are visually attractive.	The possibility of source control is, in the first place, based on physical conditions. Other conditions, such as the willingness of the inhabitants, might be very important but are not always taken into account. The SOM produced for the strategic use on a	We think that SOM can be used as a brick in building the first template ADSS because: • The relevant physical conditions are taken in account; • The decision tool can be used

Name of the model	Goal of the model	*Working of the model*	*Strengths*	*Weaknesses*	*Contribution to Daywater*
	discharging (surface or subterranean) storm water to facilities and in the need for drainage of urban area.	discharge to surface water.		global level is not directly applicable on a local and detailed level	on more than one scales; • Other elements such as risk assessment, urban dynamics can be added in order to obtain a more complete picture; • SOM is a GIS application and the results are visually attractive.
IBOS	This model gives insight in the way we should handle wastewater in the local situation that contains little or no constituents The goal is to give an advice for the development of a long-term vision and to help the decision maker make a choice with the design and control of the wastewater system and the granting of	The IBOS focuses on technical and environmental aspects concerning the handling of little polluted wastewater in urban areas. The presentation of relevant information and the results is adjusted to the local situation. Also the model is regularly updated and works at different special scales such as house, street, district or city	It is an adaptive decision support system for the Dutch situation.	- under construction - Build for the Dutch USWM situation - Not user friendly (expert tool)	This model can be very helpful in the ADSS – Daywater. The meaning of the word interactive in the name of the model: “interactive decision support system” is one way of adaptation. In this way the model is some sort of ADSS. Also the model can be used in the component BMP because it gives

Name of the model	Goal of the model	*Working of the model*	*Strengths*	*Weaknesses*	*Contribution to Daywater*
	licenses.				different possibilities for handling storm water.
TauwSim	TauwSim is a model that supports water management. It helps in decision making in new and already existing urban areas. The model gives insight in the (working of the) complex structure of water management in a relative simple manner.	In TauwSim the water system is reduced to a series of different water level tanks. These reservoirs are connected to each other. In each reservoir all the compartments of the hydrological system and the surface water are calculated.	The output is given in figures, which make them easy to understand.	- Tauwsim gives information on a global level - Not user friendly (expert tool)	TauwSim can be useful in the ADSS – Daywater. It is a simplification of a water system, which makes it easy to use and understand. It gives a good impression of the impact on the whole water system and the possibilities for source control.
Hydro works	It is a programme that makes hydraulic calculations based on GIS-maps.	The program calculates with different types of rain events and determines how much water runs off to the sewer system, how fast the sewer system is filled and how often there is a discharge of the system to the surface water	The model can make maps, graphs or tables, depending on the user. The output is visually attractive, because the use of GIS. The tool is very effective in situations where there is water on the streets as a result of too much rain.	- Hydro works is a heavy tool that needs heaps of data, before it can be used.	The tool can be of use in the ADSS – Daywater. If a new part of a city is designed, the sewer system can be dimensioned in such a way that maximum source control measures are taken into account.

5 What's next?

This report describes the first template of the ADSS in the form of a flow chart. This flow chart needs to be worked out in order to set up a digital version of the ADSS, which is the aim of WP2.

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Appendix 1

Guidelines for the survey

Appendix 2

Overview of decision tools in the flow chart of the ADSS