STORM-Rhine
Simulation Tool for River Management

Final Report - Executive Summary

for
IRMA - SPONGE
Roleplay for transboundary river management
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PREFACE

This report and the IRMA-SPONGE Umbrella Program

In recent years, several developments have contributed not only to an increased public interest in flood risk management issues, but also to a greater awareness of the need for improved knowledge supporting flood risk management. Important factors are:

- Recent flooding events and the subsequently developed national action plans.
- Socio-economic developments such as the increasing urbanisation of flood-prone areas.
- Increased awareness of ecological and socio-economic effects of measures along rivers.
- Increased likelihood of future changes in flood risks due to land use and climate changes.

The study leading to this report aimed to fill one of the identified knowledge gaps with respect to flood risk management, and was therefore incorporated in the IRMA-SPONGE Umbrella Program. This program is financed partly by the European INTERREG Rhine-Meuse Activities (IRMA), and managed by the Netherlands Centre for River Studies (NCR). It is the largest and most comprehensive effort of its kind in Europe, bringing together more than 30 European scientific and management organisations in 13 scientific projects researching a wide range of flood risk management issues along the Rivers Rhine and Meuse.

The main aim of IRMA-SPONGE is defined as: "*The development of methodologies and tools to assess the impact of flood risk reduction measures and scenarios. This to support the spatial planning process in establishing alternative strategies for an optimal realisation of the hydraulic, economical and ecological functions of the Rhine and Meuse River Basins."* A further important objective is to promote transboundary co-operation in flood risk management. Specific fields of interest are:

- Flood risk assessment.
- Efficiency of flood risk reduction measures.
- Sustainable flood risk management.
- Public participation in flood management issues.

More detailed information on the IRMA-SPONGE Umbrella Program can be found on our website: *www.irma-sponge.org*.

We would like to thank the authors of this report for their contribution to the program, and sincerely hope that the information presented here will help the reader to contribute to further developments in sustainable flood risk management.

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(NCR Secretary and IRMA-SPONGE project manager)

ABSTRACT

The Simulation Tool for River Management (STORM), based on the River Rhine case, aims to provide insight into river and floodplain management, by (1) raising awareness of river functions, (2) exploring alternative strategies, (3) showing the links between natural processes, spatial planning, engineering interventions, river functions and stakeholder interests, (4) facilitating the debate between different policy makers and stakeholders from across the basin and (5) enhancing co-operation and mutual understanding.

The simulation game is built around the new concepts of “Room for the River”, Flood Retention Areas, Resurrection of former River Channels and “Living with the Floods”. The Game focuses on the Lower and Middle Rhine from the Dutch Delta to Maxau in Germany. Influences from outside the area are included as scenarios for boundary conditions.

The heart of the tool is the hydraulic module, which calculates representative high- and low water-levels for different hydrological scenarios and influenced by river engineering measures and physical planning in the floodplains. The water levels are translated in flood risks, navigation potential, nature development and land use opportunities in the floodplain.

Players of the Game represent the institutions: National, Regional, Municipal Government and Interest Organisations, with interests in flood protection, navigation, agriculture, urban expansion, mining and nature.

Players take typical river and floodplain engineering, physical planning and administrative measures to pursue their interests in specific river functions. The players are linked by institutional arrangements and budgetary constraints.

The game particularly aims at middle and higher level staff of local and regional government, water boards and members of interest groups from across the basin, who deal with particular stretches or functions of the river but who need (1) to be better aware of the integrated whole, (2) to understand the interests and considerations of others and (3) to experience the mutual benefits of co-operation. There is potential for using the game as one of the tools in support of interactive formulation of policy and participatory decision-making in actual plans.

Keywords are: simulation game; roleplay; participatory decision-making; river functions; stakeholder interests; river engineering and management; floodplain management; institutional arrangements; biological, hydraulic and morphological processes; spatial planning and land use.

Table of Contents

ABSTRACT

1	OBJECTIVES	1
1.1	Objectives of the Project	1
1.2	Objectives of STORM	1
1.3	Making use of the STORM	1
1.4	Roleplay setting	2
1.5	Project Implementation	2
2	ANALYTICAL FRAMEWORK	3
2.1	Concepts	3
2.2	Design Conditions	3
2.3	Characteristics of the River Rhine	4
2.4	Scale of the Simulation	5
3	FUNCTIONAL DESIGN	6
3.1	Introduction	6
3.2	River and Floodplain Functions	6
3.3	River and Floodplain Management	6
3.4	Institutional Framework and Roles in the Simulation Game	8
3.5	System Model	9
3.6	Scenarios and Vision Development	10
4	RESULTS	12
4.1	STORM-Betuwe	12
4.2	STORM-Delta	12
4.3	STORM-Rhine	13
4.4	Roleplay Setting	13

TABLES

Table 1	Functions and performance criteria in STORM	6
Table 2	Management measures in STORM models	7
Table 3	Overview of river management tasks and responsibilities	8
Table 4	Categorised modules	9

FIGURES

Figure 1	Elements of simulation games	3
Figure 2	Linkages between players	3
Figure 3	River Rhine Basin	4
Figure 4	Shipping volumes and bottlenecks	5
Figure 5	Reach covered by STORM-Rhine	5
Figure 6	River management relations	7
Figure 7	Structural measures in the river and floodplain	7
Figure 8	Relation between modules and the system models	9
Figure 9	Example of STORM-Betuwe interface	12
Figure 10	Example of STORM-Delta interface	12

5 OBJECTIVES

5.1 Objectives of the Project

The objective of the project is to develop a simulation game for trans-boundary river and floodplain management, with as case study the River Rhine. The tool will be known under the name STORM (Simulation Tool for River Management).

5.2 Objectives of STORM

Considerations
Large river basins are complex management systems because of
- the highly interrelated hydraulic, morphological and biological processes
- the interactions between human activities and the physical system
- the management measures may mutually reinforce or counteract each other
- the multitude of policy makers and stakeholders with potentially conflicting interests.

Simulation games can educate on the issues, provide a uniform frame of reference, and be a catalyst in cross-sectoral and multi-disciplinary dialogues. Simulation games can also explore how stakeholders may react in case of new scenarios developing.

The River Rhine
The River Rhine is an interesting case in point, where within less than a decade a complete new approach to river and floodplain management has been introduced with concepts as Room for the River, Flood Retention Areas, Resurrection of former River Channels and Living with the Floods, while at the same time the importance of Nature is widely accepted. Although there is a fair level of consensus amongst experts and politicians, there is still a great deal of understanding and awareness raising to be explored, while the implementation of policy measures will highlight the real conflicts still to come. Besides that there are the new scenarios with higher design floods, and hence flood risks, caused by climate change and changing land use.

Objectives of STORM
The simulation game STORM intends to provide a platform for improving insight in river and floodplain management. It sets out:
- to raise awareness of different river functions
- to formulate and analyse alternative management strategies
- to show the links between natural processes, spatial planning, engineering interventions, river functions and stakeholder interests
- to facilitate the debate between different levels of policy makers and stakeholders from across the basin
- to experience the need for and mutual benefits of co-operation.

5.3 Making use of STORM

Experience shows that simulation games can be used in very different settings, focusing on one or more of the objectives above, depending upon the participants and the time available. STORM is considered particularly suitable for the following settings:
- education (particularly to gain insight in complicated multi-disciplinary issues)
- training middle and higher level staff of local and regional government, water boards and members of interest groups from across the basin, who deal with particular stretches or functions of the river, but who need (1) to be better aware of the integrated whole, (2) to understand the interests and considerations of others and (3) to experience the mutual benefits of co-operation

- the same target group as above + policy makers and experts to explore the consequences of for example (1) different visions on development and policy targets and (2) different natural conditions, such as due to climate change and catchment characteristics
- at miscellaneous meetings and conferences for providing a uniform frame of reference or simply “breaking the ice”.

A special challenge would be to use STORM in the following, be it quite different, purposes:

- to discover and explore new ways of river management
- as a tool to support interactive policy formulation and participatory decision-making in actual plans.

5.4 Roleplay Setting

Each role is preferably played by a small group of participants together. The simulation game can be ‘played’ with a computer network, whereby each role can directly enter the desired measures it is mandated to enact. However, the respective roles responsible for issuing permits or binding advice, need to have done so on their own computers, before the measure will be executed. Players may communicate via the network with e-mails. The model (on a central database server) provides feedback on the state of the river in the form of performance criteria. Based on an individual or communal evaluation, players may decide to take additional measures.

It is also possible to engage in the roleplay with one stand-alone computer which runs the model. The role representatives are then provided with hardcopy input sheets, while a ‘game-leader’ looks after processing and feedback with printed output.

With either method the need for interaction between the various roles will prove to be essential in order to produce an integrated river management approach resulting in performance criteria acceptable to most if not all stakeholders and decision makers.

5.5 Project Implementation

The research project was carried out from 1997-2001 by the following partners:

- IHE; International Institute for Infrastructural, Hydraulic and Environmental Engineering; Delft, The Netherlands
- DHL: Delft Hydraulics Laboratory; Delft, The Netherlands
- RA: Resource Analysis; Delft, The Netherlands

The research project was financed by the EU under the IRMA-Sponge Programme, LWI (ICES I), Delft Cluster (ICES II), RIZA and by the partner institutes.

6 ANALYTICAL FRAMEWORK

6.1 Concepts of the River Basin Simulation Game

The main elements of the simulation game are depicted in Figures 1 and 2 below.

The players represent the institutions and stakeholder interests. They have mandates to take measures to pursue their interest in specific river and floodplain functions. The measures may be river engineering oriented, but also land use, economic or interventions are possible. They may reinforce each other or may conflict with each other The measures are analysed by a system model and translated into effects, which describe the functioning of the river and floodplain with respect to the interests of the players. The game may be played in different rounds representing distinct time periods.
The players are linked by a regulatory framework of licensing and budgeting. Scenarios determine under which conditions the game is played for example an increased demand for navigation, a specific design flood or a predicted climate change.

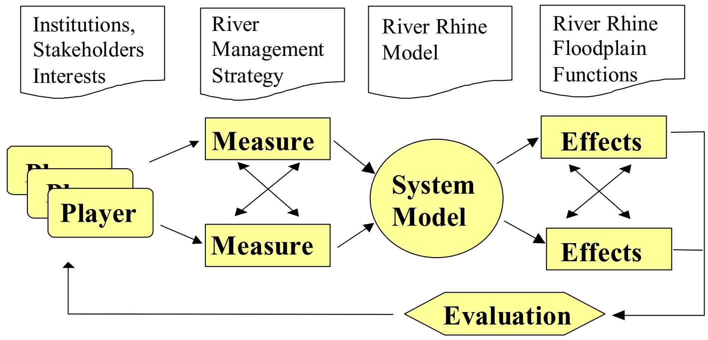


Figure 1 – Elements of a Simulation Game

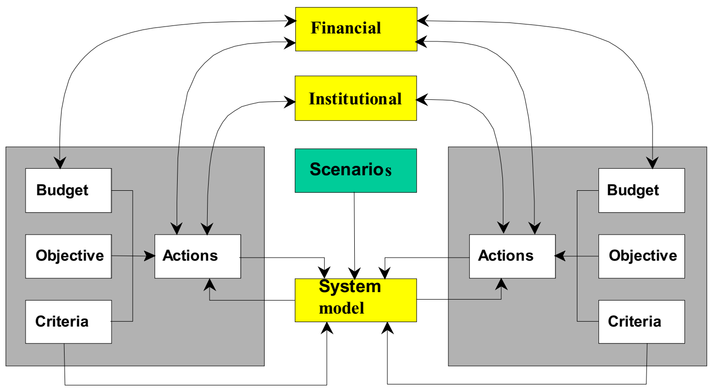


Figure 2 – Linkages between Players

6.2 Design Conditions for Simulation

The design of the simulation game should fulfil a number of conditions, in order to make it interesting to play, and achieve the objectives described above:

- *Realistic and recognisable:* players should be able to recognise the situation. The complexity of river management is that interactions affect different stakes at different scales. For example, in a policy game at river basin scale, the conflicts between decision making at different scales cannot be implemented. The policy game would be very visionary. To have decision makers at a regional or local scale playing a policy game at a river basin scale is not useful if they do not recognise their own decision level. To have decision makers at a river basin scale playing a policy game at a more regional scale, in which their role is represented, is useful. It will increase their awareness of their own role in regional decision making processes. A policy game at a more regional scale with representation of the river basin scale will create a platform for cross-level discussions.
- *Credible:* the system model should report effects, which in their order of magnitude are subscribed to by the "experts"
- *Conflict and dependability*: competing interests and river functions with alternative river management strategies have to exist

These conditions have governed a number of decisions on the scale of the simulation game and the selection of roles, measures and river functions.

6.3 Characteristics of the River Rhine of Importance for the Simulation Tool

The Rhine basin covers six countries, it stretches 1,300 km with a catchment area of 185,000 km^2. Between Rheinfelden and Maxau (Upper Rhine), elaborate river training works have been undertaken to improve navigability. Downstream of Bonn (Lower Rhine) the river becomes a typical lowland river with wide meanders and a relatively wide and flat floodplain.

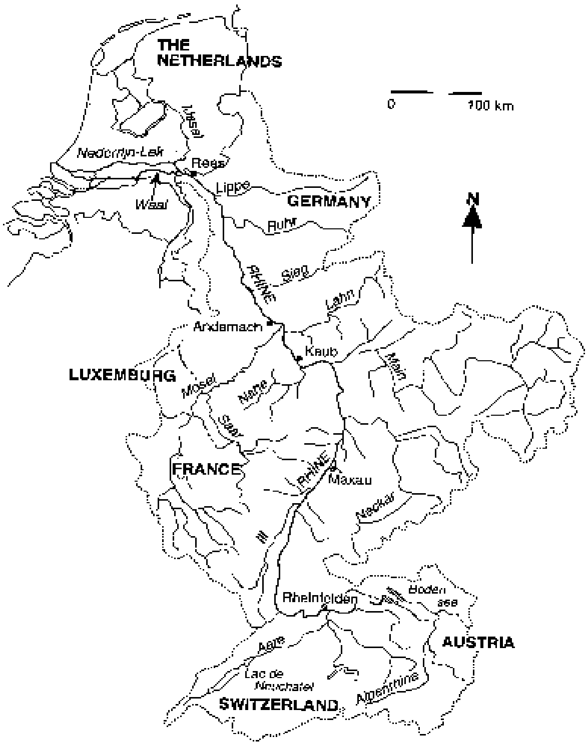


Figure 3 – River Rhine Basin

Main River Functions

The river fulfills the following main functions:

- discharge of rain water and sediments
- facilitate navigation
- provide water for agriculture and industry
- discharge of waste water
- recreation and (recreational) fisheries.

In addition, the floodplains provide for:

- agriculture
- residential and industrial areas
- ecology and nature, recreation
- building materials.

Low and high water-levels, climate change scenarios

The hydrological regime is a combination of rainfall and snowmelt.
High rainfall in the Neckar, Main and Mosel significantly contributes to the genesis of the large floods in the Lower Rhine. The coincidence of high discharge events in the different tributaries, possibly combined with high snowmelt, causes extreme floods. Reservoir operations in the Alps are of little influence. Snowmelt is a significant factor in determining low (summer) water-levels. Low water levels determine the navigation potential, especially at a number of bottlenecks. Climate change scenarios generally indicate a shift of the hydrological regime, with snow-melt regimes diminishing (lower summer water-levels) and rain-fed regimes increasing (higher winter water-levels).

Spatial Planning and Land Use

Land use in the catchment influences downstream discharges, the extent of which is under research. However, there is a kind of consensus that a change in land use policies is not a practical and effective management policy to reduce flood levels. Spatial planning studies mention the following instruments for flood protection:

- store water by preserving and extending lakes
- store water in new detention areas, mainly along the river course and in floodplains
- minimise damage potential
- protection areas with dikes and walls.

There is a link between river discharge capacity and land use in the floodplain, while at the same time the river regime is influencing the types of land use opportune in the floodplain. Consequently, land use planning in the floodplain becomes an important river management tool. Local and regional conflicts on land use are evident.

Water Quality

There has been a remarkable decrease in pollutant loads since the establishment of the International Commission for the Protection of the Rhine (ICPR) after the major pollution disaster in Basel (1986) Water quality is not considered to be a point for discussion.

Shipping

The Rhine is navigable by ocean-going vessels as far as Mannheim, and by river barges to Basel, Switzerland. Some 190,000 ships ply the Lower Rhine and 37,000 the Upper Rhine. Rotterdam is the world's largest port, Duisburg the world's largest inland port. The Rhine was declared free to international navigation in 1868, and in 1919 navigation of the river was placed under the authority of the Central Rhine Commission, with headquarters at Strasbourg. Coal, coke, grain, timber, and iron ore are the principal cargoes carried on the river. The Rhine-Main-Danube canal, completed in 1992, now allows barge traffic between the North Sea and the Black Sea. Shipping is constraint by low summer water-levels and a number of bottlenecks. There is a tendency to make use of less but larger ships.

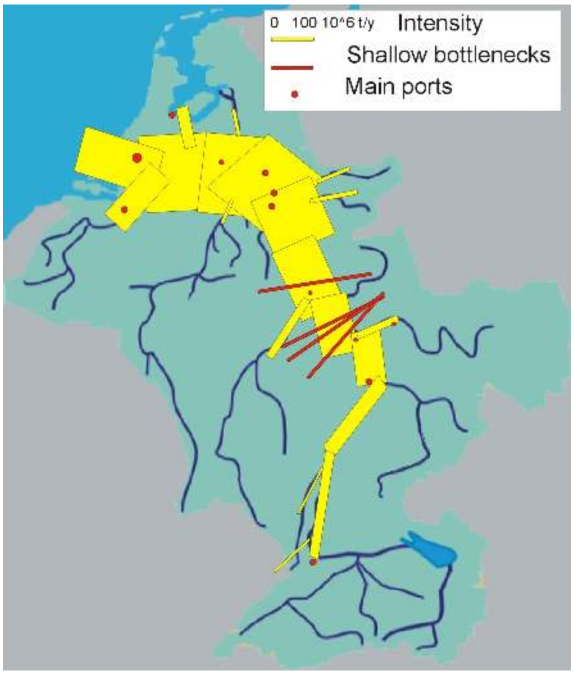


Figure 4 – Shipping on the Rhine

6.4 Scale of the Simulation

The simulation model of STORM-Rhine is restricted to the area where floodplains are of importance, as depicted in Figure 5. The upstream boundary is at Maxau, just upstream of Mannheim and just downstream of the regulated Upper Rhine. The downstream boundary is the limit of the salt intrusion in the three Dutch river branches: Waal, Lek and IJsel. The model is restricted to the main river corridor, with the tributaries incorporated as scenario variables.

The reason for this choice is that it is this reach of the Rhine where the main issues of flood protection, nature, agriculture and navigation are dominant. Directly competing interests exist, especially with respect to land use in the floodplains and between shipping and nature development. Different, interdependent management interventions are available to influence the river functions. These issues and interventions occur at a scale and level, which are recognisable by the intended players of the simulation.

All basin management issues outside this floodplain area are incorporated in the simulation game as scenarios influencing boundary conditions: both for the Rhine proper as for the major tributaries.

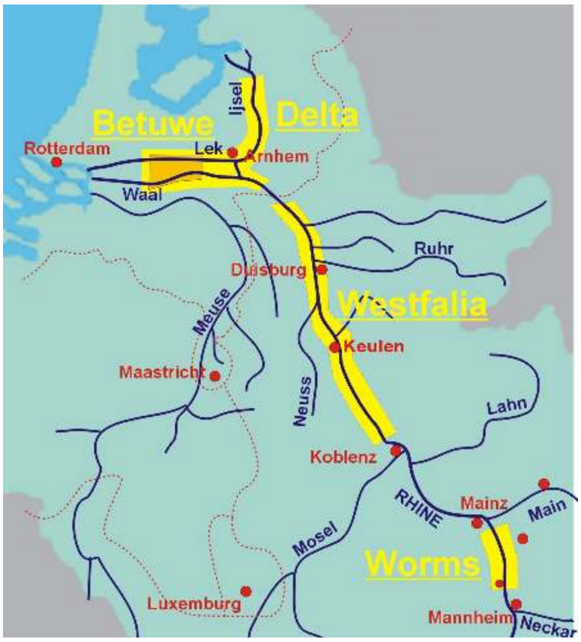


Figure 5 – Reach covered by STORM-Rhine

Three simulation models are presented: STORM Betuwe, STORM-Delta and STORM-Rhine. Westfalia and Worms may be regional roleplays to be developed in a later stage. STORM-Rhine incorporates all and covers the full stretch from Rotterdam to upstream of Mannheim. The three simulations all follow the same principles of modelling and consider the same river functions and management strategies, but describe the river at a different scale, while boundary conditions, scenarios and roles differ as well.

7 FUNCTIONAL DESIGN of STORM

7.1 Introduction

The simulated river reach is divided in 17 branches for each of which management measures can be taken, generally separately for the left and right bank. The hydraulic calculations make use of a finer grid of 83 branches. Effects of the measures are aggregated and presented for each of the 17 river branches.

7.2 River and Floodplain Functions

The river and floodplain functions identify the interests of the stakeholders. Criteria indicate the performance of the function, their value calculated by the simulation model. Table 1 shows the river functions and criteria distinguished by STORM

Table 1 – Functions and Performance Criteria in STORM Models

Function	Performance criteria	Indicator
Flood protection	– maximum water level increase – unsafe river stretch – estimated flood damage – cost of all related measures – cost of flood damages	m km /y /y
Shipping	– change in average turn over per ship/year – additional benefits industrial sector – change in employment in shipping sector – change in employment road transport sector – energy use – CO_2 emission, acid rain (NO_X + SO_2) and smog – investments in new ships – costs of depth increase	/y /y persons persons % %
Nature	– surface area nature – ecological chances – fulfilling of stepping stone function – presence of indicator species – costs of acquiring and developing nature area – cost of nature management	ha - % # /y
Agriculture	– (acquired and total) area of agriculture – yield – cost of acquisition and development	ha ton/yr
Landscape and culture	– degree of openness – agricultural character landscape – managed natural character – spontaneous natural character	% % % %
Construction Materials	– amount of mined clay, sand, gravel – amount of mined polluted soil – cost of cleaning polluted soil	m^3 m^3
Recreation	– land related recreation, water related recreation	ha
Building	– building area in floodplain	%

7.3 River and Flood Plain Management

The relations between different management measures are schematically shown in Figure 6 and briefly described below.

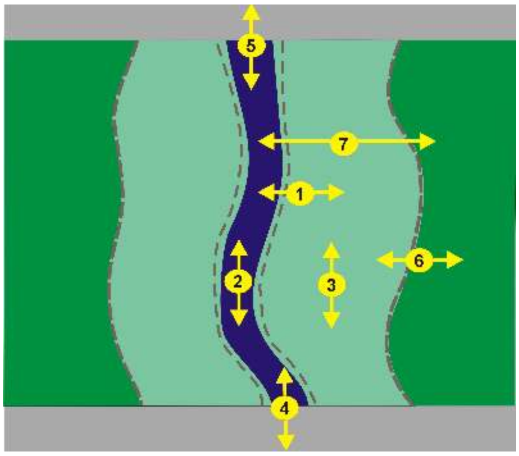


Fig. 6 – River management relations

(1) the direct relation between river and floodplain with river water-levels determining opportunities for agriculture, nature, flood-protection in the floodplain; flood plain land use and activities influence high and low river water levels
(2) measures in the riverbed influence high / low water levels, sedimentation, stability of the river channel, navigation
(3) competing interests for land use in the flood plain, such as nature – agriculture – urban
(4) the relation with upstream river stretches, such as discharges and the demand for navigation
(5) the relation with downstream river stretches, such as water-levels and discharges, demand for navigation
(6) the demand from adjacent areas and regional and national authorities for certain land use and activities in the floodplain
(7) the demand from adjacent areas and regional and national authorities for certain river functions (navigation, water supply) and safety from flooding

The management measures included in STORM are listed in Table 2. The structural measures and floodplain activities are schematically shown in Figure 7.

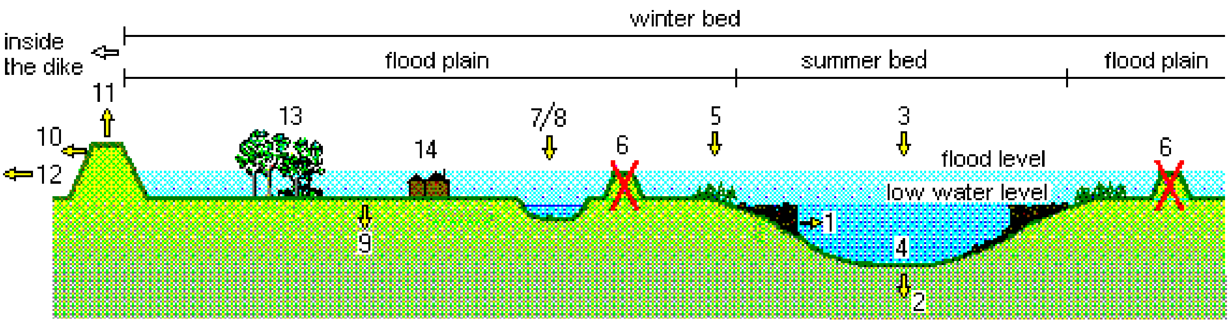


Figure 7 – Structural measures in the river and flood-plain

Table 2 – Management measures in STORM models

River Training	**Vegetation Management**
– Construct stone or natural river bank – Change length or height of groynes – Change height of summer dike – Change height of winter dike – Change distance of winter dike from river – Change depth of river, dredging – Construct / remove side channel	– Spontaneous succession – Extensive natural grazing – Meadow land management – Wetland management – Forest development – Agricultural pasture management – Agricultural crop management
Physical Planning	**Administrative**
– Construct retention areas – Lower high terrain, excavate sand, clay – Remove earthen bridge ramps – Build in floodplain (residential, industrial) – Construct recreational harbour, camp sites – Construct "green river "(outside flood-plain)	– issue floodplain activity permit – issue local land use permit – issue excavation permit – change composition shipping fleet

7.4 Institutional Framework and Roles in the Simulation Game

The number of organisations and institutions involved is enormous, however the mandates for the river management measures essentially rest with the different government institutions. In The Netherlands that are the National, Provincial and Municipal administrative levels. The Waterboards have a special operational water management function and form a level on their own, hierarchically attached to the provinces. In Germany there are the Federal, State (Supreme, Upper and Lower), and Municipal Administrations. Specific Wasserverbände may take up responsibilities for operational management. Both countries have a great number of organisations, which represent specific user groups or interests, but these organisations do not have formal river management mandates as such. They influence policy setting and decision making in a multitude of different ways. They have to be formally asked for advice in many planning and decision-making procedures. An overview of the main management tasks and responsibilities is given in Table 3 below.

Table 3 – Overview of river management tasks and responsibilities

The Netherlands	**Germany**
River and floodplain construction and maintenance	
National – Construction of dikes, roads, cross river-channel connections and harbours	Bund – Construction of river banks and bank pavements – Permits for structures for navigation in state waters
	Supreme State Authority –
Province –	Upper State Authority – Cconstruction and maintenance of winter dikes – Appoints contours of flood zones
Water-board – Responsible for water-control structures – Construction of waste water plants	Lower State Authority –
Municipality – Construction and maintenance of sewerage – Provides permits for construction and use of constructions	Municipality – Provides permits for construction in floodplains – Maintains floodplains of all order waters – Construction and maintenance of summer dikes
	Water association – May be responsible for the construction and maintenance of summer dikes
Water quantity management	
National – Strategic and operational aspects of state waters – Responsible for flood control	Bund – Strategic and operational responsibility for state waters to guarantee navigation
	Supreme State Authority – Strategic responsibility for all first order waters (can be delegated to the Upper State Authority)
Province – Strategic responsibility for regional surface waters and groundwater	Upper State Authority – Strategic and operational responsibility for all waters, except state waters in respect to navigation – Provides permits for water extraction and drainage
Water-board – Operational aspects of regional surface waters – Provides permits for water extraction – Responsible for water-control structures	Lower State Authority – Provides permits for water extraction and drainage for smaller uses
Municipality – Operational responsibility for small waters	Municipality –
	Water association – May be responsible for water extraction and drainage

Typically, the engineering measures in the river bed are the concern of the National Government in The Netherlands and the Federal Government in Germany. The construction of dikes, harbours and retention areas is the mandate of the State Government in Germany. In both countries, the land use in the floodplain is the mandate of the Local Government. Checks and balances are built in by specific permits needed or formal agreement to be given.

The representation of the institutional framework in roles in the simulation game is also constraint by a maximum number of roles still manageable, which is in the order of five to eight. This has lead to the following roles

- National Government (The Netherlands)
- Municipal Governments (The Netherlands)
- Federal Government (Germany)
- Regional Government, Left Bank (Germany)
- Regional Government, Right Bank (Germany)
- Urban Municipalities (Germany)
- Rural Municipalities (Germany)
- Environmental Lobby Groups

7.5 System Models

The relations between the different modules of the system model is shown in Figure 8.

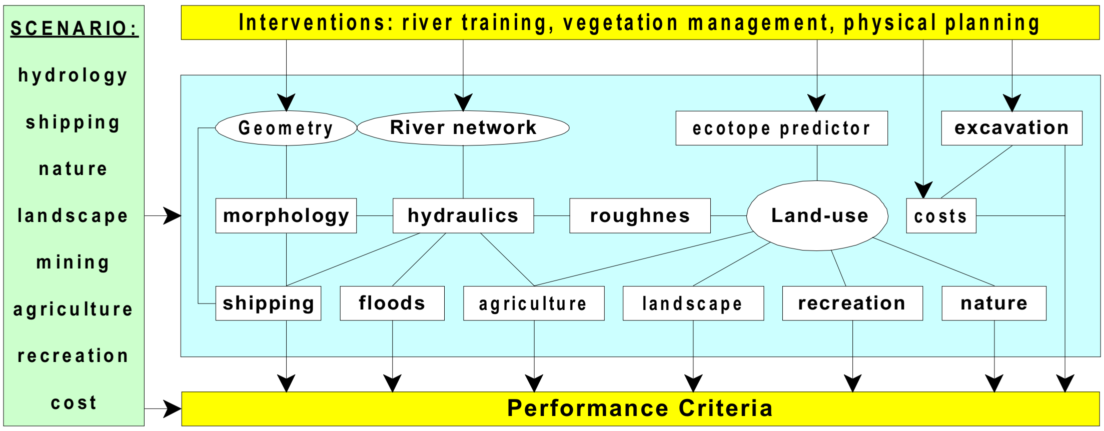


Figure 8 – Relation between modules of the system models

The models are listed in Table 4 and briefly characterised below.

Table 4 – Categorised modules

Type	Water-related	Land-use related	Other
Modules	Hydrological routing module Hydraulic module Morphological module Shipping module Hydraulic roughness module	Ecotype predictor Nature module Agriculture module Recreation module Landscape module	Excavation module Cost module

Hydrology and Hydraulics
The core of the simulation model is the hydrology and hydraulics module where the impacts on different flow conditions are determined. It essentially calculates the expected maximum, average, dominant and minimum water-levels in the river and a frequency distribution of water-levels, based on hydrological discharge scenarios. It also provides morphological calculations for bed-level changes. It makes use of the river geometry and roughness dependent on the land use in the floodplains, taking into the interventions by the players. It

incorporates the construction of retention areas and a "Green River" . The results are aggregated in 17 river branches, but for the (steady state) hydraulic computations the river is divided in 83 branches. The initial geometry is adapted from the SOBEK profiles. The water-levels and bed-levels are used to assess flood risks, navigation potential, opportunities for the development of nature, and agricultural production in accordance with the criteria given in Table 1.

Shipping Module

The simulation provides the users with feedback on the consequences of changing geometry for the shipping function of the river. A change in the intensity of shipping affects the shipping sector itself, the transport sector in general, as well as the industrial activities along the river, because transport by ship is cheaper per tonkm. Transport by ship is more environmentally friendly than transport by road (energy, $CO_{2,}$ NO_x, smog).
Ships reduce their load whenever the minimum depth on their journey is not sufficient for a full load. The frequency distribution of these depths plays an important role. Therefore climate changes and river engineering measures affect the shipping sector. Instead of investing in changes in the geometry, shipping can be increased/decreased by changes in the fleet. In the past years a European regulation has only allowed new ships to be built if this was compensated by an equal decrease in tons capacity. Therefore the number of ships has decreased and ships in general have become larger. Larger ships are more sensitive to low water depths. The shipping module:

- gives the player a mandate to change the fleet;
- translates combinations of changes in the fleet and river engineering measures to changes in the shipping sector, the industry and the environment.

Landscape and land use ecotopes

The landscape and land use ecotopes are determined by the physical planning measures, given in Table 2, conditional to the water regime in the river and floodplains. The model identifies three types of landscape: spontaneous natural, managed natural and agricultural. The model calculates the area that these types cover from the ecotopes that represent the specific landscape character.
The model distinguishes 21 land use ecotopes, which are based on hydrodynamics (water-levels and duration of flooding), flow dynamics (velocity of flow) and intensity of management (resulting in vegetation structure). The ecotope predictor generates a new 'target' ecotope distribution from the actions taken by the players. The decision rules to arrive at the distribution are based on work by Pedroli and Rademakers (1995), who developed a system called RES *(Rivier Ecotopen Stelsel).*

Potential flood damages

The model calculates the flood damages in case the winter dike is overtopped. The area flooded is based the Rhein Atlas of IKSR (1998). Four categories of damage are distinguished: Residential, Commercial, Infrastructure and Agriculture. The value of damage is based on two publications

- Potentiell Hochwasserschäden am Rhein in NRW; Ministerium für Umwelt, Raumordnung und Landwirtschaft, Dusseldorf, 2000.
- Standaardmethode schade en slachtoffers als gevolg van overstromingen; Dienst Weg- en Waterbouwkunde, Ministerie Verkeer en Waterstaat, 2001.

7.6 Scenarios and Vision Development

Scenarios

There are a number of scenarios which trigger action in the management of the River Rhine in addition to improving the current status quo. STORM-Rhine allows the game-leader to perform the simulation under different scenarios and ask the players to cope with these situations. Scenarios considered are:

- the December 1993 and January 1995 flood events, in both of which the discharge of the Mosel was a major contributor
- a new 1/1250 year design discharge of 16,000 m^3/s at Lobith
- higher high and lower low discharges (about 10%) because of climate change
- higher discharges because of land use changes
- higher economic risks, which lead higher damage and to other design standards
- lower dry season water levels which affect navigation and water quality
- navigation: a higher frequency and different type of ships
- increased demand for nature areas

Vision Development

STORM-Rhine gives the users the opportunity to 'play with the future', based on a vision they may have on how the future will develop. For reference, this paragraph briefly presents a selection of statements (directly applicable to STORM-Rhine) from the scenarios for 2025 that were given in 'Visions for the Rhine' (2000).

Vision 1: Business as Usual

- Climate changes have been as predicted with the highest probability in 2000.
- The rate of investment in flood prone areas has decreased, but since 2000 there has been a doubling of the capital in these areas.
- Retention polders are considered as the cheaper way to protect against flooding, now that river widening has been implemented.

Vision 2: Towards sustainability through Economics, Technology and the Private sector

- Climate changes have caused the sea level to rise with a few tens of centimeter. Large areas are flooded once every ten years, enhancing natural diversity.
- Mass transportation is mainly by water, but the overall demand for transport has decreased.
- Large snake-like ships power their way around kilometers of river bends and travel between major industrial clusters along the Rhine, all specially protected against flooding.
- Building in flood prone areas is allowed but at the builder's own risk. Insurance companies offer flood-insurance and take care of flood warnings.
- In times of water shortage water is pumped upstream, now that renewable energy sources have been developed.

Vision 3: Towards sustainability through a change in Values and Lifestyles

- Total transport volumes have decreased. Shipping is the most important way for transport.
- Farmers are both food producers and guardians of the landscape.
- Riverside urban areas are protected by high dikes and dams but since 2000 there have been no new settlements in areas prone to flooding.
- Many floodplains have been given back to nature and are freely accessible for extensive recreation and small scale fishing.

8 RESULTS

8.1 STORM – BETUWE

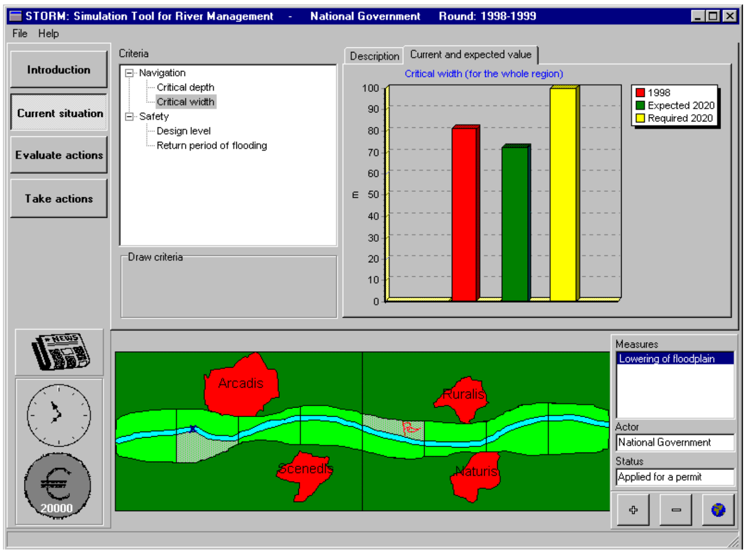
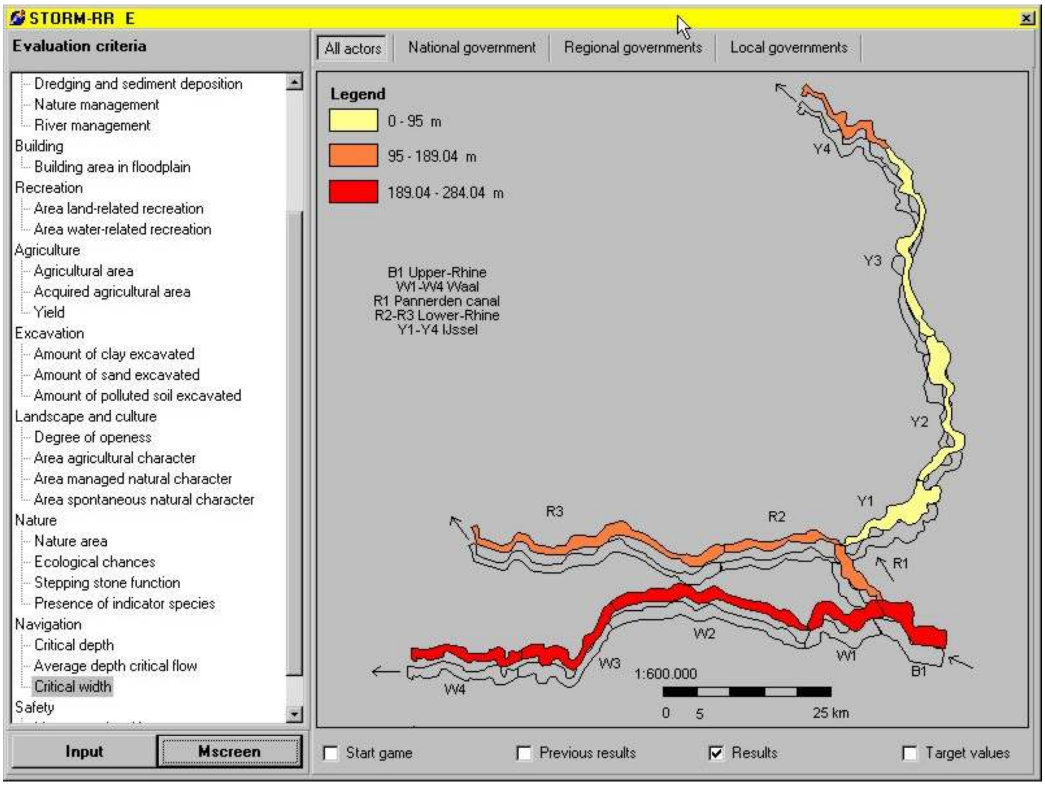


Figure 9 – Example of STORM-Betuwe interface

The STORM-Betuwe simulation game describes a typical stretch of some 60 km length of the Dutch River Rhine. The stretch is divided in 8 sections in which the players can define the measures, both for the left and right side of the river. The roles represent four municipalities, each responsible for part of the river stretch and each with its own focus on either economic development, nature, and agriculture. In addition, the provincial and national government are represented. The measures and performance criteria as given in Tables 1 and 2 above do apply, except that retention areas cannot be created. STORM-Betuwe facilitates most of the simulation game objectives described above. it was especially developed to create awareness for the Integral Reconnaissance Rhine Branches and Room for the River Projects in The Netherlands.

8.2 STORM – DELTA



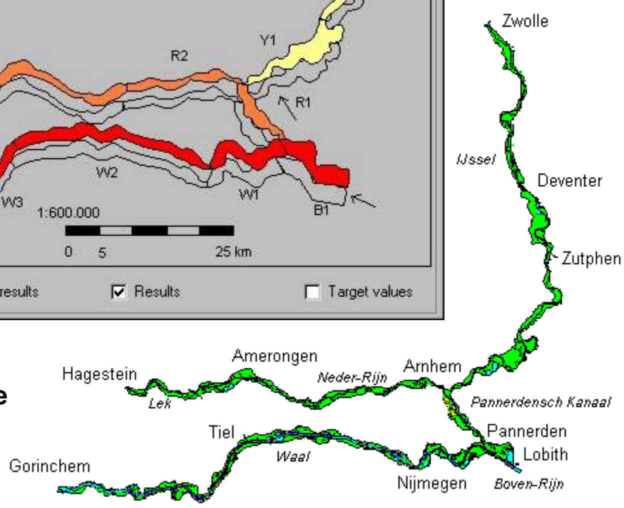


Figure 10 – Example of STORM-Delta interface

STORM-Delta describes the Dutch Rhine Delta of the rivers IJsel, Lek and Waal from the border with Germany to the boundary of the salt intrusion.

All measures and criteria listed above in Tables 1 and 2 are available, including the "Green River", flood retention areas (calamity polders) and redistribution of flows over the three river branches. However, the institutional framework has not been modelled. Consequently, there is no role-playing facility: one user may enter all measures and has access to all output.

STORM- Delta is an interactive tool to provide insight in river behaviour, to create awareness for the Room for the River concepts and to test policies to enhance river (floodplain) functions for diverse stakeholder interests.

8.3 STORM – RHINE

STORM – Rhine is a simulation game, which describes the river from the downstream boundary of salt intrusion in The Netherlands to Maxau in Germany, which is the site of the first weir in the river, see Figure 2. It covers a total length of some 650 km. The stretch is divided in 17 sections in which the typical river and floodplain management measures can be taken.

STORM – Rhine has the following objectives:

- provide insight in river and floodplain management
- facilitate debate between different levels of stakeholders
- explore the international dimension of river management
- highlight upstream – downstream effects on river basin scale
- explore river basin scale scenarios affecting river management
- create awareness for the Room for the River concepts
- raise understanding of
  - river regulation measures
  - decision-making mechanisms
  - floodplain use affects river functions
  - river regulation affects flood plain use
  - the functioning of retention areas

> NOTE:
> The STORM-Rhine maps and model interfaces were still under construction at the time of writing of this report.

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8.4 ROLE PLAY SETTING

In principle the roles can be played by individuals, but preferably by small groups. Interaction between the different roles is essential and the major objective of STORM Rhine. This interaction is structured in STORM Rhine to represent (in a very simplified manner) common procedures between actual government bodies and other stakeholders concerned with river management.

The simulation can be 'played' with a computer network, whereby each role directly enters the desired measures it is mandated to enact. However, the respective roles responsible for issuing permits or binding advice, need to have done so on their own computers. Players may communicate with each other via the network with e-mails. The data is subsequently processed on a central database server, either in various rounds representing time steps of say 10 years into the future, or in with a continuously running clock. The model provides feedback to the players on the state of the river expressed in the performance criteria. The state of the river is evaluated either individually or as a common exercise against the desired situation. Consequently, players may decide to take additional measures. It is likely that several rounds will need to be played in order to achieve the desired performance. This can only be achieved through a concerted effort on the part of all roles, since the influence of individual roles on the output of the model is limited.

As an alternative to the computer network environment, it is also possible to engage in the Role Play with one stand-alone computer which runs the model. The role representatives are then provided with hardcopy input sheets on which the specific measures to be taken are listed. These, together with the permits and advisory comments by other roles, are subsequently gathered by the 'game leader' and entered into the model. After processing the input sheets of all relevant roles, the model will print out the results, to be distributed to each of the roles and discussed and evaluated in a plenary session.

With either method the need for interaction between the various roles will prove to be essential in order to produce an integrated river management approach resulting in performance criteria acceptable to most if not all stakeholders and decision makers.