

FLOOD MANAGEMENT OF THE TRANSNATIONAL RHINE RIVER

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Abstract. This paper deals with the management aspects of the Rhine River specially those related to flood control. Current trends in flood management triggered by recent catastrophic events and some thoughts for future developments are discussed. The Rhine River is the most important waterway of Western Europe. It links the German industrial areas around Mannheim and the Ruhr with the port of Rotterdam. For this reason, it has been the object of not only wars and negotiations, but also of coordination and cooperation. In 1993, 1994, and 1995 several floods have occurred in the basin. The most extreme flood was that of January 1995 which caused extreme damage in many regions. The damage was estimated at more than 200 million Dutch guilders in the Netherlands alone. In Germany upstream flood control measures have had some negative impacts. In the lower Rhine and in the Netherlands there is a large system of embankments and during the 1995 flood there was a concern that some dikes may fail. It appears that the future management of the Rhine will require a much closer cooperation of all the basin states specially the cooperation of users organizations, and dependable real time information from all sectors and all parts of the basin should be made available.

1. INTRODUCTION

1.1 THE RHINE BASIN AND ITS DEVELOPMENT

The Rhine River, the most important waterway in Western Europe, links the German industrial areas around Mannheim and the Ruhr with the port of Rotterdam. Human hands have shaped it for almost two centuries. Sometimes the river protests and sends high floods that endanger cities and whole deltaic regions. Because the Rhine basin is highly industrialized its waters serve a variety of purposes. More than 50 % of the basin is used for agriculture, about one third for forestry and natural lands, and the remainder landuse is urban or suburban. Since the end of 1940 the Rhine has become highly polluted. All riparian states pollute the Rhine and her tributaries. Toxic pollutants derive from point and non-point sources. Tributary basins with the most industrial activity are the Neckar, the Saar, and the Ruhr. The Rhine also has a salinization problem, mainly caused by the French Alsatian potassium mines, which has particular negative impacts on Dutch drinking water production and irrigation of agricultural lands. Besides these normal pollutions there is the pollution by industrial or shipping accidents. These require special

response or remediation measures. Sedimentation of heavy metals occurs mainly in the streams and lakes of the Dutch delta and only 25 % disperses into the North Sea. During the last decade the riparian countries have been quite successful in combating pollution.

1.2 GEOGRAPHY AND HYDROLOGY OF THE RHINE

The River Rhine runs 1,237 kilometers from Switzerland to the North Sea with a drainage area of 160,000 or 185,000 km² (depending whether the area of the Netherlands, which is the Rhine delta is counted). The river can be divided into the following sections. The Alpine Rhine runs from its source in the Gotthard massif to Lake Constance (the Rhine actually has two sources, one from the Gotthard, the Vorder-Rhein, and one from the Abula, the Hinter-Rhein). The High Rhine is the reach from Lake Constance to Basel, and downstream from Basel runs the Upper Rhine till Koblenz. Then, the Middle Rhine is the reach from Koblenz to Bonn, and downstream from Bonn is the Lower Rhine. Each river section has its own drainage basin, which may have quite different climates, soil characteristics, land use, and user functions. Main tributaries of the Rhine are: the Aare, the Neckar, the Ill, the Main, the Moselle, the Lahn, the Sieg, the Wupper, the Lippe, the Ruhr, and the Emscher.

Since the Rhine originates in the Alps he may be considered as a glacier river. Here the Rhine constitutes the border between Switzerland and Liechtenstein and Austria. It crosses Lake Boden, which has a length of 60 kilometers and a width of 10 kilometers and a surface of 540 km², where it loses most of its alpine sediment. From here the Rhine travels west and passes through the famous falls of Schaffhausen (24 meters height) and thereafter it becomes the border between Switzerland and Germany. An important left side tributary is the Aare, with a length of 295 km, and a basin of 17,800 km², draining 60 % of the Swiss surface. Near Basel the Rhine bends to the north and finds itself a way between the hills of the Vogese and the Black Forest. There lies the highly contested border between Germany and France. A small left side tributary is the Ill, and a right side tributary is the Neckar. An important right side tributary is the Main, which has a length of 524 km and a basin of 27,000 km². From one of its tributaries, the Regnitz, which passes along Neurenberg, the Rhine Main-Danube Channel was dug, which was opened in 1992.

A beautiful part of the river is between Bingen and Koblenz, where the famous rock, named Lorelei is situated. The most important left-hand tributary of the Rhine is the Moselle, which embouches at Koblenz with a length of 550 km and a basin of 28,000 km². In turn, it has as tributaries the Meurthe and the Saar. The Moselle travels along Epinal, Metz en Thionville and constitutes the border between Luxemburg and Germany. On the stretch from Koblenz to the Dutch border right side tributaries are dominant. They deliver waters from the large industrial area of the Ruhr.

In the Netherlands the waters of the Rhine are diverted into three distributaries: the IJssel, the lower Rhine/Lek, and the Waal. Before entering the sea the water of the Rhine travels along the harbours of Rotterdam, Europoort being the most famous one. The Rhine-delta has been changed incredibly, mostly by human hand. Together with waters from the Meuse and the Scheldt the so-called delta was formed. Now this area has been protected from the sea by a system of dams and storm surge flood barriers. The IJssel distributary enters Lake IJssel, which has been precluded from the Waddensea by the Closure dike. Finally the Rhine reaches the North Sea, an important coastal sea, whose waters are also fed and polluted by the rivers Scheldt, Meuse, Ems, Weser, and Elbe.

1.3 ADMINISTRATION OF THE RHINE

Countries belonging to the Rhine catchment are: Switzerland, Liechtenstein, Austria, Germany, France, Luxembourg, Belgium, and the Netherlands. Most of the basin is highly industrialized and densely populated. The basin countries have more than 150 million inhabitants of whom 55 million live in the Rhine basin, with a population density of 250 per km². In Germany the Rhine drains many states, including Bayern, Baden-Württemberg, Saarland, Rheinland-Pfalz, Hessen, and Nordrhein Westfalen. All these countries and states have a rather different administrative structure. We will not go into all details, just give a sketch of the administrative structure of the most important ones, namely: Switzerland, Germany, France, and the Netherlands.

Switzerland. Switzerland is a federal state. One federation consists of twenty-five autonomous Kantons. This Confederation only has a limited number of tasks. A federal environmental protection agency (Bundesamt für Umwelt, Wald und Landschaft) was created under the Ministry of the Interior. The Swiss also established a special expert advisory body, the federal agency for water protection. Federal laws on water protection date from 1955, 1971, and 1989. These federal laws have the character of framework-legislation. The main purpose of the 1971 law (Bundesgesetz über den Schutz der Gewässer gegen Verunreinigungen) is to protect the groundwater. The 1989 law (Gewässerschutzgesetz) is more integrated. It calls for measures to halt the polluting of the waters by agriculture. Most Swiss surface waters belong to the Kantons and are public property. The Kantons decide how to use them. The Confederation has only the power to decide about the use of the waters if they constitute the borders of the nation or if they belong to several Kantons.

Germany. Germany consists of a federal state and a number of constituting states (Länder), which have a certain degree of autonomy. The federal government has powers on a limited number of issues. In those cases the states are only competent if this competence has been granted to them explicitly by federal law. On other issues, the federal government has powers next to those of the states. Furthermore, the federal government can formulate framework measures on certain issues such as those for nature conservation, land use, regional planning, and water management. In these cases, the states may state specific regulations within the context and borders given by the federal government. They also may enact additional regulations.

On the federal level, there is a "Bundestag" that is directly voted for and a "Bundesrat" composed of representatives of the states. Every state has an elected parliament of its own. The most important actor in the field of water management in Germany is the Federal Ministry of Environment, Nature Conservation, and Nuclear Safety. It also looks after the principles of water management and nature conservation through international cooperation in river (basin) committees. There also exists a Federal Ministry of Nurture, Agriculture, and Forestry that specializes in water management projects in the countryside, including flood control and control of the sea shore. It also has responsibility for legislation for groundwater, soil commissions for fertilizers, and regulation of pesticides. The Federal Ministry of Health is responsible for the supply of drinking water and, together with the Ministry of the Environment, for the quality of bathing water. The Federal Ministry of Transport is responsible for federal waterways and for navigation. The construction, management, and maintenance of the waterways (7,300 km) is the exclusive responsibility of the Federal government. The Federal Ministry of Research and Technology stimulates research in the field of water management.

The implementation of water management is the exclusive task of the Länder. These - like most other tasks - are in principle executed on three layers. The LAWA is a very influential type of cooperation between the water authorities of the respective German States. The most important act that has dominated the development of the German water management is the Wasserhaushaltsgesetz (WHG) of 1957 that entered into force on 1 January 1960. This Act has been modified in 1976 and 1986. Art. 1 of this Act states that the management of water should consider the general interest as well as the interest of individuals and should therefore be considered to be part of the environment. The Act contains a system of protected areas, management plans, and permit systems. There also is a Wasserabgabengesetz of 1976, amended in 1990. On behalf of this act, payments must be made in relation to the quantity and the damaging capacity of certain substances that have been released. These acts contain a system of regulation, classification of waters and a planning mechanism for water management. They must be supplemented and specified on the scale of the Länder. In Nordrhein-Westfalen, this has resulted in the Landeswassergesetz.

France. France has a highly centralized system of government. Under the Water Act of 1964, six basin agencies were created one of which corresponds with the French tributaries Moselle, Saar, and Ill belonging to the Rhine basin. At the State level nine ministries have water management tasks. The new law of 1992 has tried to bring somewhat more order to the water policy at state level. It stimulates integrated water management. The objective of the law is to assure the sustainable management of water resources, preserving aquatic ecosystems such as wetlands, protecting against all deterioration of the quality of surface and groundwater, and developing, protecting and enhancing the value of water resources. According to the law of 16 December 1964, each basin has an agency and a committee. The aim of the basin agencies is to stimulate solidarity through economic incentives. The costs are divided according to the interest of the parties. The basin agencies levy charges on the extraction and pollution of water and subsidize purification efforts by industries and municipalities. The basin committee is in fact a regional water parliament, consisting of representatives of users, associations and local authorities and some state representatives. The Water Act of 1992, which directs a long term planning effort, stronger controls on groundwater abstractions, and a wider scope of water management in general, demands that each basin committee makes an integrated water management plan (SDAGE). The basin agencies have been converted into water agencies (agences de l'eau). If indicated in the SDAGE, local water plans for smaller units (called SAGES) have to be made.

The Netherlands. The Dutch administration mainly consists of three layers, the State, the provinces, and the municipalities. In addition, Waterboards are old institutions, which at present have responsibilities for either or both water quantity and water quality, sometimes in combination with tasks of flood protection. The State has the management responsibility for the rivers, lakes, and estuaries. Thus the Rhine and its distributaries are managed by the State, Rijkswaterstaat. The general policy for the Rhine is described in the Third policy document on water management. Thus the State has to draw up a more operational "Beheersplan Rijkswateren". The provinces have responsibility for drawing up the water management plans for their territory. But the dikes along the rivers are managed by the waterboards. Relevant laws are the Water Management Act (1989), which contains a planning system at different levels - state, provinces and water boards-coordinated with the national environmental planning system, the Waterboards Act (1992), and the Rivers Act (1908). A Flood control bill is pending. Recently in order to speedily heighten the dikes, a specific Delta Act for Large Rivers has been enacted (1995). The present policy concept is

that of integrated water management, directed at the sustainable development of water systems, e.g. river basins.

1.4 MAIN ACTORS IN THE RHINE BASIN

In the Rhine basin, we find numerous organizations dealing with one or more aspects of river basin administration. Without being complete we mention the main ones.

1.4.1. Regional Actors

Lake Constance Convention. On October 27, 1960, a Convention was signed at Steckborn between the riparian states to protect Lake Constance (both the "Upper Lake" and the "Lower Lake") against pollution. It established a Permanent International Commission for Protection of the Waters of Lake Constance. Participating countries are: Land Baden-Württemberg, Free State of Bavaria, Republic of Austria and the Swiss Confederation. On June 1, 1973 another convention was signed, relative to the navigation on part of (only the "Obersee" and the "Überlinger See") Lake Constance.

Moselle Commission. On October 27, 1956 a Convention on the canalization of the Moselle between Thionville and Koblenz was signed at Luxembourg, in order to make this river section navigable for ships of 1,500 tons. Partners are the Federal Republic of Germany, the Republic of France, and the Grand Duchy of Luxembourg. On December 20, 1961 a Protocol was added in Paris concerning the establishment of an International Commission to protect the Moselle against pollution.

Saar Commission. At the same dates also a Convention and a Protocol concerning the Saar, a tributary of the Moselle were also signed. Participating countries are Germany and France.

Ruhr Agencies. Special attention should be paid to developments in the Ruhr area. Since 1904 a number of water agencies have been created (Genossenschaften and Verbände), who deal with water pollution, drainage, and hydropower. The most important ones were the Emschergenossenschaft, the Lippeverband, and the Ruhrverband. In 1990 they were reorganized. These organizations are responsible for the water management of their respective rivers. A number of agencies such as municipalities, Kreise, drinking water companies, and other companies owning installations that subtract more than 30,000 m³ annually of either groundwater or surface water, are required to participate. The Ministry of Environment, Planning and Agriculture is the controlling entity.

1.4.2 Basinwides Actors

Central Commission for Rhine Navigation (CCRN). During the Congress of Vienna of 1815 general rules were stated applicable to all international (navigable) rivers. For the Rhine, as is required for all navigable rivers in Europe, a Commission was established in 1816. In order to guarantee freedom of navigation on March 31, 1831 at Mayance, it was stated that navigation on the Rhine from Basel (the location from where the Rhine should be navigable) till the open sea both downstream and upstream was free. Nowadays, the Commission is based on the Revised

Convention of Mannheim of 1868. Partners are Belgium, France, Germany, Great Britain, the Netherlands, and Switzerland. Due to the treaty of Versailles the seat of the Commission was moved to Strasbourg. In 1979 an additional protocol was signed in connection with the expected opening of the Main-Danube-canal, which took place in 1992. The CCRN is a purely intergovernmental system, dealing with problems concerning navigation and the consequences thereof on technical, juridical, economical, and social matters.

International Commission for the Hydrology of the Rhine basin. The International Commission for the Hydrology of the Rhine basin was founded in 1970 within the framework of UNESCO's International Hydrological Decade. At the expiration of this Decade, the activities have been carried on in the framework of the UNESCO IHP and the WMO. Participating countries are Switzerland, Austria, Germany, France, Luxembourg, and the Netherlands. The tasks of this Commission are:

- to support the cooperation between hydrological institutes and services active in the catchment area of the Rhine;
- to promote the exchange of hydrological data and information in the Rhine basin (e.g. current data, forecasts); and
- to develop standardized methods for collecting and processing hydrological data in the Rhine riparian states.

International Commission for the Protection of the Rhine against Pollution (ICPR). Founded in 1950 by the Rhine riparian states, ICPR received official status through the Berne Agreement of April 20, 1963, which came into force in May 1965. Parties to the Convention are Switzerland, France, Germany, Luxembourg, The Netherlands, and the EC (since 1976). The Commission has a permanent secretariat at the Federal Institute for Water Research in Koblenz. According to art. 2, the duties of the ICPR are:

- to prepare and execute all research necessary for determination of the nature, importance, and origin of pollution of the Rhine and to evaluate the research results;
- to propose measures for protecting the Rhine against pollution;
- to prepare the elements for treaties between the governments involved aimed at the protection of the Rhine water.

Because the Agreement specifies that the Commission is entrusted to act on all matters that the contracting parties agreed upon, in theory, the authority of the Commission can be enlarged. The Commission has giving birth to several treaties among the basin states, such as the Chemical pollution convention. It also has been fostering the Rhine Action Program, which is implemented by the secretariat of the Commission. Recently the Rhine Ministers have decided to enlarge the activities of the ICPR. A special framework on flood control activities has been formed.

1.4.3 Other Actors

Role of EU. In 1963 an additional Agreement to the Berne Convention opened membership of the ICPR to the EC. This Agreement was signed together with the Chemical Pollution Convention and with the Chloride-Convention. As member states had transferred (national) powers in the field of

water pollution control to the EC, the member states can no longer enter into agreements with third parties without the involvement of the EC. Therefore the EC had to become a member of the ICPR. It takes a key position, which manifests itself in the fact that as a rule, the only measures, which could be agreed upon within the framework of the ICPR, were preceded by comparable measures of the EC.

NGO's. The Rhine basin has united many interest groups, for instance the drinking water companies and many local authorities. The drinking water companies in 1969 have founded the IAWR, which is a combination of three other regional associations named AWBR (Arbeitsgemeinschaft Wasserwerke Bodensee/Rhein), ARW (Arbeitsgemeinschaft Rheinwasserwerke), and RIWA (Rijncommissie Waterleidingbedrijven). Among their goals is the establishment of uniform laws in the relevant basin states in order to make the Rhine free of pollutants. They also strive towards a uniform research program for the waters of the river Rhine. The local authorities have joined existing platforms, like those around the Boden See, or have formed pressure groups of their own, like the River Municipalities Association in the Netherlands.

Other Organizations. The Rhine basin contains other organizations in the field of river basin management beyond those listed above. In Germany alone, there are about 25 river basin related organizations. Among the most important ones is the LAWA, the cooperative agency coordinating the water policies of the German States.

Other Treaties that Influence the Rhine Basin. Regional agreements dealing with the North Sea also have relevance for the management of the Rhine basin. Besides activities of the North Sea Action Programme actors, there is the Convention on the protection of the marine environment in the Northeast Atlantic Ocean (Paris-Oslo Convention 1992). This convention aims at reducing pollution of the North-Atlantic Ocean and the North Sea stemming from land.

1.5 MAIN ISSUES

Main issues in the Rhine basin, related to different river functions are:

Navigation: The Rhine is an important navigation route. Navigation begins at Rheinfelden, 149 km downstream of Constanz. There are many weirs and locks in the Rhine. Traffic is most intense between Rotterdam and the Ruhr-area. At the Dutch border in 1990 ships going upstream carried 143 million tons, those going downstream 90 million tons. Along the Rhine north of Basel, the French dug the Lateral Canal d'Alsace after the First World War. In 1992 the Rhine Danube canal was opened.

Quantity Control: Although the Rhine comes from ice and snow in Switzerland, its tributaries generate most of its waters. Major influx comes from the Moselle and also from the Main. And again in the north, many small but active rivers like the Wupper, the Ruhr, and the Emscher contribute to its waters. The annual average flow at Basel is 1,080 m³/sec, just above Koblenz 1680 m³/sec, and at Lobith (at the border of the Netherlands) 2,400 m³/sec.

River Restoration: In the region between Basel and Strasbourg, there has been a significant drop of groundwater levels. Here river restoration has been pursued. The Rhine Action Plan is directed at

restoring the Rhine ecosystem. Also in the Netherlands there are activities to revitalize the floodplains.

Hydropower: The Rhine is a border between Germany and Switzerland and between Germany and France. Both stretches are important sources of hydropower. The latter border has an especially fascinating history, during which control of the Rhine-area was of great interest. Not only did the meandering Rhine make parts of the river bed alternate between Germany and France, but the Treaty of Versailles gave France the right to use the Rhine water for its own hydropower uses.

Water Pollution: Chemical pollution from both point and non-point sources, e.g. chloride from potassium mines, and thermal from power stations, are the main sources of water pollution in the Rhine. The water quality of the Rhine was very bad, having huge concentrations of cadmium, zinc and other heavy metals. But due to a concentrated effort of all riparian states, the water quality has been improved. These activities are not only directed at reaching a cleaner river, but also at reducing the river load, which contributes to the pollution of the North Sea. Also calamities have occurred, for instance the Sandoz-fire in 1986.

Drinking Water: Water pollution has a negative effect on drinking water. In the past many dangerous substances have been detected.

Sediment: Polluted sediments have to be dredged from the river bottom and especially from the Rotterdam harbours. They may not be disposed of on land or at sea and therefore have to be stored in costly basins.

1.6 WARNING AND ALARMING SYSTEMS

In the Rhine basin, two types of warning and alarming systems exist, one for water quantity and one for water quality. The quantity system coincides with navigation, which needs to know the water depths at river stretches well in advance. International central alarming stations warn agencies downstream about sudden pollutions of the Rhine. The stations are located at Basel, Strasbourg, Mannheim, Koblenz, Düsseldorf, and Arnheim for the Rhine River, and at Metz and Luxembourg for the Moselle. A computer alarm model has been developed that can predict the advance of substances under given climatic conditions. In Germany there also exists an alarming system for the detection of nuclear radiation.

1.7 RECENT DEVELOPMENTS AND DISCUSSIONS

In the Rhine basin much impetus has been caused by the Rhine Action Plan (RAP), which was started after the Sandoz calamity of 1986. This plan was drawn up by the International Commission for the Protection of the Rhine against Pollution, and was approved by the 8th Conference of Ministers on the Protection of the Rhine against Pollution in Strasbourg in October 1, 1987. The Program intended to achieve the following results by around the year 2000:

- species previously present in the Rhine (e.g. salmon) must be able to return there;
- the use of the Rhine water for drinking water supplies must continue to be possible in the future;

- the sediment must not be polluted with harmful substances.

The action program has 3 phases:

- Phase 1 until 1989: Further elaboration of the program;
- Phase 2 until 1995: Implementation of the measures;
- Phase 3 by the year 2000: Implementation of supplementary measures in the event that the measures planned for the phases 1 and 2 fail to achieve the intended objective.

In addition, the program calls for inventorying the pollutants and the formulation of common technical standards and controlling instruments. One of the results of the Rhine Action Program is the Ecological Masterplan for the Rhine: "Salmon 2000".

1.8 FLOOD PREVENTIVE MEASURES

In Germany, there is a law that compels all water managers and water users to pay attention to flow management. In Germany upstream flood protection measures have had some negative impacts. A substantial rise in flood peaks has resulted from the reduction of flood plain area through dyke construction, and acceleration of flood waves as a result of river training, which often coincide with the flood waves of the tributaries. In order to cope with potential future floods, plans have been made to reduce the flood peaks by retention measures such as dykes. Small tributaries have to be retained in a near natural condition or re-naturalized. At the lower Rhine in Germany and in the Netherlands there is a large system of embankments. In the Netherlands, river engineers advocated the heightening of the dykes. But due to opposition from the greens and shortage of national funds this operation was postponed.

2. RECENT FLOODS IN THE RHINE

2.1 BRIEF OVERVIEW

Several floods have stricken the Rhine basin in the 1990's. A first high flood occurred in late 1993/early 1994. It led to considerable damage along the Moselle and the Middle and Lower Rhine. Also the Meuse valley, especially in the Netherlands, was subject to flooding. The most spectacular flood was the one of January 1995. In the last week of January 1995 an enormous amount of rain came down in the middle and upper part of the Rhine basin. This resulted in high waters from Koblenz north, which led to the flooding of the old town of Koln and to dramatic situations in the Netherlands. Eventually, 250,000 people were evacuated because the authorities feared that dikes might collapse because of piping, which is the undermining of the dikes during long periods of high water. Also at some places the dikes themselves softened. The damage caused was estimated at more than 200 million Dutch guilders in the Netherlands only.

For most people in the Netherlands the high water came as a surprise. After the big flood of 1953 the Netherlands had built large dams into several estuaries and reinforced dikes that could be threatened by storm floods from the sea. In order to finance this program they had to postpone works on upstream river dikes. Also there was much opposition by the greens and local communities against heightening of the dikes, which became a cumbersome issue, a field in which

no political credit could be gathered.

From such flood events, the following lessons may be drawn:

- The existing dikes have to be managed well; financing their reinforcement should continue a top priority.
- Heightening of the dikes will not always be the answer. In some cases, more space has to be given to the river.
- New urban or industrial developments in flood-prone floodplains should be discouraged.

A few months after the disaster the Dutch parliament enacted a law (Delta Act Large Rivers) enabling the authorities to reinforce 150 km. of new dikes within the next two years without having to deal with cumbersome lengthy procedures, which could have easily lasted for 5 till 10 years.

2.2 FLOOD MITIGATION MEASURES

Flood mitigation efforts were carried out at the national, basin and international scales. They are summarized below.

National Level. In the Netherlands, in 1994, a Commission of specialists (the "Commissie Boertien II") was asked to design plans to alleviate the inundation problems of flood plains, especially those along the Meuse River. It advised several measures, among them the building of "quais" up to 1-meter high along parts of the Meuse River. Plans were also made to broaden the Grensmaas. After the 1995 disaster, for all dikes along the Rhine and its tributaries and the downstream Meuse River a special act, the Delta Act Large Rivers, was enacted. Three months after the calamity reinforcement works begun.

Also all people who had suffered from the floods were compensated. All types of damages were taken care of by special funds: the citizens who had to be evacuated, those who had taken preventive measures, and those who were flooded, the farmers, the industry, and the municipalities.

A new type of compulsory insurance was introduced, which will be collected by the insurance companies that are insuring real estate properties. This insurance will cover all types of natural catastrophes.

Basin, International Level. The following actions were made at the international and basin-levels.

a. **Declaration of Arles.** Right after the damaging floods, on February 4, 1995 the Environment ministers of France, Germany, Belgium, Luxembourg, and the Netherlands met in Arles (F) and discussed tackling the problems caused by the high water level of Rhine and Meuse. They edited a declaration, which is known as the Arles Declaration. They deemed it necessary that concrete measures must be taken in several fields, including spatial planning and land use (e.g. agriculture, forestry, nature management, urbanization, and recreation) and water management (e.g. buffer zones, dikes and embankments, and flow management). As soon as possible a plan of action for both the Rhine basin and the Meuse basin should be drawn up. To expedite matters, maximum use should initially be made of existing consultation structures (such as the IRC and the RAP) and research institutions. Art. 6 of the Declaration states: "in developing such plans of actions the ministers deem it necessary to examine possibilities of:

- an internationally coordinated water management system, e.g. with regard to overflow management;
- taking spatial planning measures to permit greater water storage in the whole river basin, such as changes to land use, afforestation, returning riverside areas to nature, the development of overflow zones and impounding basins, and the de-canalization of streams;
- preventing further urbanization in vulnerable areas along the Meuse and Rhine (possibly including a ban on further construction)".

In the context of the conference of EU ministers on spatial planning, a basis should be laid for consultations on spatial planning per river basin.

b. Changing Tasks of ICPR. In line with the above referred declaration, the ICPR has installed a working group to deal with quantity problems in the Rhine basin. This activity was in line with other developments that had led to proposals around 1994 to change the scope of the ICPR. The Ministers of the basin states have asked the IRC to prepare a new treaty for the Rhine, which should enter into force at the latest in the year 2000. It should cover the Rhine from the Lower Lake of Constance till the shore of the North Sea, including all the aquatic and terrestrial ecosystems that have direct relations with the river and those parts of the basin, in so far their runoff has unwanted impacts on the river.

Also a statement has been prepared in which the Ministers of the basin states ask for intensifying integrative cooperation in order to reach an ecosystem oriented management of the Rhine. They also look at unifying the legal basis and actual practice of spilling polluted effluents in the river. The Ministers of the basin states will also request all parties involved to reduce the use of fertilizers and pesticides. They also are preparing market like instruments to bring the farmers to sustainable use of the waters of the Rhine basin. In the Netherlands and in Switzerland this type of instruments have already been introduced.

Many specific actions are being planned in the separate river-sections. In the Hochrhein, 12 restoration projects will be executed. In the Oberrhein, more space will be given to the river for two reasons: better flood protection and regeneration of the floodplains. Also, connections should be made between ecological strongholds. In the Niederrhein some dikes will be altered in order to give 220 ha back to the river. Another 1,500 ha will serve as retention plain. As a goal 40% of the floodplain should be more or less in a natural condition. In the Netherlands, all borders of the Rhine should be fit to act as connection-zones between ecological strongholds.

3. RESEARCH NEEDS

- Connecting hydrological models (both surface and groundwater) to policy making models. There is a need for research on what types of models are needed by the basin authorities to develop and implement policies of a more integrative and sustainable kind.
- Developing systems for collecting data on basin level. In order to feed the above-referred models, an ever-increasing amount of dependable data is required. Research is needed to develop systems of dependable data gathering.
- Many basinwide problems require in depth studies, for instance on areas where flood prevention measures may yield substantial results.
- The problem of delineating the borders of the competence of the river authorities on flood

plains is deciding which are to be inundated. If floodplains are allowed to be inundated, the questions of who should decide in the planning stage and when is the need for action arise. If damage occurs by deliberate human actions, who is responsible?

- Plans or projects-approach. What strategy is the best for a river basin approach? Making an integrated policy plan for the whole basin and wait to see what happens or piecemeal working with projects for which impact studies have to be made.
- Stating lists of elements that spatial planners should include in their planning and plans. The interconnection between water management and spatial planning is gaining momentum. Need arises to provide spatial planners with checklists of provisions to be included into their studies and plans.
- Developing expert systems for flood management including warning systems, competent authorities for taking measures, flood prevention and action measures, and strategies for reservoir-management. Expert systems for actual crisis management should be developed.

4. CONCLUDING REMARKS

From the above mentioned facts and trends the following remarks are outlined:

- (a) During the past years, many types of transnational cooperation have been developed along the Rhine basin states. The common culture and economic conditions have favored this development.
- (b) Two crises (one of water quality, the other of water quantity) have sped up the process and given the cooperation a wider scope. First the Sandoz calamity, which gave rise to the Rhine Action Plan, then the high waters and floods of 1995, which gave rise to the Declaration of Arles.
- (c) The present trend is to take the whole basin into account and deal with problems in an integrated way.

Taking into consideration these trends the following developments may be expected:

- (i) Future management of the Rhine will ask for a close cooperation of all the basin states to establish a special river authority with powers to allocate the water-uses within the basin.
- (ii) Such future river basin management will be more a matter of all water users (including nature conservation) than of the respective governments.
- (iii) In order to allocate water-uses in a dynamic way, dependable real-time information from all sectors and all parts of the basin should be made available.

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