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The **Associated Programme on Flood Management** (APFM) is a joint initiative of the World Meteorological Organization (WMO) and the Global Water Partnership (GWP).

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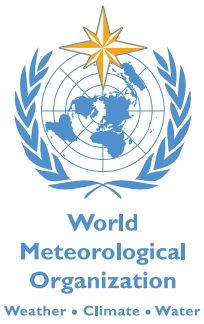

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To the reader

This publication is part of the *"Flood Management Tools Series"* being compiled by the Associated Programme on Flood Management. The *"Transboundary Flood Management"* Tool is based on available literature, and draws findings from relevant works wherever possible.

This Tool addresses the needs of practitioners and allows them to easily access relevant guidance materials. The Tool is considered as a resource guide/material for practitioners and not an academic paper. References used are mostly available on the Internet and hyperlinks are provided in the *References* section.

This Tool is a *"living document"* and will be updated based on sharing of experiences with its readers. The Associated Programme on Flood Management encourages disaster managers and related experts engaged in flood management of transboundary basins around the globe to participate in the enrichment of the Tool. For this purpose, **comments and other inputs are cordially invited**. Authorship and contributions would be appropriately acknowledged. Please kindly submit your inputs to the following email address: apfm@wmo.int under Subject: *"Transboundary Flood Management"*.

Acknowledgements

This tool makes use of the works of many organizations and experts, as listed in the references. The APFM team is grateful to Mr Manfred Spreafico of the Geographic Institute, University of Berne, Switzerland, for his expertise and for bringing various aspects into focus.

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1 INTRODUCTION

1 Integrated water-resources management **(IWRM)** covers the issues of optimal use of water resources, protection of water resources and the environment, and protection against harmfulimpacts of water. Ecology, economy and sociology must be well balanced **(Figure 1**).

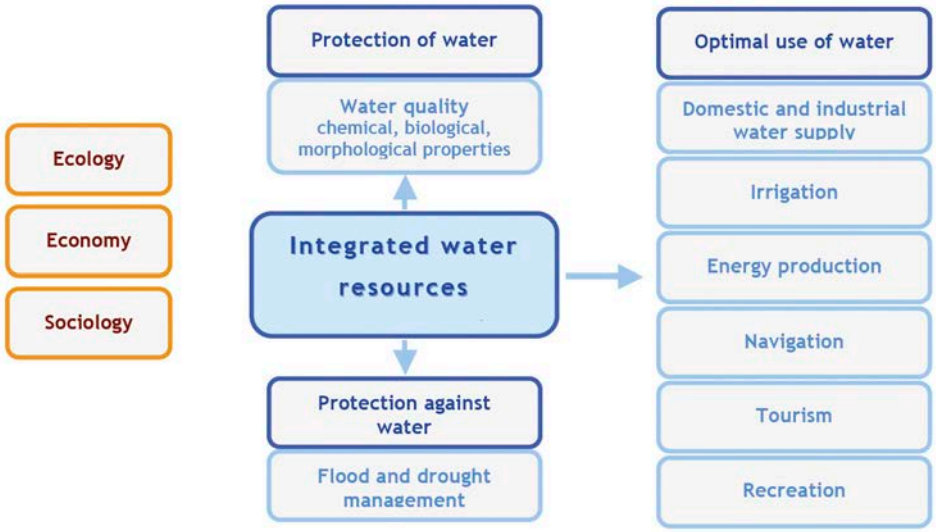

Figure 1 — Aspects of integrated water-resources management

2 This means that social aspects (protection of the population and infrastructure), environmental aspects (protection of the nature and the environment) and economic aspects (benefit-cost analysis) must be taken into account. Comprehensive protection should preventthe increased cost of damage by the implementation of a sophisticated prevention strategy. Residential and commercial space should be protected to a higher degree than agriculturalland. Waterways should be respected as vital, integrated parts of nature and the landscape. These requirements can be shown in the flood management cycle **(Figure 2)**.

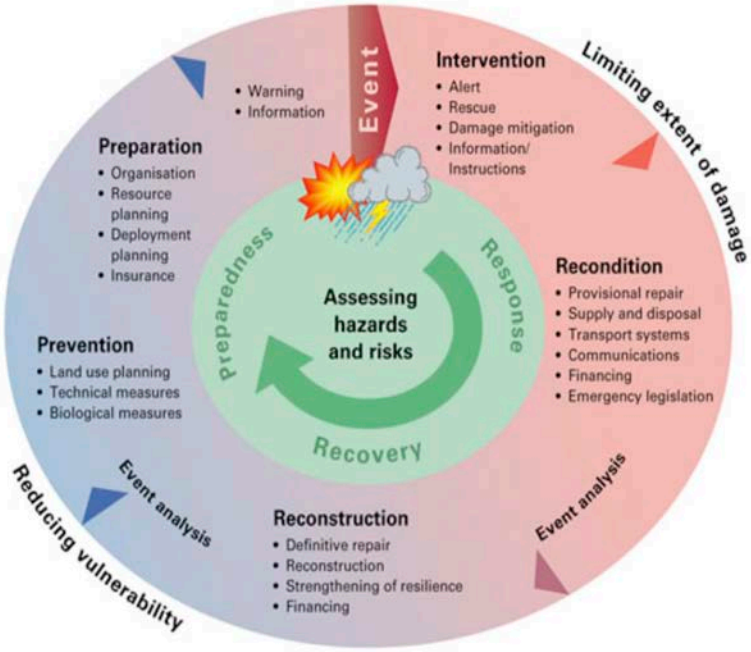

Figure 2 — Framework of the integrated flood risk management cycle (PLANAT, 2003)

3 In many countries, integrated flood risk management procedures are already implemented. This is a good basis for the establishment of transboundary flood management but there isstill the problem of how institutional development can be incorporated on a river-basin scale. What are institutional requirements, opportunities, constraints and prevalent practices for theimplementation of IFM in international river basins and how can transboundary cooperationbe organized? In this publication, based on the experiences of existing cooperation in manyinternational river basins, procedures and lessons learned will be presented.

4 Goals and benefits of cooperation in transboundary river basins are:

- Support of the sustainable use of the water resources;
- Securing the environmentally sound management of the water;
- Strengthening of integrated flood management;
- Support of peace and security;
- Strengthening of sustainable development;
- Support of poverty alleviation.

5 The strengthening of IFM as part of transboundary cooperation is important, because floods can occur everywhere and do not stop at political borders. Preparation of a concerted river-basin management plan is necessary and should be based on the results of existingmonitoring programmes. From this management plan, more developed monitoring andassessment programmes can be derived. Information required may include, among others:

- The actual situation related to water transfer, protection measures, land use, deforestation, etc.;

- Identification of functions and uses of the river basin;
- Inventories on the basis of available and accessible information;
- Definition of lacking information;
- Identification of criteria and targets;
- Evaluation of water legislation in riparian countries;
- Commitments and legal obligations.

6 Best practices in transboundary flood management should be used, in particular on the following topics:

- Integrated river-basin approach;
- Research, education and exchange of knowledge;
- Strengthening of institutional capacities;
- Retention of water and non-structural measures;
- Land use, zoning and risk assessment;
- Structural measures and their impacts;
- Public awareness, public participation and insurance;
- Early warning, flow forecasting, flood emergency;
- Minimizing environmental impacts.

7 Cooperation on transboundary flood management can be envisaged at three levels:

- At the regional level, it is possible to consider general recommendations applicable to allwater bodies common to two or more countries, e.g. the European Directive on theAssessment and Management of Flood Risks;
- The second subregional level would cover basin-wide arrangements established inaccordance with the international drainage basin concept, e.g. the International Commission for the Protection of the Rhine (ICPR);
- The third level corresponds to bilateral agreements concerning specific sites or boundary regions. This is the level at which the most detailed measures for joint management can be discussed and agreed upon (for example, the Columbia River Treaty).

8 Joint commissions are often the main executive instrument of treaties or conventions, administering and applying their rules and principles. Joint commissions can conduct studiesand make recommendations but they generally have no authority either to act upon or enforce decisions. Most commissions have mainly investigatory and advisory responsibilities pertaining to questions or matters of dispute among participating countries. It is forgovernments to decide whether or not and how to act on the recommendations of acommission.

9 International cooperation can be greatly facilitated if appropriate institutional structures andinfrastructures exist at the national level in the countries concerned. These structures and infrastructures include elements such as legal regulatory systems, monitoring networks, water authorities and research. National water authorities capable of defining priorities,

policydirections, targets and, where appropriate, prescribing standards, are helpful in defining cooperation.

10 The most appropriate geographical entity for the planning and management of waterresources and flood control is the basin, including its surface-and groundwater. Ideally, the effective integrated planning and development of transboundary river or lake basins hassimilar institutional requirements as in the case of a basin entirely within one country andshould be based on the same principles. The essential function of international basinorganizations is one of reconciling and harmonizing the interests of riparian countries, monitoring water quantity and quality, developing concerted action programmes, exchanging information and enforcing agreements.

11 The most pivotal and complex function of a national authority lies in the establishment ofeffective integration of the overall socio-economic and environmental decision-makingprocess with the formulation of policies and programmes. Similar linkages are required inorder to conserve ecosystems and development needs on a sustainable basis. Such an authority may also provide an enabling environment for local resource mobilization and theflow of financial resources and the coordination of external support. Other functions of anational authority could be concerned with the coordination and management of data, including national monitoring networks, the formation of a regulatory framework, thefacilitation of technology transfer, the support of human-resources development, thepromotion of sustainable water management and full public participation in all aspects ofwater.

12 The national authority provides the necessary support for river and lake basin authorities orcommittees with responsibility for the integrated management of the water resources in thebasin. At the very least, a central authority needs to provide a system of linkages betweenexisting organizations dealing with water resources, with a view to harmonizing approachesand policies. In the case of federated countries, parallel states or provincial authorities maybe needed to perform related functions falling under the jurisdiction of states or provinces.

13 IFM in transboundary basins must be based on policies, legislations, regulations andordinances, as well as on technical standards of the riparian countries. Because these issues are normally different from one country to another, it is very difficult or evenimpossible to set up legislation, regulations, etc., which are binding for all countries involved. In such a situation, basic directives stated by a regional authority and valid for allstakeholders involved, could be very helpful. For example, the European Union (EU) Directive on the Assessment and Management of Flood Risks, which entered into force in 2007, requires measures to reduce and manage negative impacts of floods on human health, the environment, cultural heritage and economic activities. For international river-basin districts, such as the Rhine basin with several riparian States which may sometimes even bebeyond the boundaries of the EU, the aim is a single flood risk management plan. Theimplementation of the Directive is coordinated by the International Commission for theProtection of the River Rhine, which facilitates the cooperation process in the Rhine Basin.

14 Hydrology is an important topic in the framework of IWRM and IFM. Hydrology also plays animportant role, therefore, in transboundary cooperation. The relationship between hydrology, integrated water resources and flood management is shown in **Figure 3**.

15 Cost-benefit analysis plays an important role in transboundary cooperation. For the participating countries, win-win situations provide the best guarantee for successfulcooperation.

Box 1 — Benefits of cooperation in the Nile Basin

The Nile Basin Initiative (NBI - www.nilebasin.org) is an intergovernmental organization dedicated to the equitable and sustainable management and development of the shared water resources of the Nile Basin. Its efforts in basin-wide water and water-related natural resources assessment, monitoring and reporting, knowledge management, data and information exchange, basin-wide planning and advisory services, regional policy development, communication, awareness-raising and stakeholder involvement have brought benefits to the countries involved. For example, Egypt derives benefits from NBI's facilitation in the following core areas:

– Water-resource development: the NBI assists Member States (MSs) to identify development opportunities, prepare projects and seek investments;

– Water-resource management: the NBI provides analytical tools and a shared information system that enables MSs to monitor and sustainably manage the water resources;

– Facilitating cooperation: the NBI provides a platform upon which MSs can deliberate issues of transboundary water-resources management and development.

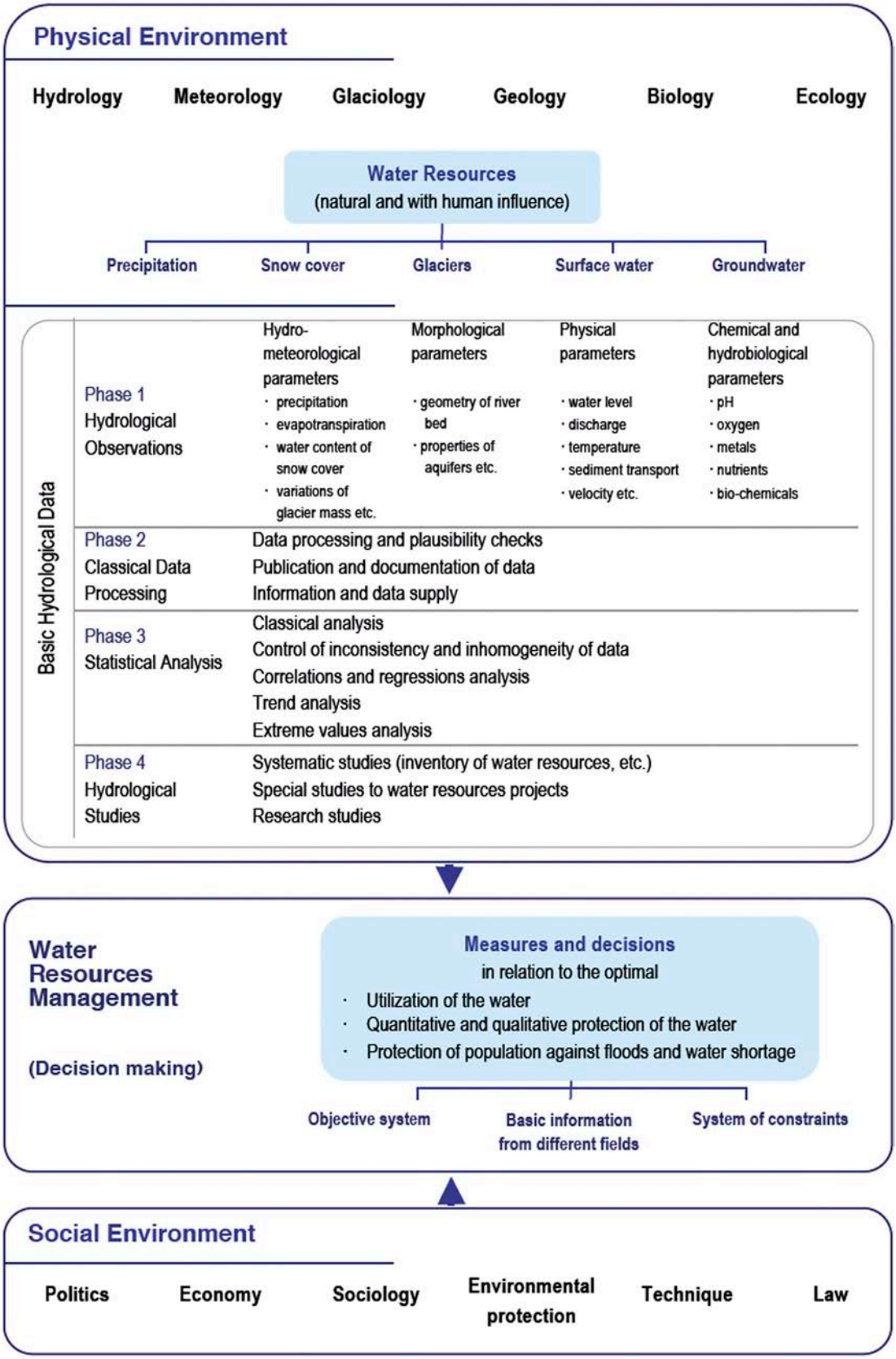

Figure 3 — Relationship between hydrology and IWRM (based on Emmenegger & Spreafico, 1979)

2 PROCEDURES FOR TRANSBOUNDARY FLOOD MANAGEMENT

2.1 General

16 The Charter of the United Nations and the principles of international law confer the sovereign right on countries bordering transboundary waters to use such waters within their territory in accordance with their own policy for the environment and impose on them an obligation toensure that their activities do not cause undue damage to the environment of other countries or of areas outside their national territory.

17 On the basis of the principle of reciprocity and neighbourly cooperation, all countries bordering watercourses are called upon, in the interest of the optimum management ofresources – and especially in the field of flood protection – to cooperate, if wished by at least one of those countries.

18 The United Nations/Economic Commission for Europe (UNECE) Water Convention on the Protection and Use of Transboundary Watercourses and International Lakes became aglobal convention on 6 February 2013, open to all United Nations Member States. Theentering-into-force of the amendments will create a strong legal base for present and futureParties of the Convention to join forces to protect transboundary waters and the benefits deriving from them. It will strengthen political support to transboundary water cooperation.

19 In bilateral or multilateral agreements, countries bordering transboundary watercourses or lakes should agree on cooperating in as practical a way as possible, resulting in a continuousand detailed exchange of information, regular consultations and decisions concerning research of common interest, developments, objectives, forecasts, programmes and specific measurements, including the use and monitoring of these measurements.

20 There are no fixed models that can fit the diversity of situations in transboundary river basins. In all cases, however, a balance between economic and political considerations, as well as awin-win situation, must be attained.

21 The necessary activities for transboundary management can be structured into five steps:

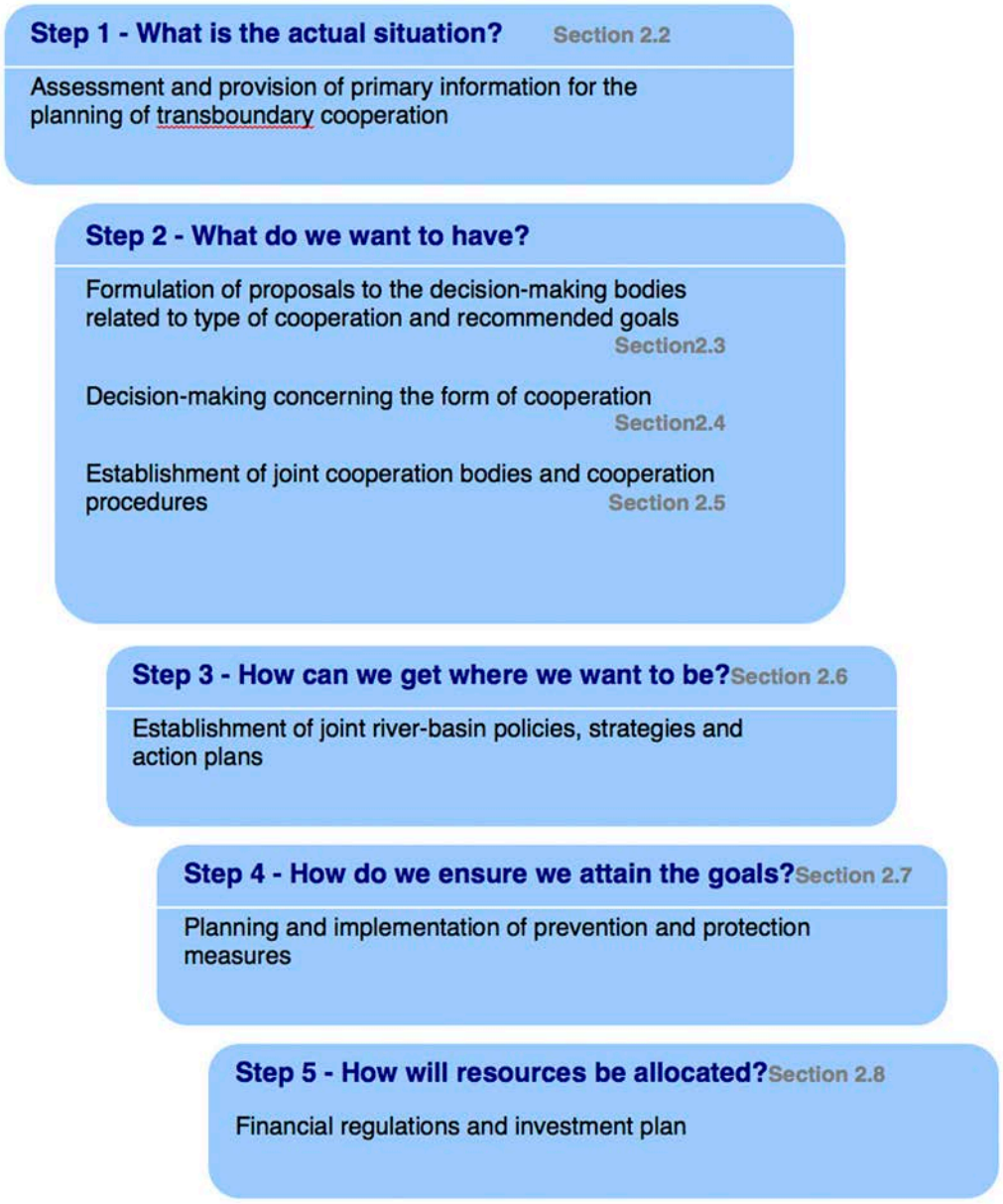

Figure 4 — Steps of transboundary flood management

2.2 Assessment of primary information for the planning oftransboundary cooperation

22 As a first step, all information concerning the current situation in the riparian countries shouldbe collected and analysed. Ideally, country monographs or basin monographs already exist.

23 The information needed for transboundary flood management covers:

24 Physiographical, climatic, hydrological and sociological description and information;

- Economic aspects;
- Government and authorities' issues;
- Overview of current problems and hot spots;
- All information relevant to floods, including damage potential;
- Vision, mission, strategies and policies currently used;
- Responsible authorities for flood protection and the decision-making process;
- Existing laws, regulations and ordinances related to water resources and flood management;
- Flood-management procedures used;
- Guidelines for flood protection at rivers and lakes;
- Guides for the execution of river works, flood protection works and prevention;
- Reports with findings based on the detailed analysis of recent flood events and casestudies with examples of successful practices, recommendations on the procedures forestimating damage potential, leaflets on the integral planning of river works and regional drainage planning, etc.;
- Flood-retention facilities and possibilities (natural lakes, artificial reservoirs, floodplains, etc.);
- Land use, zoning and risk assessment (hazard maps, hazard assessment, risk maps, etc.);
- Existing inventories and bibliographies;
- Finances for flood-protection allocation;
- Overview of structural river works and their impacts;
- Flood forecast systems in use and warning/alarm procedures;
- Current state of flood emergency planning and measures;
- Procedures implemented for the prevention of water pollution from floods, including that of groundwater;
- Information from research and training facilities;
- Tasks/role of stakeholders (government, national, regional and local authorities, private institutions (such as insurance agencies), the general public and the media) in theplanning, implementation, operation and maintenance of flood protection;
- Information about any already existing transboundary collaboration in other topics within the basin.

25 In a first phase, it is advisable to collect information that is accessible and readily available. Aprofound analysis of the information, structure and set-up of priorities must be carried out. Initial proposals for cooperation can be developed, based on these results.

26 Good experiences for this process have been made with the organization of seminars with representatives of governmental agencies, research institutions and non-governmental organizations (NGOs). In such a seminar, delegations can present the general principles which have been formulated and applied in their countries and which could serve as thebasis for

cooperation on transboundary flood management. Participants can compare theirexperiences with various forms of cooperation and can provide detailed information. Different forms of treaties, codes and contractual arrangements can be discussed.

27 Also recommended is the presentation and discussion of existing examples concerning the implementation of bi-and multilateral agreements, including the wide variety of differentmechanisms ranging from working parties to well-established international river commissions.

28 Delegations should also exchange experiences in the application of compatiblemeasurement devices and monitoring systems. Ideas for the implementation of nationalmonitoring stations or methods into international basin-wide monitoring systems can also bediscussed. In addition, systems for joint data collection, analysis, interpretation, processingand final publication can be reviewed. Possible cost-sharing arrangements should bepresented and discussed. Efforts which can help coordinate national policies, including land- use planning, long-term planning and basin-wide planning, should be defined.

29 The international impacts of floods should be considered, not only from the hydrological andsocio-economic points of view, but also from that of water-quality management, since floodscan carry sediments with increased concentrations of pollutants, including toxic, persistent and bioaccumulative pollutants, which might lead, in particular, to groundwater pollution downstream.

30 Additional baseline information for transboundary flood management can be found in a widerange of publications, e.g. the concept paper on Integrated Flood Management from WMO/GWP's *Associated Programme on Flood Management* (WMO, 2009), the *Guidelines for Sustainable Flood Prevention* (2000), the UNECE *Proposals of Best Practices on Flood Prevention, Protection and Mitigation* (2003) and the WMO *Guide to Hydrological Practices* (2008) can support the determination and harmonization of hydrological dataassessment.

31 The documents and presentations provided and the results of the discussions and proposalsare the basis for recommendations to the decision-making bodies of the countries concerns. In addition, the results provide information to fill gaps and can point out the need for anynecessary investigations in the future.

2.3 Formulation of proposals to the decision-making bodies related to the type of cooperation and recommended goals

32 The political will and commitment to cooperate with other countries in a basin is the mostimportant prerequisite for the successful implementation of transboundary cooperation. Cooperation in transboundary basins can focus on only one topic, e.g. flood protection, but can also cover several topics, e.g. water quality and flood protection, or even handle alltopics of integrated flood management.

To set up cooperation, goals must be formulated first, e.g.:

- Selected common safety standards in the riparian States should be guaranteed within a defined time;
- Defined sustainable measures for flood protection must be planned and implemented in the basin within a certain time period;
- A common flood-forecast and flood-information system should be installed and operatedto limit the remaining risk;
- A coordinated comprehensive hazard assessment in the basin should be carried out;
- Sophisticated cooperative planning of protection measures should be carried out;
- Definition of flood-flow reduction targets and goals for selected regions and cross-sectionprofiles can be used to formulate cooperation goals. Targets in the Rhine basin, forexample, are:
  - Reduction of damage risk by 10 per cent by 2005 and up to 20 per cent by 2020;
  - Reduction of extreme flood stages downstream of the impounded part of the Upper Rhine by up to 30 cm by 2005 and by up to 70 cm by 2020.

Goals can also be set up related to flood-protection principles and their application in the basin, e.g.:

- Comprehensive analysis and documentation of the hazards;
- Greater degree of protection of areas and objects of high value than those of lower value;
- Retardation of flood discharge in retention areas in order to dampen flood peaks;
- Appropriate maintenance of river and stream channels;
- Provision of safety from floods with minimum impact on the natural habitat.

2.4 Decision-making concerning the form of cooperation

33 The form of cooperation depends on needs, the problems to be solved, the capacities of the cooperation parties and the available finances. Forms of cooperation must be concretized, e.g. by binding treaties between central governments or by legally non-binding flood-action plans or by formal agreements between bordering regions or agreements of scientificinstitutions in the basin.

34 Bi-and multilateral agreements should define and describe the objectives andimplementation of cooperation. A convention or agreement should, if possible, come into force as soon as at least two of the contracting parties have completed the procedure foraccession. Provision should also be made concerning the period of validity of a convention oragreement, the possibilities regarding notice of termination and periods for giving notice, and the sharing of expenses arising from the application of the cooperation.

35 Experience has shown that the conventions and agreements should make provision, in the first instance, for the establishment of expert working groups or commissions to study andelaborate particular arrangements for precise measures.

36 In all the agreements relating to transboundary flood management, the recording, collectionand joint evaluation of the data and information are of extreme importance for neighbourlycooperation and joint efforts to ensure protection against floods.

2.5 Establishment of joint cooperation bodies and cooperation procedures

2.5.1 General

37 By implementing a cooperation body, four basic decisions must be taken:

- Bilateral or multilateral cooperation in flood management;
- Cooperation focused on the topic of flood management or integration into a joint institution with IWRM duties;
- Temporal or permanent cooperation;
- Status of political and/or technical cooperation body.

38 Having formulated the goals and aims of a project, it will be necessary to decide whetherthere should be bi-or multilateral collaboration with neighbouring countries. In many cases, bilateral cooperation is to be preferred, as it is much easier to organize. Even when morethan two countries are involved, it seems easier, in general, to conclude bilateral agreementsinitially, even if these have to be extended and adapted later on, in a second phase. Examples for such a step-by-step approach are the forecasting systems of the Rhine Riverand the Mekong River (see **Section 2.7.2**).

39 Each year, the cooperating bodies should submit to participating governments a report whichwill give an account of their activities aimed at achieving the common objectives. This annualreport may also contain an evaluation of the data of continuous monitoring and be used to inform the public.

40 A convention or agreement making provision for the establishment of joint commissionsshould, as far as possible, define in detail its composition, tasks and final arrangements sothat, in the common interest, the commission may be able to undertake its work as quicklyand as effectively as possible and in accordance with the terms of the agreement. The commission should consist of delegations nominated for the purpose by the variouscontracting parties. It should adopt its own internal regulations to organize its work. Commissions having many participants and important tasks are advised to have their own secretary and secretariat; in smaller commissions, the function of the secretariat should beentrusted to the president. Commissions should have the right to consult experts andscientific institutes and to designate special or permanent working groups.

41 If projects are of limited duration or are implemented only once, it will be enough, as ageneral rule, to entrust the examination of questions of common interest to working groups established by the contracting parties. If activities are of a wider scope and the projects oflonger duration, however, it will be necessary to establish a joint commission. For example, the International Commission for the Study of Floods on the Rhine was established as atemporary commission

in 1968 with the task of carrying out an overall study on floods of theRhine. Upon publication of the report in 1978, the Commission was abandoned. Theobjectives of holistic flood prevention and protection were than integrated into the tasks of the ICPR and are now part of this permanent cooperation.

42 It would be necessary to take full account of the national structure and legal arrangementsamong the contracting countries and also the intergovernmental structures. Theseconsiderations should help resolve the problem of knowing whether a new commissionshould be of a merely advisory nature and, if not, to what extent it should be authorized toobtain the conclusion of obligatory arrangements directly between contracting countries.

43 The following details for the implementation of a cooperation body must be defined:

- Legal and political aspects;
- Composition and organization of the joint commission;
- Work procedure and schedule;
- Tasks of the commission and all stakeholders;
- Defining responsibilities and competences;
- Organization of the secretariat;
- Procedures for decision-making;
- Financing procedures;
- Possibilities of implementing specific programmes;
- Procedure for collaboration with other institutions.

44 Guidelines for Creating a Memorandum of Understanding and a Standard OperatingProcedure between a National Meteorological or Hydrometeorological Service and a Partner Agency are the subject of WMO 2012.

2.5.2 Examples

Box 2 — Columbia River Treaty

- **Type:** cooperation based on a bilateral agreement
- **Parties:** Canada and the United States of America
- **Goal:** development and operation of the water resources of the Columbia River Basin for thebenefit of flood control and power production

Further information on the Columbia River Treaty is available at:
http://digital.law.washington.edu/dspace-law/bitstream/handle/1773.1/1147/2WJELP001.pdf?sequence=1

45 The Columbia River is the fourth largest river in North America and is shared by Canada and the United States of America (USA). Some 50 percent of the flows in the downstream area at The Dalles during the worst flood in 1894 crossed the Canadian border. The Columbia River is the largest hydroelectric power-producing river of the continent (Bankes, 2012).

46 In 1909, principles and procedures affecting boundary waters were established and anInternational Joint Commission was created to study issues relating to their joint use. In1959, the Commission recommended principles for determining and apportioning benefits forthe cooperative use of storage. Treaty negotiations began and the Columbia River Treatywas ratified and implemented in 1964. It is valid until 2024.

47 The Treaty required Canada to build and operate dams on the Columbia and on a tributary in Canada. This storage reduces flood flows, reduces spill and shifts energy from low-value time periods to high-value time periods. Under the Treaty, the USA must deliver electricpower to Canada equal to one-half the estimated US power benefits from the operation ofCanadian treaty storage. In addition, the USA paid money to Canada relating to the expectedUS flood damage prevented from 1968 to 2024, owing to the operation of the dams in Canada.

48 The Treaty states that either nation can terminate most of its provisions, beginning in 2024, with a minimum 10 years' written notice. It gives the USA rights to storage in Canadian reservoirs after 2024 but the operation can be changed. This example shows that transboundary cooperation is a dynamic process and may need continuous updating or updating from time to time.

49 Benefit of cooperation: The Treaty provides benefit to both countries and is a typical win-win situation. Treaty coordination between Canada and the USA on power and flood controlprovides US$ 100 million of annual mutual benefits across the Columbia River Basin. Itpromoted infrastructure and governance development, such as the electrical intertie to California, regional power preference legislation, added generators at most Columbia dams and produced several regional power coordination agreements (Bankes, 2012).

Box 3 — Mekong River Commission (MRC)

- **Type:** cooperation based on a bilateral agreement
- **Parties:** Cambodia, Lao People's Democratic Republic (Lao PDR), Thailand and Viet Nam
- **Goal:** promote and coordinate sustainable management and development of water and related resources for mutual benefit and people's well-being

Further information on the Mekong River Commission, its organization, programs, publications, forecasts and data portal are available at: http://www.mrcmekong.org

50 From the 1950s, information about the Mekong River was collected within the framework of the Mekong Committee, founded by the United Nations. The Mekong River Commission **(MCR)**, the successor of the Mekong Committee, was established in 1995 by the Mekong Agreement. No longer under the umbrella of other organizations, the management responsibility of the Commission is in the hands of its four Member Countries: Cambodia, Lao PDR, Thailand and Viet Nam. The agreement of 1995 changed the focus from development of large-scale projects to sustainable development and management of natural resources. The MRC is another example of how transboundary-cooperation goals and strategies can change over time.

51 The MRC is planned as a world-class, financially secure international river basin organization assisting the Mekong countries to reach an economically prosperous, socially strong and environmentally sound river basin.

52 The MRC is a politically guided commission. Environment and water ministers of the fourcountries are members of the Council of the MRC and take decisions. The MRC Joint Committee has high-level officials and national technical agencies and brings the decisionsand policies of the Council forward by putting them into action. The MRC secretariat supportsall relevant technical and administrative action necessary for implementation.

53 MRC operates a large number of programmes, such as the Agriculture and IrrigationProgramme, Basin Development Programme, Environmental Programme, NavigationProgramme, etc. The Flood Management and Mitigation Programme **(FMMP)** is a special programme in the framework of MRC. The MRC working paper *Legal aspects of themandate of the 1995 Mekong Agreement for enhancing cooperation in addressingtransboundary flood and related issues* of October 2007 provides interesting information. The FMMP is designed to minimize negative flood-related impacts, whilst preserving thebenefits. The Regional Flood Management and Mitigation Centre based in Phnom Penh hashelped State agencies in the four riparian countries to manage flooding through data andtools that make timely flood forecasting and impact mitigation possible.

54 The Centre provides daily warnings to the government agencies and communities in Cambodia and Lao PDR with advanced notice of rising water levels. Other preparedness tools provided by the Programme include flood markers and community billboards that provide clear information on current and predicted water levels. Through online postings, radio-communication, dissemination of guidebooks and the holding of workshops, FMMP strives to reach a wide audience throughout the entire Mekong Basin.

55 In the tributaries of the Mekong, flash flooding as a result of intensive rainfall is the largest risk for people and infrastructure. The FMMP is also developing a flash-flood guidancesystem for tributary rivers. This tool will be used to indicate the likelihood of flooding fromsmall streams over wide areas.

56 The regional Flood Forum serves to coordinate flood-management activities with planners, scientists, international organizations and civil society organizations. The Forum acts as aplatform to share experiences, information and lessons learned.

57 Since 2005, the Annual Flood Report has provided an overview of flooding in the Lower Mekong Basin.

Box 4 — International Commission for the Protection of the Rhine (ICPR)

- **Type:** cooperation based on a multi-lateral convention and covers several topics
- **Parties:** France, Germany, Luxembourg, the Netherlands and Switzerland
- **Goal:** the Rhine ecosystem is to be sustainably developed. Rhine water will continue to be suitable for drinking-water production. The quality of Rhine sediments is to be improved to the extent that dredged material may be deposited without causing any environmental harm. Holistic flood prevention and protection will take ecological requirements into account

Further information on ICPR is available at: http://www.iksr.org

58 The ICPR was established by France, Germany, Luxembourg, the Netherlands and Switzerland. Cooperation started with the Treaty of Berne in 1963 and intensified with theConvention on the Protection of the Rhine in 1999.

59 The tasks of ICPR are:

- Water-resources protection and conservation;
- Monitoring and surveillance of water resources;
- Protection and improvement of water quality;
- Water-pollution prevention and control;
- Protection of groundwater;
- Protection of aquatic ecosystems and freshwater living resources;
- Flood prevention and protection, as well as flood management;
- Evaluation of impacts and adaptation to climate change.

60 Topics covered by the ICPR are given in **Figure 5**:

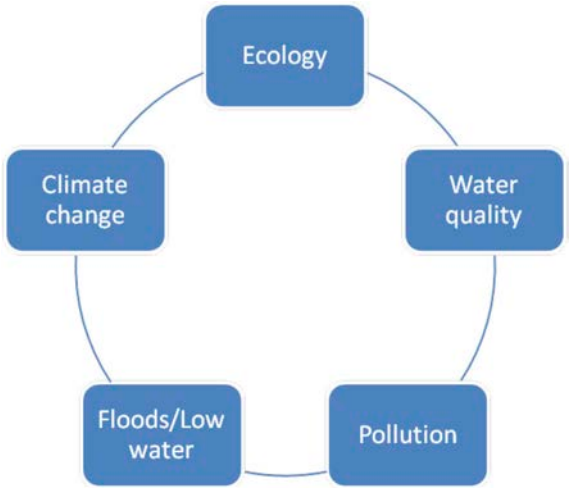

Figure 5 — The five main areas of the ICPR mandate

61 The legal basis of the ICPR:

- Treaty of Berne, 1963;
- Chemical Convention, 1972;
- Convention on the Protection of the Rhine, including flood prevention and protection, 1999;
- European Water Framework Directive, 2000;
- European Flood Management Directive, 2007;
- Rules of Procedure and Financial Regulations, 2010.

62 Organization of ICPR:

Ministers of the contracting countries decide on commitments for the States and define precise tasks for the Commission. The decisions are binding for the countries **(Figure 6)**.

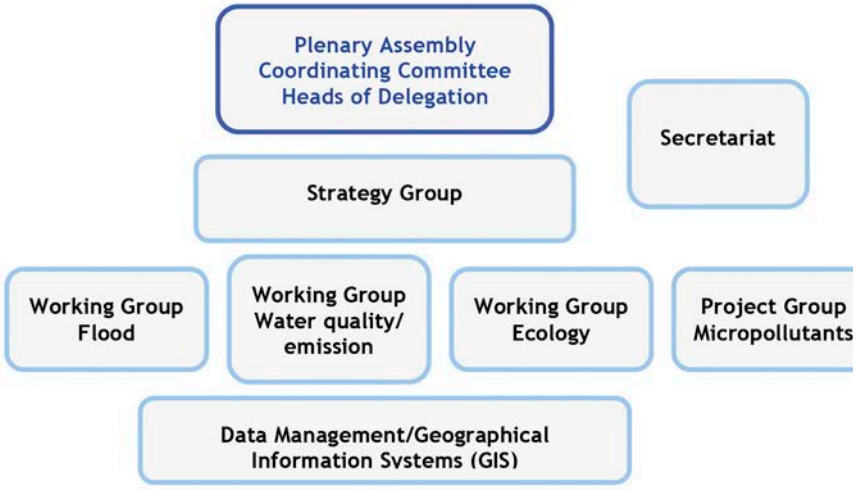

Figure 6 — Organizational structure of ICPR

63 Concerning flood management, several actions have been carried out and measures planned and implemented, e.g.:

- An inventory on flood protection, level of actual protection, damage potential andmeasures planned for all parts of the Rhine has been made;
- An Action Plan on Floods was implemented in 1998. It aims at improving flood protectionfor people and property by 2020 and extending and enhancing the floodplains of the Rhine. Clearly defined objectives and targets are fixed (see **Section 2.3**);
- A Rhine atlas of flood danger and potential damage from extreme floods has beendeveloped with the aim of alerting people living along the Rhine to personal risk and possible property damage;
- A guideline for measures and their effectiveness in non-structural floodplain managementhas been produced by experts of the participating countries;
- A sediment management plan for the Rhine has been established. This has been animportant step because the problems of erosion, sediment transport and sediment deposition are often underestimated by flood management;
- Flood forecasts are provided and alarm centres have been set up along the Rhine (see **Section 2.7.2**).

64 The 2007 European Union Directive on the Assessment and Management of Flood Risks also goes in the direction of harmonization. The targets of the Directive are legally binding forall countries of the European Union. The ICPR coordinates, based on a decision of ministersof the Rhine riparian States, the activities of transboundary cooperation in the Rhine basin.

Box 5 — Shared watercourse systems in theSouthern African Development Community region

- **Type:** regional protocol concerning river basins in southern Africa
- **Parties:** Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, the United Republic of Tanzania, Zambia and Zimbabwe
- **Goal:** to implement principles of how international rivers within the SADC community will be managed

Further information on watercourses in the SADC region is available at: http://www.sadc.int

65 For a long time there were no regional conventions regulating common utilization and management of the resources of shared transboundary rivers and lakes systems in the SADC region. Based on the concepts of environmentally sound management, sustainable development and equitable utilization of transboundary waters, the countries of the SADC setup a protocol on shared watercourse systems. The protocol covers issues such as generalprinciples, establishment of river-basin management institutions, their objectives andfunctions, financial and regulatory framework, settlement of disputes, signature, ratification, entry-into-force, accession, amendments, withdrawal and termination. It states that the original of the protocol and all instruments of ratification and accession shall be depositedwith the Executive Secretary of SADC, who will transmit certified copies to all MemberStates. The Executive Secretary shall register this Protocol with the Secretariats of the UnitedNations Organization and the Organization of African Unity.

66 Of special interest are the principles mentioned in the protocol on which cooperation should be based:

- The utilization of shared watercourse systems shall be open to each riparian or basin State within its territory and without prejudice to its sovereign rights;
- Member States undertake to respect and apply the existing rules of general or customaryinternational law relating to the utilization and management of the resources of sharedwatercourse systems and, in particular, to respect and abide by the principles ofcommunity interests in the equitable utilization of those systems and related resources;
- Member States lying within the basin of a shared watercourse system shall maintain aproper balance between resource development for a higher standard of living for their peoples and conservation and enhancement of the environment to promote sustainable development;
- Member States within a shared watercourse system undertake to pursue and establishclose cooperation with regard to the study and execution of all projects likely to have an effect on the regime of the watercourse system;
- Member States shall exchange available information and data regarding the hydrological, hydrogeological, water-quality, meteorological and ecological conditions;
- Member States shall notify, without delay, other potentially affected States and competentinternational organizations of any emergency originating within their respective territory;
- In the event that implementation or execution of any planned measures is of the utmosturgency in order to save life, protect public health and safety, or other equally important interests as a result of an emergency situation, the Member States planning themeasures may immediately proceed with implementation or execution, provided that, insuch an event, a formal declaration of the urgency of the measures shall becommunicated to the other Member States;
- Member States shall maintain and protect shared watercourse systems and related installations, facilities and other works in order to prevent pollution or environmental degradation.

67 The entry-into-force is also fixed in the protocol as being 30 days after the deposit of theinstruments of ratification by two-thirds of the Member States of SADC. Such a protocol, when it is in force, can be helpful for the planning and implementation of bi-and multilateralcooperation procedures and harmonization activities in the region.

2.5.3 The role of cooperation between research institutions of riparian countries and knowledge provision

68 To set up an organization of cooperating research institutions in a transboundary basin is ahelpful tool to support basin commissions in their tasks of integrated water-resources andflood management. A good example is the International Commission for the Hydrology of the Rhine Basin (CHR).

Box 6 — International Commission for the Hydrology of the Rhine Basin (CHR)

- **Type:** multilateral scientific institution for cooperation in the field of hydrology
- **Parties:** leading scientific institutions of Austria, France, Germany, Luxembourg, the Netherlands and Switzerland
- **Goal:** the CHR initiates and compiles hydrological studies which are important for the long-term management of the Rhine and the rivers in its catchment areas

Further information on CHR available at: http://www.chr-khr.org

69 Founded in 1970, the CHR is a permanent, independent international commission and performs its work throughout the entire Rhine Basin. It is incorporated as a foundation in theNetherlands. CHR cooperates with and supports other international commissions acting in the Rhine Basin with hydrological information, such as the:

- International Commission for the Protection of the Rhine;
- International Commission for the Protection of the Mosel and Saar;
- International Association of Water Treatment Plants;
- International Commission for the Protection of Lake Constance;
- Central Commission for Navigation on the Rhine.

70 The Commission started with the following tasks:

- To study the development and variation of flows in the Rhine Basin;
- To gather, edit and publish observations;
- To promote studies of droughts, floods, forecasts, etc.

71 A period of consolidation followed from 1975 to 1990 with the continuation of CHR's work within the scope of the International Hydrological Programme (IHP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the WMO's Operational Hydrological Programme. The tasks were adapted in line with current requirements in the CHR statutes in 1991.

Figure 7 — Tasks of CHR from 1991 to 2000

72 The political and institutional conditions then changed again, fundamentally. The European64 Union is significantly involved in shaping water policy and international organizations such as the ICPR have become more prominent. The CHR therefore updated its tasks in 2000.

73 The CHR supports the implementation of long-term water management by:

- Making the findings of its studies available to decision-making authorities in the countries along the Rhine as well as to the EU; and
- Contributing towards the evaluation and development of strategies and courses of action.

74 The CHR makes a conscious effort to optimize the use of scientific resources by:

- Fostering cooperation between the hydrological institutions in the Rhine river basin, performing joint studies and developing standardized procedures for collecting and processing hydrological data;
- Cooperating with scientific and official agencies, as well as with international organizations in the Rhine basin;
- Promoting the exchange of information between these agencies;
- Maintaining contact with similar organizations in other river basins within and outside Europe;
- Taking part in UNESCO's IHP and WMO's Hydrology and Water Resources Programme (HWRP) and incorporating its findings therein.

75 The following topics are central to this work. These topics are interrelated, i.e. models andmethods are prerequisites for developing strategies and concepts. Consequently, it isimportant to give due consideration to all topic areas, despite the restricted potential of the CHR.

- Identifying significant loopholes in scientific and technical research (understanding, data, modelling) for the lasting management of rivers. Hydrological questions are of uppermostimportance;
- Identifying key factors and discussing possible courses of actions in conjunction withlong-term river management (CHR working as a strategy forum);
- Hydrological questions in the context of water management and flood management;
- Influencing variables (properties of catchment areas and rivers) for the river regime;
- Sediment regime in the function of the river regime and the morphological processes;
- Ecological functions of hydrological and morphological processes;
- Models which enable hydrological and morphological processes to be described andwhich record the effects of various forms of intervention in rivers;
- Methods of recording and processing data, information exchange and hydrologicalforecasting;
- Monographs with information of hydrological relevance.

76 The presidency alternates between Member States. The president supports the work of the CHR, sets new incentives, represents the Commission externally and chairs its meetings. The Secretariat (1.5 persons) is funded by the Netherlands and is based there. Publications and

activities are financed by Member countries. The Scientific Secretary supports the President in the discharge of his duties and monitors the work of the reporters/rapporteurs and working groups.

77 The National Representatives' Assembly is the management committee. The nationalrepresentatives put forward the interests of their countries and ensure that the national scientific, governmental and private organizations are properly involved. They come fromleading official and scientific agencies in the countries along the Rhine.

78 The Assembly:

- Decides CHR strategy and work programme;
- Constitutes a forum for debating strategic questions regarding long-term river management in the Rhine basin;
- Creates and safeguards good relations with the scientific and governmental agencies ofthe countries along the Rhine and in the EU, as well as with international organizations; and
- Takes decisions on carrying out projects and the publication of completed projects.

79 The projects are carried out by rapporteurs and international working groups.

80 In order to create synergies, CHR cooperates with other international organizations and commissions active in the Rhine Basin.

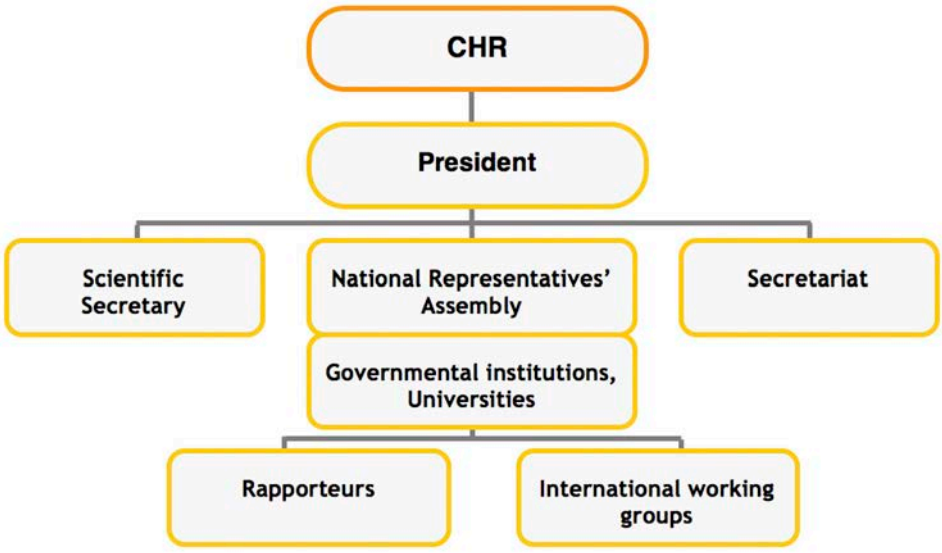

Figure 8 — Organization of the CHR

81 Selected studies and investigations of the CHR are:

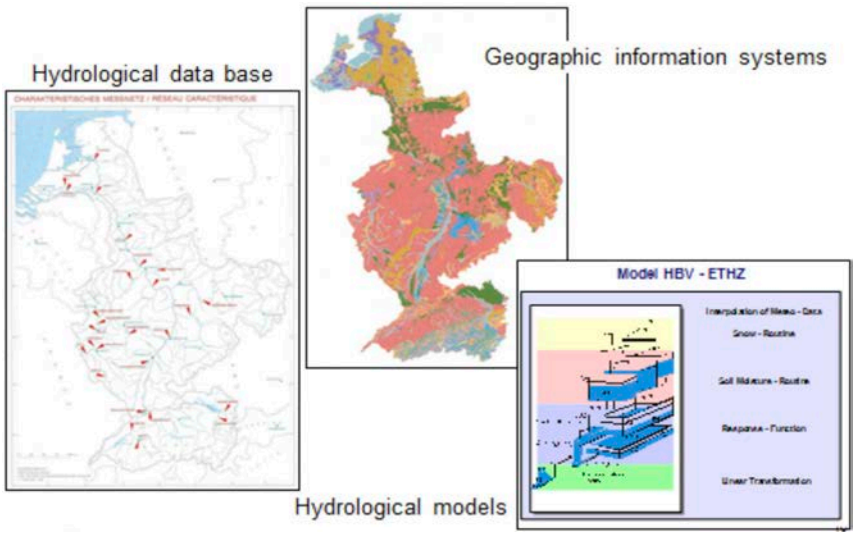

Figure 9 — Development of a monograph and exchange of data, knowledge and products

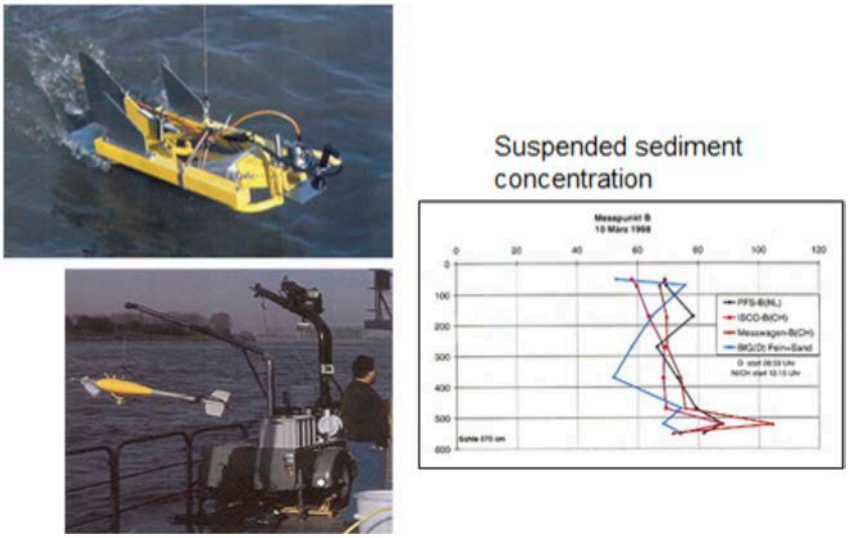

Figure 10 — Provision of high-quality data and comparison of measurement techniques

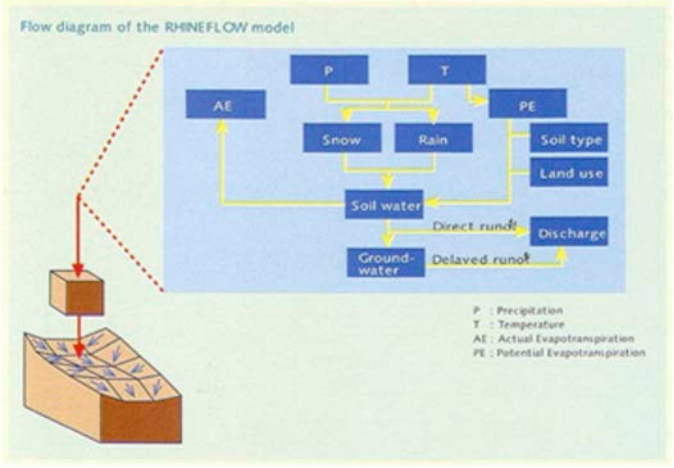

Figure 11 — Analysis of long-term time series and modelling of impacts of climate change,

including proposals for adaptation principles

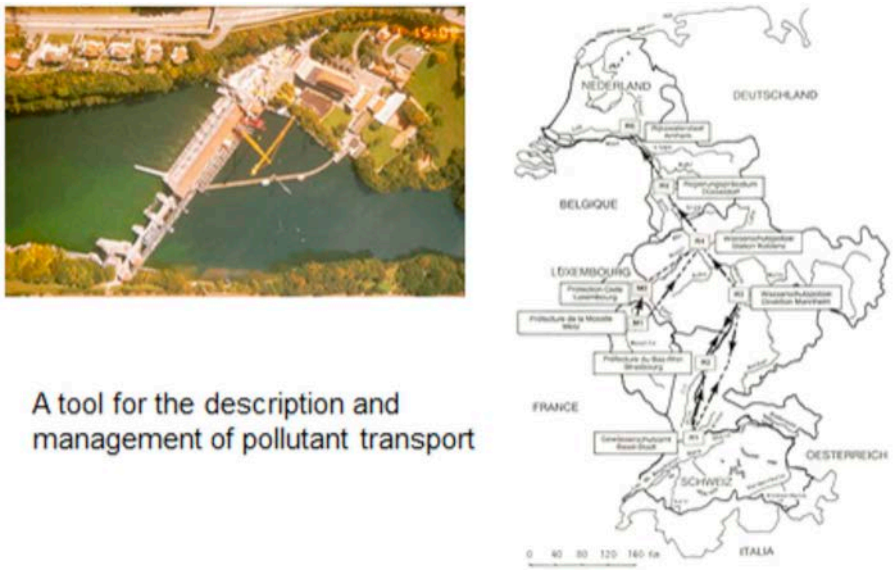

Figure 12 — Development and implementation of an alarm model in the Rhine Basin

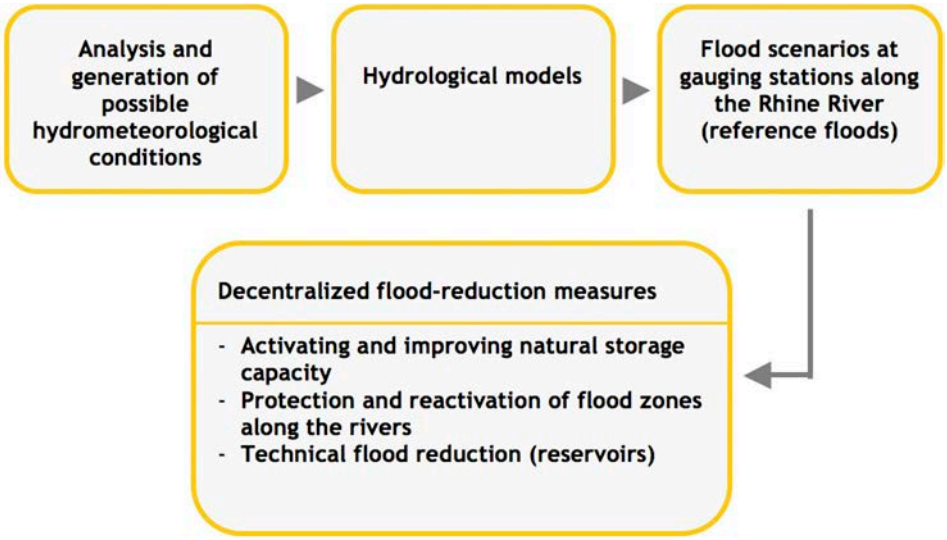

Figure 13 — Methodology for the efficiency control of flood protection measures

82 Cooperation within the CHR is good. As an independent technical and scientific body, it is highly flexible in terms of its choice of projects and decision-making procedures are simple. This enables the CHR to respond quickly and efficiently to requirements. Projects areselected for processing which are of great political importance in the individual countriesand/or which help to solve important problems. The multilateral cooperation enablessupraregional problems to be coordinated and tackled on a global scale. As the funding forthe projects is not normally secured by means of governmental rulings, the requisite financing or manpower has to be provided by the institutions involved. This means thatresources for processing the project have to be released by the national representatives in their institutions or countries. This often proves to be difficult, given the shortage of funding and manpower that is commonplace nowadays. Conversely, the lack of resources meansthat great care is taken in the selection of projects and cooperation with other international institutions is increased.

83 Bearing in mind that many of the problems identified by the CHR in individual countries had to be resolved anyway, the benefits of the CHR are self-evident. The countries are able to solve selected national and supraregional problems in the form of multilateral, efficient andcost-effective cooperation in the CHR. The synergies which are created through the exchange of findings, information and software and the resulting financial savings more thancover the cost of running the Commission.

Box 7 — Nile Initiative knowledge sites

The Nile Information System **(Nile-IS)** is a Web-based information system for the Nile Basin where users can obtain and contribute information from different locations. It supports systematic storage, retrieval and exchange of information. The purpose of Nile-IS is to organize and integrate Nile Basin knowledge assets into a common knowledge base and to provide a trusted, authoritative and reliable source of information of the Nile Basin. It provides a platform for sharing and exchanging information to support decision-making. The Nile Basin library provides access to the information resources required by members of the NBI for research, learning and teaching. Three centres are based in Uganda (Secretariat), Ethiopia and Rwanda. The centres house a collective wealth of some 25,000 print and electronic materials.

2.6 Establishment of joint river basin policies, strategies and action plans

84 A core group of the Water Directors of the European Union, Norway and Switzerland has setup the publication *Best practices on flood prevention, protection and mitigation*, which isbased on the UNECE Guidelines on Sustainable Flood Prevention. For the development ofpolicies and strategies, it is recommended that:

- All appropriate action should be taken to create legal, stable and enabling administrativeand economic frameworks within which the public, private and voluntary sectors can each make its contribution to flood prevention, dam safety and the reduction of adverseimpacts of dangerous flood events on human health and safety and valuable goods andproperty, and on the aquatic and terrestrial environment;
- Priority should be given to IWRM measures for the whole catchment area rather than on the management of floods as such. The impact of all major human activities concerningflood prevention and protection in the catchment area on society as a whole should beproperly considered. All major undertakings with the potential of adversely affectinghuman health or significantly affecting water quality or quantity, biological communities, landscape, climatic factors, architectural and archaeological heritage or the relationshipbetween them should be subject to environmental impact assessment;
- Physical planning, as well as urban and rural development and construction, should takeinto account the requirements of flood prevention and reduction, including the provision ofretention areas. The real development is to be surveyed by monitoring urban settlementsin areas that may be seriously affected by floods;
- Local problems, needs and knowledge and local decision-making mechanisms should be duly taken into consideration;
- An information policy that covers risk communication and facilitates public participation indecision-making should be developed.

85 All envisaged measures concerning flood prevention and protection should be compiled in acomprehensive action plan covering several decades. An integrated action plan for reducing flood damage must:

- Draw long-term conclusions for preventive action in water management, land use, settlement policy and finance;
- Define the scope of responsibilities in the flood-protection system at government andlocal administration levels and responsibilities of public and business companies;
- Ensure permanent and integrated planning of functions and use of the river basin;
- Specify principles for its organization and coordinate investment activities and otheractivities affecting the river basin. It should also form conditions for ensuring permanentharmony of all natural, socio-economic and cultural functions in the basin.

86 Action plan, management of floods and targets: The Rhine Ministers adopted the Action Plan on Floods in 1998. It is based on the five guiding principles of preventive flood protection:

- Water is part of the natural ecological cycle and floods must be accepted as a natural event;
- Water must be stored in the watershed and along the Rhine as much as possible and as long as possible;
- Room for the river must be expanded, allowing the river to inundate when in flood;
- A residual risk will always remain and people must again learn to live with flood risk. Theymust be aware of flood risk and possible effects and should know what preventivemeasures can be taken and what must be done in an emergency situation;
- Integrated and concerted action in the entire catchment area is a prerequisite forsuccessful prevention and protection.

87 Four main actions have been selected here:

- Reduction of damage risks;
- Reduction of extreme flood stages;
- Increase of awareness of flooding by drawing risk maps;
- Improvement of the flood-forecasting system.

88 Action targets were defined relating to these main actions. This could be done in asophisticated way, because much baseline information had already been collected andanalysed. Such targets were:

- Damage risk should be reduced by 10 per cent by 2005 and 25 per cent by 2020 (reference year 1995);
- Extreme flood stages downstream of the impounded part of the Upper Rhine should be reduced by up to 30cm until 2005 and 70cm by 2020;
- Risk maps for 100 per cent of the floodplains and for areas at risk of flooding must be setup by 2005;
- The flood-forecasting period must be prolonged.

89 The results of the implementation of measures were investigated in 2005 and updated where necessary.

90 Artificial reservoirs and natural lakes (regulated and non-regulated ones) can play animportant role in flood management. They can help to reduce flow in downstream areas bywater retention and should be implemented in transboundary flood-management strategiesand action plans. Sometimes, it is advisable to set up a separate commission fortransboundary lakes. Many such cooperation bodies have been set up around the world. Mostly, they cover the topics of water use and water protection. For example, the bilateralInternational Commission for the Lake of Geneva of France and Switzerland has as its main task to monitor the evolution of the water quality of the lake and its tributaries. Commissionsfor flood management can similarly be installed or the objective of flood protection can beimplemented in an existing lake commission.

91 As described in the concept paper *Integrated Flood Management* (WMO, 2009), riverine aquatic ecosystems – including rivers, wetlands and estuaries – provide many benefits tostakeholders. Variability in flow quantity, quality, timing and duration is often critical for themaintenance of river ecosystems. Different flood-management measures have varying impacts on the ecosystem and, at the same time, changes in the ecosystem haveconsequential impacts on the flood situation, flood characteristics and river behaviour. Sustainable flood protection should support flourishing riparian vegetation and should provideample space for the development of natural diversity in the aquatic, amphibian and terrestrial ecosystems.

92 The importance of transboundary groundwater should also not be underestimated. Groundwater is an integral part of the water cycle and must be taken into account by flood management.

93 Catchment flood management plans **(CFMPs)** give an overview of flood risks across each river catchment. They recommend ways of managing those risks now and over the coming 50–100 years. They also take into account the likely impacts of climate change, the effects ofland management, the needs of the environment and the development and optimal use of the water (see, for example www.environment-agency.gov.uk/research/planning/33586.aspx.)

94 Transboundary flood management plans can be implemented based on the CFMPs of the85 countries involved or developed on the principles of the CFMPs.

2.7 Planning and implementation of prevention and protection measures

95 The following principles have been applied successfully in several basins (e.g. *Flood protection in Switzerland, Strategy 2001,* Federal Office for Water and Geology, Berne):

– Retain where possible, let pass where necessary: in order to limit flood peaks, flood discharge should be retarded within retention areas wherever possible. Natural retention areas should therefore not only be maintained but also re-established where appropriate. Flood waves should be allowed to continue to downstream areas if the local situation requires, e.g. in narrow settlements. Flood corridors should be established there or kept free, in order to provide enough space for extreme events;

– Minimize impact: sufficient flow cross-sections are a basic condition for securing floodprotection, balancing the sediment budget and guaranteeing drainage of an area. Nevertheless, safety from flood hazards should be provided with minimum impact on the natural system;

– Check possible failure points: the unpredictability of the natural system has to be considered carefully. Thus, the safety of protection structures needs to be adapted andoptimized.

96 Moreover, the functioning and structural safety of protection structures need to be checked for overstress during extreme events. Possible failure points might be recognized and eliminated eventually through periodic checks of the fitness and usefulness of existing structures;

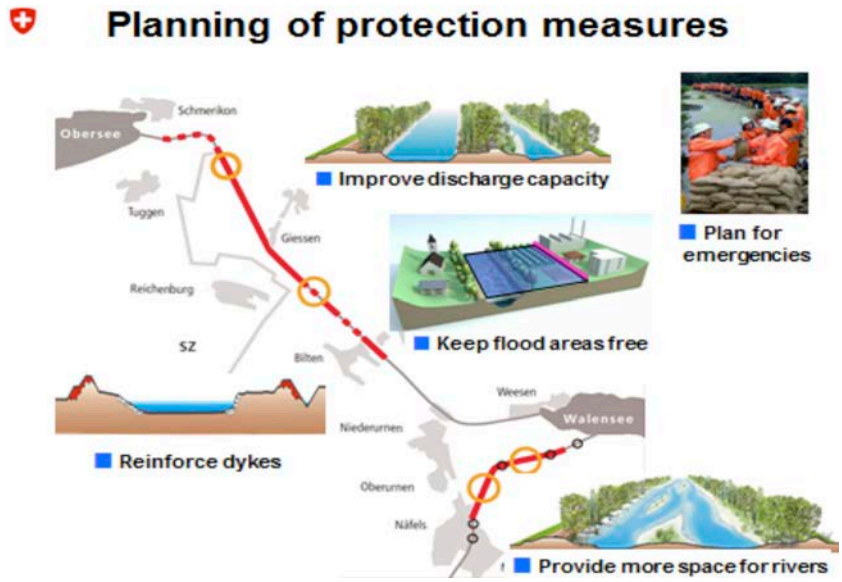

Figure 14 — Specific protection measures

– Guarantee maintenance: appropriate maintenance of watercourses is a permanent task. It ensures maintenance of the substance of existing protection structures andcorresponding discharge capacity;

– Secure spatial requirements: a creek must be more than a simple gutter and a river morethan a channel. Land use in the vicinity of watercourses requires maintenance ofsufficient distance. The responsible authorities are obliged to determine the space required for rivers, to establish this within the structural or land-use plan and to consider itfor all spatially related activities.

2.7.1 Structural and non-structural measures

97 Comprehensive knowledge of hydrological and hydraulic conditions and prevailing hazardswithin watercourses is necessary if protection requirements are to be properly evaluated. Existing hazards and conflicts can be understood by documenting flood events, making complete event inventories and establishing hazard-index maps. Comprehensive analysis and documentation of social, economic and ecological information are necessary.

98 To define the necessary measures based on the action plan, comprehensive information must be collected:

– Identification of potential significant flood-risk areas in the basin (inventories);

- Carrying-out flood risk assessment: the assessment includes a delimitation of thecatchments and sub-basins in the river-basin district, a description of flood events in thepast and the probability of future floods, as well as an estimation of the potential negativeconsequences, taking into account long-term developments, such as climate change, onthe occurrence of floods;
- Development of flood-hazard and flood-risk maps;
- Definition of measures of non-structural floodplain management with indications of their effectiveness. Types of hazards, determination of damage, land-use management, flood-proofing constructions, flood forecasting, flood preparedness, emergency planning;
- Definition of measures for technical flood protection by the construction of dykes, protection walls, retention basins, object protection, etc.

99 Based on this information, a flood-risk management plan can be set up. The most appropriate measures must be planned and implemented with stakeholder participation of the riparian countries.

2.7.2 Early warning and forecasting systems

100 Early warning and forecasting systems are efficient tools for flood prevention and flood emergency. Length of flow forecast period, reliability of forecasts, sophisticated hydrometeorological observation and information systems are key factors for the usefulnessof the forecast. There are various possibilities to implement such systems:

- Forecast and alert systems for large-scale areas: for example, the European Flood Forecasting and Flood Alert System aims to provide information up to 10 days in advance. The forecasts are not as detailed as those of national systems and cannot replace them;
- Forecast and alert systems for transboundary basins can be based on a large-scaleforecast or on a combination of the forecasts of the riparian countries, e.g. the headwater country calculates the forecast and provides the results to the downstream country, whichcan base its forecast on these results;
- National runoff forecast and alert centres are based on global, regional and local meteorological models, on real-time monitoring stations and on detailed warning and alert systems. National and local emergency organizations are responsible for emergency measures.

101 Rhine River forecasting system: At the beginning of transboundary cooperation in the Rhine Basin, the riparian countries operated their own forecasts, with the runoff forecast of Switzerland being used as input forthe forecast systems of downstream countries. Later, flood forecasting and warning centreswere set up along the Rhine River and the hydrological models used were harmonized[1].

102 Nowadays, a forecast model for the whole Rhine is available. National forecast systems are still in operation.

1 Further information on the International Commission for the Protection of the Rhine: www.iksr.org

Figure 15 — Main alarm and forecast centres in the Rhine basin

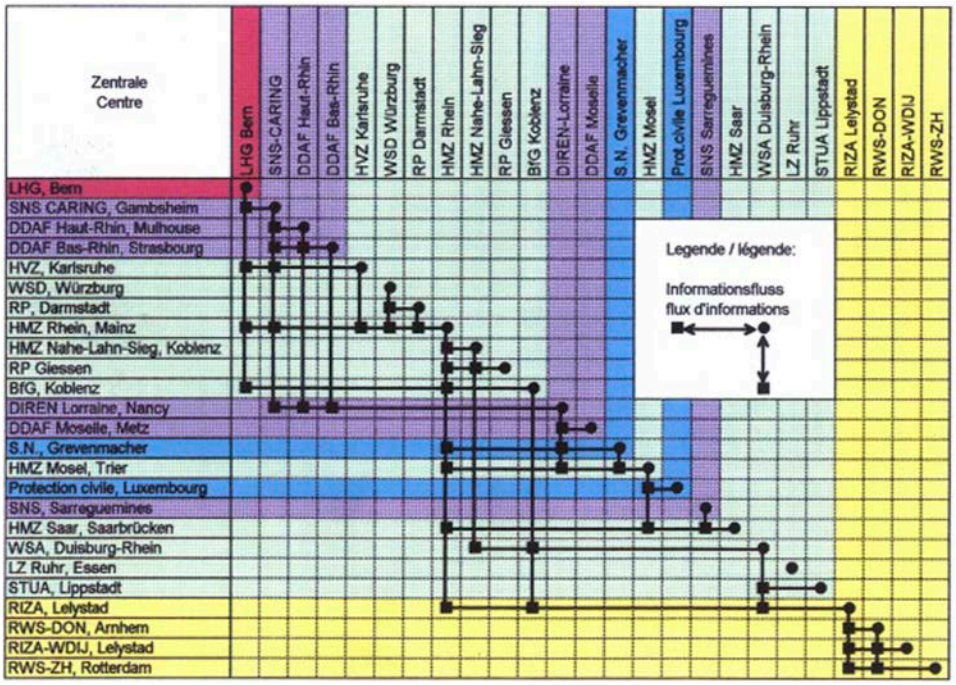

Figure 16 — Flow forecasting, warning and alert system in the Rhine Basin: connections between the alarm and forecast centres

103 **Mekong River forecasting and early warning:** During the June–November flood season, the Regional Flood Management and Mitigation Centre[2] issues daily flood forecasts and warnings. Data from 138 hydrometeorological stations are used to predict water levels at 23 forecasting points on the Mekong River system. The Flood Management and Mitigation Programme communicates these dailybulletins by fax, e-mail and on the MRC home page and dedicated Flood Forecasting Website to National Mekong Committees, NGOs, the media and the public. The daily warnings provide government agencies and communities in Cambodia and Lao PDR withadvance notice of rising water levels. Other preparedness tools include flood markers and community billboards that provide clear information on the current and predicted water levels. Warning messages and awareness-raising are delivered through online postings, radio-communication and dissemination of guidebooks, as well as workshops. A flash flood guidance system for tributary rivers is under development.

104 Selected UNECE "best practices" for transboundary forecast and alert systems are given below:

- A compatible meteorological and hydrological information system and database, ifpossible with a fully automated data-communication system, should be created for the entire river basin. Experience shows, however, that there is a need for redundancy in measuring and communication systems, particularly because of the adverse conditions encountered during the most extreme events;
- An automatic information system, providing and exchanging data about the operation of relevant water-storage reservoirs and other hydraulic structures, should be established and operated, together with the flood-warning services and those participating in floodprotection, i.e. mainly administrators of watercourses and operators of hydraulicstructures. This is a prerequisite for real-time operation of dams and retention basins inthe event of floods;
- An effective and reliable system of flood forecasting and warning dissemination should beset up to inform, at each level, flood authorities and citizens in threatened areas. Traditional and new media such as official warnings, state and private broadcastingservices, satellite-based communication systems, radio alarm calls (radios switched onby remote control), mobile telephones, the Internet, teletext, etc. should be used, testedand performed, according to technical progress. Alarms and action plans must beadapted to local conditions;
- Flood-forecasting models should be worked out, verified and adopted and, if appropriate, harmonized by riparian countries, introduced and regularly improved for the catchmentarea of the main watercourse and its most important tributaries. That means, in particular, harmonizing the technical procedures for hydrological and meteorological forecasting, the procedure of use, storage and exchange of data between neighbouring countries.

2.7.3 Establishment and operation of transboundary flood information systems

105 Flood information systems in international river basins are useful tools for transboundary cooperation and can provide a win-win situation for the participating countries. The real-time information exchange on the hydrometeorological situation and anthropogenic regulation offlows (reservoir operation, diversions, etc.) is helpful for flood-management activities. There are various possibilities for the organization of information exchange:

- Operation of a centralized centre for information collection, analysis and provision of information to the countries involved, e.g. the MRC;

2 Further information on the Mekong River Commission: www.mrcmekong.org

– Operation of a network of centres along a transboundary river, e.g. the ICPR;
– Exchange of flood information between two countries with a bilateral agreement, e.g. the Columbia River Treaty.

2.7.3.1 Example of multilateral regional cooperation for a flood-monitoring and flood-information system: The Hindu-Kush-Himalayan Hydrological Cycle Observing System (HKH-HYCOS)

Box 8 — The Hindu-Kush-Himalayan Hydrological Cycle Observing System (HKH-HYCOS)

Overview Management: Director of Programme of International Centre of Integrated MountainDevelopment **(ICIMOD)**

Support: WMO and private consultants

Parties: Bangladesh, Bhutan, Nepal and Pakistan, with the support of China

Phase 1: Feasibility study and infrastructure testing (2001–2005)

Phase 2: HKH-HYCOS implementation (2009–2013) funded by Finland with five main components:

– Framework for cooperationExpected outcome: strengthened framework for cooperation in sharing regional flood data and information among partner countries;
– Regional flood information networkExpected outcome: establishment of a flood observation network in selected basins inpartner countries24 hydrometeorological stations have been installed. Real-time data transfer and dataprocessing are in operation;
– Flood information systemsExpected outcome: establishment of regional and national flood-information systems to share real-time data and increase lead-time;
– Training and public awarenessExpected outcome: enhanced technical capacity of partners in flood forecasting and communication to end-users;
– Planning and full-scale regional projectExpected outcome: fully integrated regional project planned and agreed among partnercountries.

Phase 3: Implementation of a full-scale project (from 2014 over five years)

– Extension to flood outlook and flow forecast of the Ganges River;
– Overall objective: to minimize loss of life and property by reducing flood vulnerability in the HKH region.

106 The HKH region produces one of the world's largest renewable supplies of freshwater and is the source of 10 of the world's largest rivers: the Indus, Ganges, Brahmaputra, Mekong, Yangtze, Yellow River, Irrawaddy, Salween, Amu Darya and Tarim. These rivers are vital for the survival and well-being of more than a billion people in Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan.

107 It is widely recognized that floods in the HKH region cannot be totally controlled and that efforts should therefore be directed towards reducing flood vulnerability and mitigating flood impact through improved flood management. At the level of an international river basin, effective flood management calls for meaningful cooperation of the riparian countries. An important approach to non-structural flood management is the provision of end-to-end flood-forecasting and warning services. In the international river basins of the HKH region, this approach has the greatest potential for regional cooperation. The flood-forecasting and warning systems need to be integrated with the overall disaster management activities, both nationally and

internationally. Riparian States need to agree on the free exchange of relevant hydrological data among them on a real-time basis. In this connection, the value of satellite technology for the real-time transmission of data on high-intensity rainfall and associated river stage should be recognized: for that purpose, the installation of an adequate satellite-linked observation network throughout the region is essential.

2.7.3.2 Project genesis

108 With the objective of developing a framework for a regional flood-information system to support disaster prevention and flood management, ICIMOD and WMO organized, in May 2001, a high-level consultative meeting on regional cooperation for flood forecasting and information exchange. This meeting was attended by representatives of Bangladesh, Bhutan, China, India, Nepal and Pakistan, who reached consensus on the need for sharing high river flow data. They expressed interest in establishing a regional flood-information system basedon the proven concept of the World Hydrological Cycle Observing System (WHYCOS). The second high-level meeting of government representatives held in Kathmandu, Nepal, in March 2003 led to the continuation of this process. The meeting agreed on the regional concept of a flood-information system and recognized the need for existing bilateral agreements to be enhanced in order to contribute to the regional exchange of flood-related data. It recommended that the participating countries should organize national consultations that would serve to identify national needs and priorities for timely and accurate flood forecasting and for selecting basins for the testing of a regional flood-information system.

109 The national consultations were organized by the national agencies concerned in collaboration with ICIMOD and WMO. Subsequently, a technical meeting on country and regional telecommunication strategies, data management and dissemination of regional flood information was held in Kathmandu in November 2004. A major achievement of the technicalmeeting was the consensus on a regional telecommunication strategy. Partner countries also identified and agreed to share important hydrological data from selected stations during a demonstration and testing phase during the monsoon season of 2005. Moreover, the meeting resulted in the decision to provide minor upgrades to a few selected stations. During the high-level (Secretary) meeting held in May 2005 in Thimphu, Bhutan, all the countries agreed on the project document and recommended raising finances to advance and sustainflood-risk management efforts through advanced forecasting and information sharing between participating countries.

2.7.3.3 The project

110 Since 1995, WMO has been successfully implementing WHYCOS in Mediterranean and southern African regions with the active participation of national governments. The project has been able to promote and facilitate theexchange and use of water-resources data and information, using modern information technologies. Inspired by this global initiative and as aspired to by the Secretary-level meeting of HKH countries held in 2005, ICIMOD in partnership with WMO and in consultation with the countries concerned, developed the HKH-HYCOS project. This project is a regional component of the global WHYCOS programme and is funded by the Ministry of Foreign Affairs of Finland.

111 The main focus areas of the project are: capacity-building for flood forecasting, establishment of a regional flood-information system and methodologies to obtain real-time hydrological

observations. The core of the project will be a regional flood information system that will be accessible to all participating countries and relevant regional entities. River level/flow, rainfall and related information will be observed at specific sites and transmitted in real-time using agreed and reliable means of telecommunication to the National Meteorological and Hydrological Services for flood-forecasting purposes. The observations will then be transmitted simultaneously to a dedicated regional centre and the National Meteorological or Hydrological Service.

112 The regional databases are also of value in improving the knowledge of global climate issues that require hydrological and meteorological information. Addressing regional water-and-climate-related issues calls for regional commitment and cooperation and is the basis on which HKH-HYCOS will be built. The database would also serve to enhance climate-scale prediction efforts and benefit both the agricultural and water-management sectors.

113 The project Regional Steering Committee **(RSC)** was set up to guide the project activities leading to the implementation of the project. It is chaired by the Director of Programmes ofICIMOD and the mandated organizations in the participating countries are its members. Since its formation, the RSC has met three times and finalized the hydrometeorological stations for upgrading and selected the types of instruments required for different stations. Most of the partners have completed the civil works and installation of the stations.

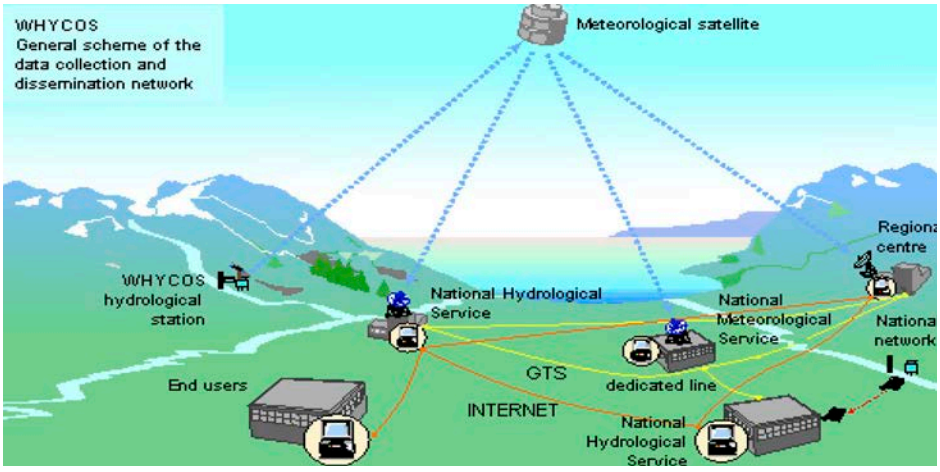

Figure 17 — General scheme of a data-collection and dissemination network

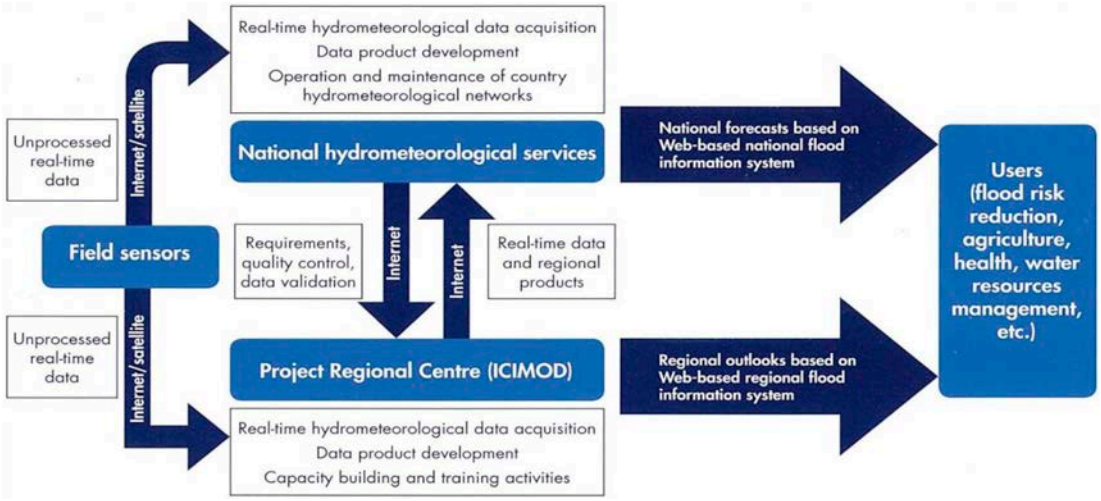

Figure 18 — HKH-HYCOS information flow

2.8 Financial regulations and investment plan

114 With regard to the financing of transboundary cooperation, various procedures are available, depending on the capacities of the countries involved. In a region such as the Rhine Basin, all riparian countries are able to contribute to the cost of planning and implementation ofmeasures. Regional structure funds exist in some regions, e.g. the European Regional Development Fund (ERDF), which can support financially cooperative activities in a basin.

115 In other cooperation projects such as the HKH-HYCOS project on flood information, a donor country financially supports the management and setting-up of monitoring stations, a regional data-processing system, etc. The countries contribute by carrying out additional measures and it is planned that, in the future, the countries will finance the operation of the information system themselves. WMO provides know-how for the project and facilitates the use of global systems.

116 With regard to the financing of a joint commission, each contracting party should bear the cost of studies being undertaken within its territory. The expenses of the budget of the commission should be shared among the contracting parties according to a fixed scale. If required by the particular interests of a contracting party, different arrangements should be made. For example, the expenditure to cover the annual budget is shared by the contracting parties of the ICPR as follows: the European Union pays a 2.5 per cent share; Switzerland12 per cent; Germany 32.5 per cent; France 32.5 per cent; Luxemburg 2.5 per cent; and the Netherlands 32.5 per cent. The rules of procedure and financial regulations can be found at www.iksr.com.

3 ADAPTATION OF RIVER-BASIN FLOOD MANAGEMENT TO CLIMATECHANGE

117 Model calculations show (with all uncertainties involved) that the frequency and magnitude of flood events will change in the future. Greater regional and seasonal differences are expected. In the Rhine Basin in general an increase of flood volumes and peaks is expected in the winter period. Overall, there will be an increase in sediment transport. Seasonal increased flood discharge and larger total sediment load require adequate cross-section and deposition zone areas. This leads to the conclusion that watercourses will need more space than they do at present.

118 To develop strategies for climate-change adaptation in a transboundary basin, it is necessary to carry out a sophisticated study on the impact of climate change on hydrological regimes and water-resources management, including flood-risk management. To that end, recent climate-change scenarios and process-oriented hydrometeorological models must be available. As an example of such an investigation in a transboundary basin, the studies *Impact of Climate Change on Hydrological Regimes and Water Resources Management inthe Rhine Basin* (CHR, 1997) and *Assessment of Climate Change Impacts on Discharge inthe Rhine River Basin* (CHR, 2010) can be mentioned.

119 In (CHR 1997), based on the calculations of the impacts of climate change on discharge, proposals on the management of water resources under changing climatic conditions are presented. Balancing required actions against economic costs and the existing uncertainties in the climate-change scenarios and hydrometeorological models, a policy of "no regret" is recommended. A policy of no regret means: anticipatory adaptive measures are undertakenin response to the impacts of climate change in combination with ongoing activities to improve flood protection. It is important that the measures taken today against future changes are flexible. It should be possible to adapt and extend the implemented measures relatively easily for changed conditions. For investments with a long expected lifetime, such as large weirs or storm-surge barriers, the design should take the present knowledge of the possible magnitude of long-term changes into account. Adaptation at a later stage is expected to be more expensive.

120 The policy brief *Climate change adaptation: the pivotal role of water* (www.unwater.org) gives some valid guiding principles:

- Mainstreaming adaptation within the broader development context;
- Strengthening water governance and integration of land and water management;
- Improving and sharing knowledge and information;
- Building long-term resilience;
- Cost-effective, adaptive water management and technology transfer;
- Additional and innovative funding.

121 These guiding principles can also be used for adaptation procedures in transboundary riverbasins.

122 Sustainable flood protection requires the consistent implementation of an integral risk-management approach. The recommendations of the Commission for Flood Protection of the Swiss Water Resources Society are also valid for transboundary basins:

- For the planning of measures, the consequences of climate change have to be factored in by means of appropriate scenarios;
- The worst-case scenarios have to be considered in order to determine the space requirements for a watercourse – this space must be available;
- Physical protection measures have to be planned in such a way that they can be adapted with a justifiable effort. They have to be robust and cater for overload;
- The overload case has greater significance in relation to climate change;
- Residual risks cannot be avoided completely but they can be minimized by adopting secondary measures (individual flood protection) and with organizational planning (emergency plan and emergency concept).

123 It is of the utmost significance to acquire more knowledge and reduce the unknowns. A comprehensive understanding of the fundamentals is an important prerequisite to dealing adequately with natural hazards:

- To quantify the hydrological consequences of current climate scenarios, models with a high time and space discretization of water balance and discharge formation are needed. Consequently, a denser network of hydrometric stations is required;
- Scenario-based design requires a profound knowledge of the processes involved and of the behaviour of the measures proposed. A thorough analysis of past events is a prerequisite to furthering understanding and reducing uncertainties.

124 The general public has to be sensitized to flood hazards in order to be able to recognize their personal responsibilities:

- Simple adaptation of buildings and infrastructure can reduce damage during an extreme event. The appropriate knowledge has to be communicated to owners, architects and planners through public channels and education;

– Insurance institutions should play a role and promote individual responsibility throughinformation programmes and adaptation of premium policies.

125 The funds available for flood protection are limited. The protection measures that are already necessary today cannot be implemented simultaneously. Where flood-control projects cannot be realized immediately, risks can often be significantly reduced with other inexpensive measures from other domains of integral risk management, such as urban and rural planning, individual object protection or emergency planning.

4 LESSONS LEARNED, RECOMMENDATIONS AND STATEMENTS

126 **Procedures for transboundary flood management:** Transboundary flood management should be carried-out in an integral way by:

- Strengthening IFM;
- Supporting the sustainable, optimal use of the water resources;
- Securing the environmentally sound management of the water resources;
- Supporting peace and security;
- Strengthening sustainable development;
- Supporting poverty alleviation.

127 There is no general procedure of cooperation that can fit the diversity of situations in international river basins, but a balance must be attained between economic, ecological andpolitical/social considerations. Win-win situations should be developed.

128 The creation of confidence among cooperating parties to attain a civilized and peacefulsolution is a must. To attain this, it can be an advantage to focus at the beginning ofcooperation on one common topic only, e.g. flood protection. Cooperation requires patience, persistence and realism. It requires linking water reforms to broader political and economicreforms. To reach sustainability is the most difficult task in transboundary river-basin cooperation.

129 Assessment of primary information:

- The water law, land use, development planning and disaster-response procedures should be harmonized as much as possible.

- The data should be provided not only as a list of parameters, but also interpreted and assessed by experts with relevant recommendations for management action.
- Public awareness programmes to show the benefits gained by international cooperation are necessary. The implementation of a broad spectrum of the population into the decision-making process is helpful.
- The type and nature of the water body must be fully understood, most frequently through preliminary surveys. In particular, the spatial and temporal variability within the whole water body must be known.
- Assessment strategies are required to design and operate monitoring programmes in such a way that the desired information is obtained. This implies the translation of information needs into monitoring networks. The effectiveness and efficiency of monitoring are essential.
- Hydrometeorology is the most important tool to support integrated flood management and international cooperation. Permanent and accurate hydrological observations are needed for the management of the quantity and quality of surface- and ground-water resources. Free access to all types of data and hydrological products should be provided to all stakeholders. Standardized procedures for monitoring, processing, analysing and providing data are vital. The cycle for planning, monitoring and provision of hydrologicali nformation for decision-making is shown in **Figure 19**.

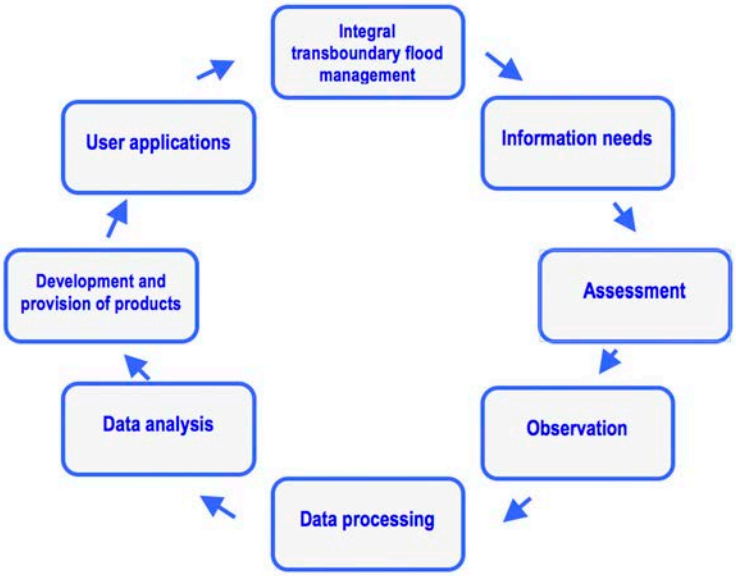

Figure 19 — Cycle of IFM in transboundary rivers

130 **Formulation of proposals to decision-making bodies:** International conventions signed by many countries, such as the UNECE Convention on Environmental Impact Assessment in a Transboundary Context (the Espoo (EIA) Convention) can support the implementation of cooperation. The Espoo Convention sets out the obligations of parties to assess the environmental impact of certain activities at an early stage of planning. It also lays down the general obligation of States to notify and consult each other on all major projects under consideration that are likely to have significant adverse environmental impact across boundaries. The Convention was adopted in 1991 and entered into force in December 1997.

131 Establishment of joint cooperation bodies and cooperation procedures:

- The development of new partnerships and the expansion of existing ones to enhance the long-term sustainability of agreements are important.
- The initialization of processes for approximation of laws and their adaptation to international conventions: for example, the UNECE Convention on the Protection and Use of Transboundary Water Courses and International Lakes (which came into force on 6 February 2013 and is now a global convention) or the 1997 UN Convention on the Law of the Non-Navigational Uses of International Water Courses, will strengthen riparian countries' support for regional cooperation, even if they are not ratified by all countries.
- Global or regional systems operated by international organizations or agencies and open to all countries are excellent tools to set up basin-wide cooperation.
- Sharing cooperation tasks by different organizations in a transboundary river basin (floodmanagement, water protection, water supply, navigation, etc.) is a useful approach.

132 Role of cooperation between research institutions: It is important to establish and institutionalize the structures and mechanisms for sharing knowledge and experiences for the cooperative planning of flood-management issues. The availability or establishment of a system of collaboration among research institutes of riparian countries is of great value for cooperation. Activities could cover, inter alia:

- Supporting the exchange of hydrometeorological data and other products;
- Developing standardized procedures;
- Cooperative carrying-out of monitoring and studies and providing sophisticated products to all stakeholders.

133 Establishment of joint river basin policies, strategies and action plans: Joint basin flood-action plans must be consistent and compatible with the sustainabledevelopment priorities of participating countries. Problems to be solved by cooperation must be of primary importance for the countries involved. It is better to have only a few clear and agreed objectives rather than too many vague ones.

134 Planning and implementation of prevention and protection measures:

- Awareness-building concerning the impact of floods and the possible protection measures on regional, national, local and private level should be strengthened.
- There is always a risk that all structural and non-structural flood protection measures cannot avoid damages by extreme floods. The measures for handling und reducing the remaining risk must be planned.

135 Financial regulations and investment plan: Cost-effectiveness is an absolute necessity in transboundary flood management.

136 Adaptation of river-basin flood management to climate change: The impact of climate change on flood flow should be estimated and taken into account for flood management in transboundary basins.

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