WHYCOS, a programme supporting regional and global hydrology

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Abstract Regional and global hydrology are relatively new concepts. They both depend on reliable national hydrological information systems and on the willingness of the countries to cooperate at regional and global levels, notably through the exchange and dissemination of good quality data and information. Unfortunately, recent studies and international conferences have stressed that hydrological information systems are inadequate or do not exist in many countries, and that regional and international cooperation is rather limited. For these reasons, the World Meteorological Organization (WMO), with the support of the World Bank (WB) and other partners, started to promote, in 1993, the World Hydrological Cycle Observing System (WHYCOS), a programme aimed at supporting the establishment and improvement of hydrological information systems. This global approach is being implemented through components (HYCOSs) established at the level of hydrological, economic and political regions.

INTRODUCTION

Regional and global hydrology are relatively new concepts. These "new" ways of approaching hydrological processes correspond to real demands both from the scientific (knowledge base) point of view as well as from the sustainable development one.

It should be recalled that the International Conference on Water and the Environment (ICWE, 1992), held in Dublin (Ireland), stated that "the most appropriate geographical entity for the planning and the management of water resources was the basin", which very often extend beyond the national border of a single country. Obviously, regional and global hydrology will be extremely helpful in this regard.

Similarly, the UN Commission on Sustainable Development (UNCSD, 1994) declared that "many countries face a water crisis with rapid deterioration of water quality, serious water shortages and reduced availability of freshwater, which effects severely human health, the ecosystem and economic development". CSD urged UN agencies, including WMO, "to strengthen their efforts towards a comprehensive assessment of the world freshwater resources, with the aim of identifying the availability of such resources, making projections of future needs and identifying problems to be considered by the 1997 Special Session of the General Assembly" (UNCSD, 1994). Once again, the new concepts will be very appropriate tools for undertaking reliable periodical assessments. Above all, they will be instrumental for a better knowledge of the hydrological cycle (quantity and quality) which, according to Chapter 18 of Agenda 21 (UNCED, 1992), is essential for the efficient and

sustainable management of the water resources, since life on this planet takes place at the mercy of the water cycle (Falkenmark, 1994), which imposes its constraints to both the social sphere (socio-economic development) and the landscape sphere (environment), within which the development takes place.

Finally, several global initiatives which need a thorough knowledge of the hydrological cycle at the appropriate scales will benefit from regional and global hydrology such as: the World Climate Research Programme (WCRP) and the Global Climate Observing System (GCOS), aimed at improving regional and global climate models to predict seasonal and interannual climate variability, to detect climate change and to reduce uncertainties in climate prediction; the Global Ocean Observing System (GOOS); and the Global Environment Monitoring System (GEMS), etc.

Regional and global hydrology require international cooperation and collaboration, notably through data exchange and dissemination and the establishment of easily accessible regional and international hydrological databases. The FRIEND project of UNESCO has already succeeded in establishing some of these databases with selected sets of historical data for northwest Europe, the Alpine and Mediterranean countries, southern and west and Central Africa, etc. However, hydrological databases are only one piece of a much broader set of activities, harmoniously integrated in what could be called a **hydrological information system**. This system should include collection and dissemination of data and "plays an important role in estimating the quantity and quality of water available, as well as the current and prospective water use and demand patterns" (World Bank, 1994). An example is shown in Fig. 1. Databases are totally dependant from the quality, timeliness, consistency and sustainability of the data flow which feed them. At the basin, regional and international levels this can only be achieved, in a sustainable way, if the national information systems are operational and have more or less reached the same status of development and if the countries have institutionalized their willingness to cooperate, notably by disseminating and exchanging data and information.

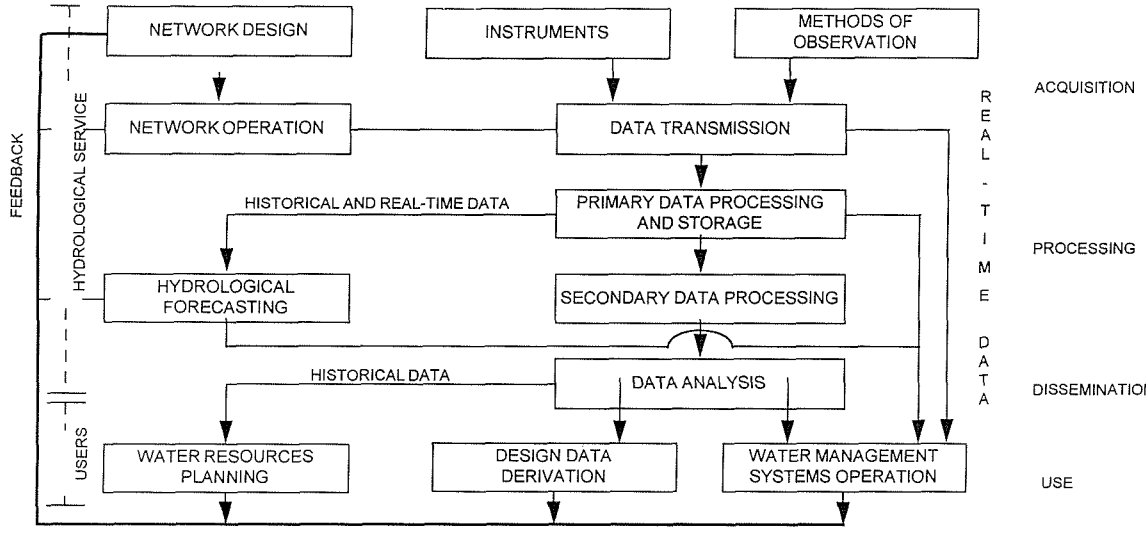

Fig. 1 Hydrological information system.

THE STATUS OF HYDROLOGICAL INFORMATION SYSTEMS

Both Chapter 18, the ICWE report and the WMO/UNESCO report (1991) on water resources assessment (WRA), clearly indicate that in many regions of the world these systems are not working correctly or do not exist at all. Fig. 2, which was prepared by using information collected by WMO for the preparation of the 1995 edition of the INFOHYDRO Manual (WMO, 1995), illustrates the situation which is prevailing in the different Regional Associations (RAs) of WMO. There is a great disparity between the measurement activities within the various regions. For example, in 1994 there were 5703 stations for river discharge measurement in Africa (the second largest continent) and 20 008 such stations in Europe. For water quality stations, the figures were 5297 and 55 379 respectively. Although the number of national data banks grew substantially between the Mar del Plata Conference held in 1977 and 1994, the WRA report (WMO/UNESCO, 1991) notes that in the later part of the 1980s and into 1990s some ground gained in the early 1980s has been lost in both water data collection and management.

Moreover, the Comprehensive Freshwater Assessment, prepared for the CSD by UN agencies, including WMO, and the Stockholm Environment Institute, clearly indicates that the access to reliable data is presently inadequate and that there is a need for national and internationally harmonized information systems, including

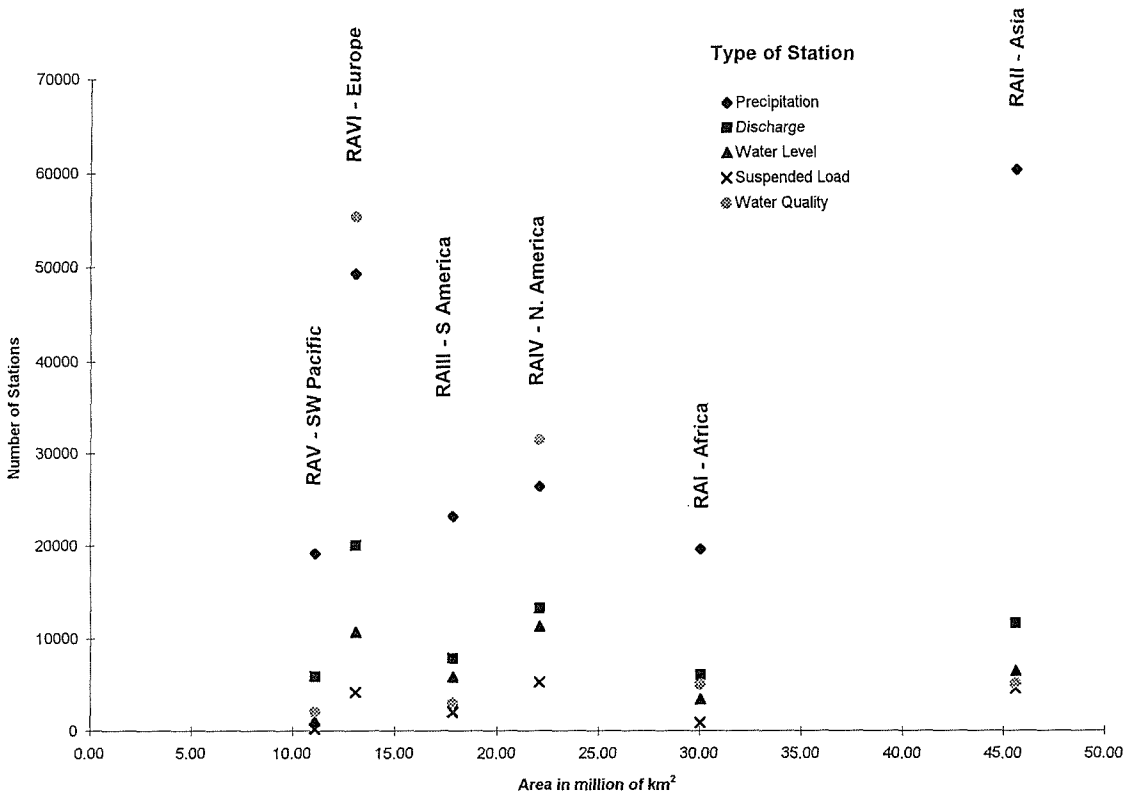

Fig. 2 Number of hydrological stations by area of WMO region.

hydrological ones, that provide data needed for planning and decision making, as well as common ways of analysing the information.

As an example of this situation, the conclusions of the sub-Saharan Africa Hydrological Assessment (SSAHA), executed by the World Bank from 1988 to 1995 with the financial support of UNDP, the African Development Bank (ADB), the European Community and the French Government, demonstrate that the situation of most of the hydrological information systems, and of the services which are responsible for these in the Region, is declining rapidly.

The causes of this situation were discussed during the Addis Ababa Conference organized in Ethiopia by WMO and the United Nations Economic Commission for Africa (ECA), in March 1995 (WMO/ECA, 1995). There is no doubt that the fundamental cause for the decline of water resources assessment and management systems (at national, subregional and international river basin levels), is the slow-down or even reversal of socio-economic progress in a large number of the countries of the Region. In addition, the adverse economic situation has emphasized other historical and structural pre-existing causes.

As a general rule, politicians and decision makers, facing a number of problems, are not aware of the degree of priority of the water sector and for the need for integrated and sustainable development. Above all, in many cases they have generally no idea of the economic value, direct and indirect, of hydrological information systems. It is therefore not surprising that they are not willing to disburse the meagre available funds for the assessment and monitoring of the water resources. Moreover, the general public largely ignore the status of water resources in terms of supply and demand, quantity, scarcity and ecological value. In addition, the National Hydrological Services (NHSs) have increasingly been confined to data collection, network maintenance and operation, with too little involvement in the socio-economic development and promotion of their activities.

This experience, gained from SSAHA, cannot be transferred directly to the other regions of the world. However, the fact that the knowledge-base related to the global hydrological cycle is not adequate has become more and more evident, notably during the recent assessment of global water resources undertaken by WMO/UNESCO, as part of the Comprehensive Freshwater Assessment Project requested by the UNCSD (1994).

ONE POSSIBLE WAY FORWARD

WMO, with the support of the World Bank and other partners, started in 1993 (Rodda *et al.*, 1993) to promote the World Hydrological Cycle Observing System (WHYCOS).

Basic concept and objectives

The underlying principle of this worldwide programme is cooperation between the participating countries in the domain of water resources assessment and management.

The objective of the WHYCOS initiative is to provide a scientific basis for water resources monitoring, assessment and integrated development and management, at different time and space scales, through the improvement of exchange of consistent, reliable and timely available data and information. It will contribute to the knowledge of hydrological processes in their interaction with climate and the environment, and will encourage intersectoral sharing of water resource data and information for development and natural capital management.

Improved cooperation between the participating countries would notably help to address ensuing problems by:

(a) improving consistency in data acquisition, transmission, processing and use; and
(b) strengthening technology transfer and capacity building; and
(c) promoting the free exchange and dissemination of data and information.
(d) supporting the NHSs throughout the world, by carrying out more accurate, sustainable and cost-effective monitoring and management of the world water resources.

Implementation

Originally this programme was essentially conceived to be based on the implementation of a global network of reference stations (hydrological observatories), with real-time data transmission, through satellite whenever possible, to enable the development of consistent, high-quality and constantly updated distributed national, regional and international databases on river flow, water quality and key climatic variables.

The programme however progressively moved from this technological approach to an integrated one, aimed at improving not only the collection of consistent and reliable data, but also the preparation and the dissemination of relevant information on the hydrological cycle at national, basin, regional and international levels, through the implementation/improvement of hydrological information systems meeting the demand.

The vision of the programme is to create a sustainable basis and a logical framework for the "revival" of operational hydrology, demand driven and action oriented, in order to put at the disposal of the end-users information in different domains of application (WMO, 1996).

This revival has to be undertaken with the participation of decision makers, and users at national, regional and international levels and, when necessary, funding agencies. It has to be adapted to the actual short and medium term possibilities of the countries, using first of all the existing resources in terms of personnel, equipment and knowledge. This revival has also to be harmonized with other related ongoing or planned projects in domains such as health, famine and poverty alleviation.

To reach this objective, WHYCOS is being implemented through a two-pronged fully integrated approach with, on the one side, a **global conceptual basis** providing a framework and general guidance based on the improvement of cooperation between the participating countries in the field of water resources assessment and management; and, on the other, **a number of operational activities**, which are being developed interactively and concurrently through the implementation of regional

components: the HYCOSs. This approach allows an independent implementation of each component, notably to be able to establish the institutional and financial agreements which best fit the specific needs and conditions prevailing in the region.

The intention is that the regional projects would be implemented by a Pilot Regional Centre (PRC), hosted by an operational organization existing in the region, either a NHS or a regional organization, under the control of a Regional Technical Committee (RTC) with representatives of all participating countries. According to the situation, a Steering Committee with representatives from the funding agencies, countries and executing agency, might be set up. At the global level, the need for a coordinating body is being considered. The different HYCOSs projects, programmes such as the Global Runoff Data Centre (GRDC) and FRIEND, global observing systems, and users from both public and private sectors, should be represented.

Expected products

Installation of networks of key stations These stations will be multi sensor-equipped Data Collection Platforms (DCPs) to establish a basic network of benchmark stations sited on major rivers for the collection and transmission of several variables related to water resources monitoring. A small number of significant lakes and reservoirs will also be monitored. The stations will be proposed by the participating countries from existing stations which might be easily upgraded to meet a common WHYCOS technical standard.

The stations will be selected according to the WHYCOS criteria: (a) availability of long historic series record; (b) stable calibration curves; (c) regional significance of data collected; and (d) needs expressed. They will transmit data to regional and national centres, mainly through meteorological satellites (METEOSAT, GOES, etc.) and the Global Telecommunication System (GTS) of the World Weather Watch (WWW) of WMO. The variables the programme intends to collect are listed in Table 1.

Development and implementation of regional databases These databases are aimed at providing consistent, good quality, updated and timely available data They will be designed on the basis of the needs expressed by the users. In order to facilitate easy access, the database will have an integrated Web server. Modalities for accessing data and information will be decided by the participating countries, notably on the basis of international recommendations and regulations, such as Resolution 40 of WMO's Twelfth Congress for the exchange of meteorological data and its equivalent for hydrological data (in preparation). It is proposed that during the implementation phase the regional database be developed and installed at the PRC. Later on, the countries might decide to establish a distributed database by interconnecting the national bases using the regional computer network.

Implementation of regional computer networks These networks are aimed at monitoring the regional water resources and promoting data exchange, and encouraging regional and international collaboration between governments, NHSs and other research or operational institutions and organizations. The network will also enable the exchange of information with other databases.

Table 1 WHYCOS: Data to be collected and transmitted.

		Frequency of measurement per day
Environmental variables		
1.	Water level (upstream)	1 to 6 (depending on size of river)
2.	Water level (downstream)	1 to 6 (depending on size of river)
3.	Water conductivity	1
4.	Water temperature	1
5.	Turbidity	1
6.	Air temperature	8 (synoptic hours)
7.	Rainfall	24, plus daily total
8.	Relative humidity	8 (synoptic hours)
9.	Wind speed	8 (synoptic hours)
10.	Wind direction	8 (synoptic hours)
11.	Net radiation	8 (synoptic hours)
Housekeeping variables		
12.	Battery voltage	1
13.	Solar panel voltage	1
14.	Memory status	1
15.	Temperature inside instrument housing	1

Hydrological products These products will be prepared using the data available in the regional database and those made available from other sources at national, regional and international levels. During the first step of the implementation, these products will be developed on a regional basis by the PRC, in cooperation and collaboration with the NHSs of the participating countries and other partners, as necessary. The products will be distributed using several ways such as: the Web of the Internet which will allow a dynamic presentation of the information, E-mail, CD-ROM and other traditional ways. The dissemination will be targeted to the greatest possible number of users. A survey of the impact of these products will be conducted and new products developed, in line with the results of the survey. Later on, NHSs of participating countries will be trained to develop products at national level and therefore create/improve the market for hydrological information.

Training The NHSs will be in charge for installing, operating and maintaining the WHYCOS hydrological stations, carrying out regular stage/discharge calibration, maintaining databases and network connections, and validating raw data. Additional observational and telecommunication instrumentation might be provided for the upgrading of the selected stations forming the WHYCOS network. When necessary, the NHSs will also be provided with hardware and software for the national databases, and for the preparation of hydrological products and their dissemination. Relevant training programmes will be developed to cover all aspects of the programme, including marketing, promotion and public relation.

STATUS OF THE PROGRAMME

Several regional projects are at different stages of development or implementation:

(a) **MED-HYCOS** (Mediterranean rim), is being implemented with WMO as the executing agency, with support from the World Bank and other partners. The PRC is hosted by the French Scientific Research Institute for Development through Cooperation (Orstom), in Montpellier (France). The installation of the first 20 DCPs is being done and a regional telecommunication system, based on the use of existing segments of the GTS and of Internet, is being developed concurrently with relevant training sessions. The implementation of the project would be extended to the Black Sea, as new funds become available.

(b) **SADC-HYCOS** (Southern Africa Development Community). The project document was prepared by SADC and WMO at the request of the European Union (EU) which is now funding the implementation of the project under the Lomé Fund, with WMO as the supervising agency. The PRC will be hosted by the Directorate of Hydrology, in Pretoria (South Africa) and 50 DCPs would be installed during the year 1997.

(c) **AOC-HYCOS** (West and Central Africa). The project document has been prepared by WMO and local experts, through a contract signed with the French Ministry of Cooperation, and presented to the Ministry in the early 1997. Web sites for MED-HYCOS and for a pilot AOC-HYCOS project can be reached through WMO's home page (http:// wmo.www.ch) under Hydrology and Water Resources Programme.

(d) **Congo-HYCOS** (Congo River basin). Would be part of a Regional Environment Information Management Project for the Central Africa Region (REIMP-CAR). The preparation of the project document by WMO is funded directly by the European Commission, under a contract signed with WMO in February 1997.

(e) **Aral Sea-HYCOS** (central Asia). The relevant project document has been prepared by WMO in cooperation with Swiss experts. It would be one of the components in a World Bank's Aral Sea Programme. Other HYCOSs are under consideration for the preparation of the corresponding project documents such as **IGAD-HYCOS** (Eastern Africa), **CARIB-HYCOS** (Caribbean region) and **NILE-HYCOS** (Nile basin).

CONCLUSION

A number of surveys, reports, and international Conferences have recently highlighted the **absence or the inadequacy of the hydrological information systems** mainly, but not exclusively, in developing countries. Moreover, **regional cooperation for the assessment and management of shared water resources is difficult to establish and to sustain.**

These are obviously **limiting factors** for the development of regional and global hydrology, which at the same time are responding to needs expressed by users ranging from national to international agencies.

In addition to the economic problems, which a number of countries are facing, there is an absence of a real understanding by the decision makers of the role of the hydrological cycle in the socio-economic development and in environment and biodiversity protection.

Therefore, WHYCOS is being implemented in order to participate in the sustainable revival of these systems and of the regional and international cooperation in the field of water resources assessment and management. The approach chosen is regional and integrated, through the utilization of appropriate and well-tried tools, development of human resources, tailored and targeted financial support, promotion and dialogue with the users at national, regional and international levels in a new information context.

Thus, the WHYCOS programme of WMO and the FRIEND programme of UNESCO are working hand-in-hand for the development/improvement of regional and global hydrology for the benefit of knowledge and sustainable socio-economic development.

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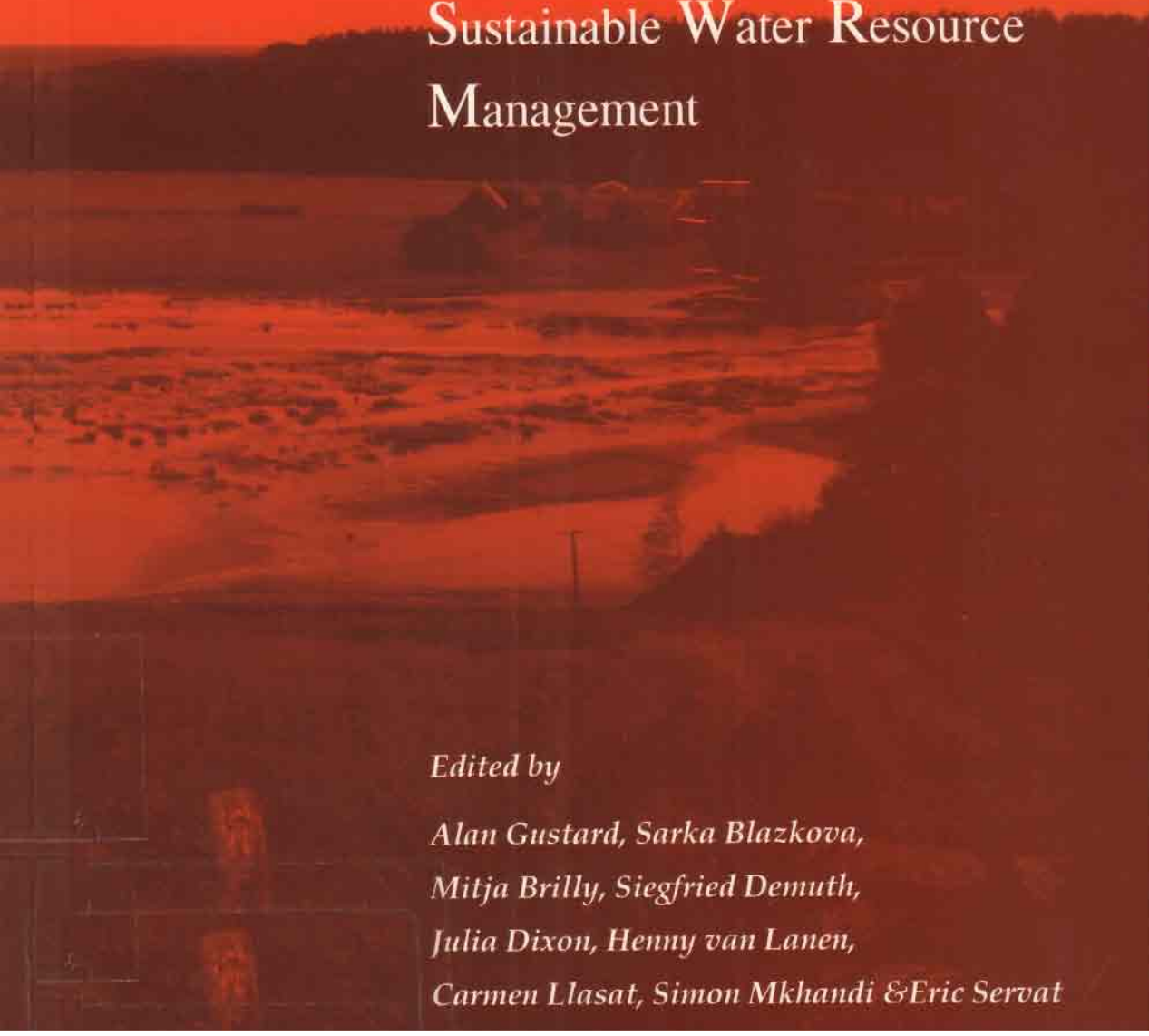

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