3

Water resources assessment

3.1 Background

Water resources assessment (WRA), comprises the continuing determination of the location, extent, dependability and quality of water resources and of the human activities that affect those resources.

WRA is a prerequisite for sustainable development and management of the world's water resources. It provides the basis for the vast range of activities where water is involved. Without detailed WRA it is impossible properly to plan, design, construct, operate and maintain projects for the following purposes: irrigation and drainage; mitigation of flood losses; industrial and domestic water supply; urban drainage; energy production (including hydropower); health; agriculture; fisheries; drought mitigation and the preservation of aquatic ecosystems, estuarine and coastal waters.

The nature of the decisions based on WRA information may involve major capital investments with potentially massive environmental impacts. WRA provides a sound scientific basis for these investments, reducing risks and avoiding failure. It is also vital for government policies and programmes necessary to ensure sustainable development. Indeed, without the knowledge of the quantity and quality of surface- and groundwater resources derived from their comprehensive monitoring, it is impossible to determine whether sustainable development is being achieved and what to do if it is not.

There is growing concern that at a time when more precise and reliable information is needed about water resources, hydrological services and related bodies are less able than before to provide this information, especially information on groundwater and water quality. Major impediments are the lack of financial resources for water resources assessment, the fragmented nature of hydrological services and the insufficient numbers of qualified staff. At the same time, the

Table 13. *Institutional framework in support of water resources assessment*

Activities and related means of implementation	Level[1]	Considered by	
		ICWE[2]	UNCED[3]
1. Define the information needs of users for WRA, including the needs for flood and drought forecasting.	NP	X	X
2. Establish a national policy, a legislative framework, economic instruments and regulatory arrangements.	N	X	X
3. Establish the institutional arrangements needed to ensure the efficient collection, processing, storage, retrieval and dissemination to users of information about the quality and quantity of available water resources at the level of catchments and groundwater aquifers in an integrated manner.	N	X	X
4. Establish and maintain effective cooperation at the national level between the various agencies responsible for the collection, storage and analysis of hydrological data.	N	X	X
	N	X	X
5. Ensure that the assessment information is fully utilized in the development of water management policies.	N		X
6. Cooperate in the assessment of transboundary water resources.	IN	X	X
7. Encourage the application of methodologies developed and endorsed at the international level.	IN	X	
8. Develop and disseminate information on the means of estimating benefits and costs of WRA activities.	IN	X	

[1] Level of implementation: I=International; N=National; P=Provincial or sub-national; L=Local.
[2] Considered in ICWE *Report of the Conference* section 3.
[3] Considered in UNCED Agenda 21 paragraph: 18.23–34.

advancing technology for data capture and management is increasingly difficult for developing countries to access. Establishment of national databases is, however, vital to water resources assessment and to mitigation of the effects of floods, droughts, desertification and pollution.

3.2 Institutional framework in support of water resources assessment

Basis for action:

The assessment of the water resources of a country is a national responsibility and the activities concerned should be designed to meet the specific needs of that country. Many of its component activities may be undertaken at the local and provincial levels. Given the importance of assessment information to support sustainable development and for the maintenance of ecosystem integrity, all countries are urged to achieve a level of WRA activity appropriate to their needs as soon as is practicable.

Various institutional arrangements can support effective WRA programmes. In most countries responsibility for WRA is, unfortunately, divided between a number of ministries and national or provincial bodies. The growing need for integrated water resource management points to the desirability of close coordination between the different bodies involved in the collection, storage and analysis of the relevant data.

Should this responsibility be shared among neighbouring countries, such as in the case of transboundary water resources, international programmes and projects can provide valuable assistance.

Major international assessment initiatives have been undertaken through the Operational Hydrology Programme (WMO) and the International Hydrological Programme (UNESCO). These have been summarized for ICWE in WMO/UNESCO, (1991a) and Ayibotele, (1992).

Strategy and programme targets:

The national policy should be that all WRA activities are fully coordinated and adequately funded. The approach taken to achieve this may differ from country to country, but it will usually involve the establishment of regulations and a series of administrative decisions, particularly on the allocation of funds.

The success of these efforts can be measured by the general level of WRA activities and by a review of the degree of duplication of effort. Whether responsibility is centralized or distributed, WRA requires investment of financial resources if it is to provide the support to sustainable socio-economic development that is demanded of it. These resources, however, represent only a small fraction (say 0.2 to 1.0%) of the funds spent on the water sector as a whole.

Table 14. *Collection and storage of hydrological data*

Activities and related means of implementation	Level[1]	Considered by	
		ICWE[2]	UNCED[3]
1. Review existing data-collection networks and assess their adequacy, including those that provide real-time data for flood and drought forecasting.	IN		X
2. Install monitoring systems and improve networks designed to provide data on water quantity and quality for surface and groundwater, as well as relevant land-use data. Ensure the continuous operation of such systems in support of studies requiring long-term data, such as those relating to climate change.	N	X	X
3. Upgrade facilities and procedures used to store, process and analyze hydrological data and apply standards and other means to ensure data compatibility.	IN	X	X
4. Implement techniques for processing hydrological data and assimilating related information by: (a) establishing databases on the availability of all types of hydrological data at the national level; (b) implementing 'data rescue' operations, for example, by the establishment of national archives of water resources; (c) implementing appropriate well-tried techniques for the processing of hydrological data; (d) deriving area-related estimates from point hydrological data; (e) assimilating remotely sensed data and by using, where appropriate, geographical information systems.	IN	X	X
5. Make available to all countries water resources assessment technology that is appropriate to their needs, irrespective of their level of development, including methods for the assessment of the impact of climate change on freshwaters.	IN	X	X
6. Ensure the transfer of appropriate technology, particularly between hydrological services.	IN	X	

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[3] Considered in UNCED Agenda 21 paragraph: 18.23–34.

3.3 Collection and storage of hydrological data

Basis for action:

Reliable information on the condition of and trends in a country's water resources, including surface water, water in the unsaturated zone and groundwater, in respect of both quantity and quality, is required for a number of purposes, such as:

- assessing the resource and its potential for supplying the current and foreseeable demand
- protecting people and property against water-related hazards
- planning, designing and operating water projects
- monitoring the response of water bodies to anthropogenic influences, to climate variability and change, and to other environmental factors.

Integrated monitoring and information systems should be established and data collected and stored on all aspects of water resources which are required for a full comprehension of the nature of those resources and for their sustainable development. These include not only hydrological data, but also related geological, climatological, hydrobiological and topographic data and data on soil types, land use, desertification and deforestation, as well as data on water use and reuse, sewage discharges, point and non-point sources of pollution and the loads discharged to seas and oceans. This involves the installation of observation networks and other data-gathering mechanisms designed to monitor various climatic and topographic regimes, plus the development of data-storage and processing facilities. Where, at national, regional and international levels, water-related information is handled by a number of information systems, it is important that these systems be coordinated.

The capability of collecting and storing hydrological data varies markedly from country to country. Nowhere is it entirely satisfactory. Instrument networks may be too sparse, only a few of the hydrological variables may be measured and the records may be too short to be of value. In some cases the lack of data is extremely serious and poses a major problem for those planning long-term sustainable development.

Strategy and programme targets:

Data should be collected and stored on all aspects of water resources which are required for a full comprehension of the nature of those resources and for their sustainable development.

This involves the installation of networks of stations and other data-gathering mechanisms, the development of data-storage facilities and the systems for processing and analyzing the data in them.

Table 15. *Dissemination of water information*

Activities and related means of implementation	Level[1]	Considered by	
		ICWE[2]	UNCED[3]
1. Analyze and disseminate data and information on water resources in the forms required for planning and management of countries' socio-economic development and for use in environmental protection strategies and in the design and operation of specific water-related projects to assure the incorporation of water resources information in decision-making processes.	N	X	X
2. Disseminate assessments of the risk of flooding from rainfall, snowmelt, storm surges and land-slides by installing hydrological forecasting and warning systems within the context of the International Decade for Natural Disaster Reduction (IDNDR).	N	X	X
3. Disseminate assessments of the risk of drought by installing drought warning systems in support of schemes to mitigate the effects of drought within the context of the IDNDR.	N	X	X
4. Disseminate assessments of surface-water and groundwater resources and of the interactions between surface water and groundwater.	N	X	
5. Disseminate basin-wide, regional and global sets of water-related data and information for use, *inter alia*, in the management of resources within international river basins and in climate change studies.	IN	X	

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3.4 Dissemination of water information

Basis for action:

The collection of hydrological data is not an end in itself. To have value, data must be used and their use must have an impact on decisions. This does not exclude the possibility that some data are collected as an insurance against future unforeseen needs.

Nevertheless, too often the potential user of hydrological data is not considered in the planning of data-collection systems and is not adequately informed of the availability of data that are collected.

Those who plan, design and operate water projects, and those who are concerned with the protection of life, property and the environment from natural or man-made disasters, should have access to the water-related information necessary for their work. They should be informed of the availability of such information and be able to obtain it in forms that are convenient for their use, including the free and urgent exchange of data required for mitigating natural disasters.

To be of real value in practical work, data must be compiled into sets and disseminated in a form appropriate for their use. There is a very real and growing need for large-scale regional and global sets of hydrological data for use in studies of global change, in particular within the context of climate change.

The approach should be to assess the data and information needs of potential users and to match these with the services provided by information centres and forecasting systems. This includes the strengthening of existing global data bases and the call for countries to supply data to such bases. In this, increasing use will be made of geographic information systems and similar computer-based technology.

Commercialization of water-related information should not prevent its full use, and dissemination of water-related information should be on a non-profit basis.

One particular application of hydrological data, and one that is being highlighted in the 1990s during the International Decade for Natural Disaster Reduction (IDNDR), is in the installation and operation of the hydrological forecasting systems, which are vital to safeguard lives and property in the face of major natural disasters.

Strategy and programme targets:

Those who plan, design and operate water projects, and those who are concerned with the protection of life, property and the environment from natural or man-made disasters, should have access to the water-related information necessary for their work. They should be informed of the availability of such data and be able to obtain them in forms that are convenient and timely for their use.

Table 16. *Research and development in the water sciences*

Activities and related means of implementation	Level[1]	Considered by	
		ICWE[2]	UNCED[3]
1. Establish and strengthen research and development programmes at national, regional and international levels so as to increase understanding of the fundamental processes involved in the water cycle, including the interactions between water, land and the atmosphere, and to support WRA and hydrological forecasting activities.	IN	X	X
2. Promote the development of new technology for WRA and hydrological forecasting.	IN	X	
3. Monitor research and development activities to ensure that they make full use of local expertise and other local resources.	IN	X	X
4. Transfer appropriate technology to users.	IN	X	

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The approach is to assess the data needs of potential users and to match these with the services provided by information centres and forecasting systems.

3.5 Research and development in the water sciences

Basis for action:

WRA (including studies of floods, drought and desertification, and the use of hydrological forecasting) should be based on a sound understanding of the scientific principles involved, which in turn are dependent on technology for their implementation. Both science and technology have made remarkable progress in recent years, but there are still large areas where the water sciences have yet to make a significant breakthrough and where new technological developments are badly needed. These concerns have been addressed in National Research Council (1991), Ayibotele and Falkenmark (1992) and Plate (1992).

In addition to a lack of resources, research and development in the hydrological sciences suffer from insufficient coordination and a need to take more account of regional and national variations in the problems to be solved and in the expertise available. Research and development activities should necessarily be based on a strategic analysis of the very varied needs of countries. They should take account of, and strengthen, indigenous expertise.

Important research needs include (a) development of global hydrological models in support of analysis of climate change impact and of macroscale water resources assessment; (b) closing the gap between terrestrial hydrology and ecology at different scales, including the critical water-related processes behind loss of vegetation and land degradation and its restoration; and (c) study of the key processes in water-quality genesis, closing the gap between hydrological flows and biogeochemical processes. The research models should build upon hydrological balance studies and also include the consumptive use of water. This approach should also, when appropriate, be applied at the catchment level.

Water resources assessment necessitates the strengthening of existing systems for technology transfer, adaptation and diffusion, and the development of new technology for use under field conditions, as well as the development of endogenous capacity. Prior to inaugurating the above activities, it is necessary to prepare catalogues of the water resources information held by government services, the private sector, educational institutes, consultants, local water-use organizations and others.

Strategy and programme targets:

Research and development activities should be planned so as to meet the very varied needs of countries and should take account of indigenous expertise.

Table 17. *Human resources development*

Activities and related means of implementation	Level[1]	Considered by	
		ICWE[2]	UNCED[3]
1. Ensure sufficient numbers of appropriately qualified and capable staff are recruited and retained by water resources assessment agencies and provided with the training and retraining they will need to carry out their responsibilities successfully.	N	X	X
2. Identify education and training needs geared to the specific requirements of countries.	IN	X	X
3. Establish and strengthen education and training programmes on water-related topics, within an environmental and developmental context, for all categories of staff involved in WRA activities, using advanced educational technology where appropriate and involving both men and women.	INP	X	X
4. Develop sound recruitment, personnel and pay policies for staff of national and local water agencies.	NPL	X	X
5. Strengthen the managerial capabilities of water-user groups, including women, youth, indigenous people and local communities, to improve water-use efficiency at the local level.	NPL		X
6. Use water projects for on-the-job training of local staff.	NPL		
7. Promote the national capacity for the organization of workshops, seminars and conferences on subjects related to WRA and flood forecasting.	N		

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Great benefit can be gained from a cooperative approach at both the national and international levels.

3.6 Human resources development

Basis for action:

Salaries and wages commonly account for half or more of the expenditure of an effective programme for WRA and hydrological forecasting. People are the most important resource available to the manager of such a programme, and because of this, personnel matters should receive great attention. These matters include the assessment of personnel requirements, the provision of attractive terms of employment and the establishment and use of effective schemes for the education and training of staff. Human resources development, an integral part of Capacity Building is treated in detail in IHE-Delft/UNDP (1991) and in Chapter 9 of this book.

Water resources assessment requires the establishment and maintenance of a body of well-trained and motivated staff sufficient in number to undertake the above activities. Education and training programmes designed to ensure an adequate supply of these trained personnel should be established or strengthened at the local, national, sub-regional or regional level. In addition, the provision of attractive terms of employment and career paths for professional and technical staff should be encouraged. Human resource needs should be monitored periodically, including all levels of employment. Plans have to be established to meet those needs through education and training opportunities and international programmes of courses and conferences.

Because well-trained people are particularly important to water resources assessment and hydrological forecasting, personnel matters should receive special attention in this area. The aim should be to attract and retain personnel to work on water resources assessment who are sufficient in number and adequate in their level of education to ensure the effective implementation of the activities that are planned. Education may be called for at both the national and the international level, with adequate terms of employment being a national responsibility.

The conduct of water resources assessment on the basis of operational national hydrometric networks requires an enabling environment at all levels.

Strategy and programme targets:

The aim should be to attract and retain personnel to work on WRA who are sufficient in number and adequate in their level of education to ensure the effective implementation of the activities that are planned.

Education may be called for at both the national and international level, while adequate terms of employment are a national responsibility.

3.7 Targets and costs

Targets

(a) All countries should have studied in detail the feasibility of installing WRA services by the year 2000;
(b) There should be WRA services with a high-density hydrometric network installed in 70 countries, and services with limited but adequate capacity in 60 additional countries, by the year 2000;
(c) There should be 110 countries with fully developed services, and 40 additional countries with services of a limited capacity, by the year 2025;
(d) The longer-term target is to have fully operational services, based upon high-density hydrometric networks, available in all countries.

Cost estimates

In order to attain the targets for the year 2000, total average annual funding (1993–2000) in the order of US$ 355 million is required, including contributions from external sources of US$ 145 million on grant or concessional terms*. The strengthening of international institutions for the development and exchange of information and technology requires about US$ 5 million per year (included above).

* Financial support is required primarily for the establishment and strengthening of national hydrometric networks, also covering transboundary watercourses.