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By
UNESCO-IHE (Institute for Water Education)

Madhukari Ganokendra (People’s Centre), in Rajapur village, western Bangladesh, holds monthly meetings to discuss primary school attendance and other important issues for the community to take action.
Key messages:

Financial investments made in the last decades in the water sector have often failed to bring about the expected outcomes, largely due to lack of attention given to enhancing knowledge and capacity. While infrastructure is needed, it is doomed to deteriorate if not properly maintained by adequate human resources and institutional capacity within an enabling environment. In a time of climate change and declining hydrological data collection systems, all countries need to take seriously the threat to their water resources and invest in capacity development.

- Self-assessments of knowledge and capacity needs are urgently required to assist water resources managers in all challenge areas in setting priorities, identifying gaps and improving the effectiveness with which they can respond to a continuously changing environment.

- It is essential that the knowledge base of capacity development be enhanced through case studies, best practices, twinning organizations and shared experiences and that the capabilities of national statistical agencies to deal with water sector data be improved.

- Increased access to education at all levels through information and communication technologies is a cornerstone for development, and efforts to broaden individual capacities through education should be actively pursued.

- Knowledge requires continuous investment to enable society to adapt to an uncertain future generated by climate change. In particular, increased investments in the hydrological data network and remote sensing are needed to provide the information necessary for modelling future scenarios.

- The capacity of water management institutions should be increased to ensure that they have a clear mandate, an effective organizational system, and improved decision support through lessons learned and indigenous knowledge.

An education programme provides free of cost relevant life skills ranging from reading, writing, simple calculating to tailoring, furniture making, etc. to out of school youth and adults in Bhutan. Katha public school provides an education to 5–16 years olds in Govindpuri slums, south Delhi, India.
The knowledge base is seen to be of a higher order than a database... it relates to how such collected explicit knowledge on the world’s water resources and their use is archived and analysed.

Part 1. Assessing Knowledge and Capacity

Spurred by the Millennium Development Goals (MDGs), many nations are now intensifying their actions to improve water services and infrastructure development. Over the past two decades, developing countries have invested hundreds of billions of dollars in water services and water resources, a substantial portion of which has failed to bring about the desired outcomes and impacts. The operations assessments by the development banks and other donors attribute this in many cases to inadequate knowledge bases and weak capacities.

As our understanding of the interactions between water management and society develops, it becomes increasingly evident that the past focus on developing infrastructure has overlooked the need for a strong knowledge base and capacity to plan, manage and use that infrastructure and enable proper governance of the water sector. Today, there is a growing consensus that knowledge and capacity in the water sector is a primary condition for sustainable development and management of water services.

Knowledge development and accessibility lie at the heart of this concern. Knowledge takes a variety of forms: as databases; as the competence to integrate and interpret data and create meaningful information that can inform decisions; as capacity to generate new data and information, to identify gaps, to learn from past experiences and to explore the future; and educational and dissemination mechanisms. A knowledge system extends well beyond data pertaining to physical and technical parameters. Involving civil society and increased community participation foster a greater understanding of the interactions of the complex social and environmental processes involved in water management, which enables the rethinking of approaches to effective water development.

The knowledge base is made up of databases, documents, models, procedures, tools and products. It also includes knowledge that may not be explicitly available because it is contextual, cultural and relates to skills, heuristics, experience and natural talents (such as local or indigenous knowledge). This implicit knowledge leads the way for capacity-to-act or a competence to solve problems, but describing and communicating such implicit knowledge remains challenging (Snowden, 2003).

The support of a strong knowledge base can greatly improve capacity development and spur the kind of informed decision-making that drives policy directives, which enable local institutions to be better equipped to direct their own self-sufficient and sustainable futures in the face of change. As such, research, assessment, know-how and communication are not simply components of a development initiative that compete with other components: they are primary targets in any effort towards effective and sustainable development in water-related sectors.

1a. From knowledge to capacity development

Capacity development is the process by which individuals, organizations, institutions and societies develop abilities (individually and collectively) to perform functions, solve problems and set and achieve objectives (UNDP, 1997; Lopes and Theisohn, 2003). A country’s capacity to address water-related issues is not just the sum total of individual capacities, but rather a broad holistic view of the central concerns of management, namely how to resolve conflict, manage change and institutional pluralism, enhance coordination, foster communication, and ensure that data and information are collected, analysed and shared. This involves not only individual capacities (human resources), but also the effectiveness, flexibility and adaptability of organizational processes (institutional capacity) and an enabling and stimulating management framework (the enabling environment).

These three levels of capacity development are presented in Figure 13.1 with its associated activities, outputs and goals. A detailed description of these three levels is included in Part 3 of this chapter.

Sustainable development increasingly requires countries to have the capacity to put in place effective knowledge generation and learning mechanisms. This capacity-to-learn or ‘adaptive capacity’ is the potential or capability of a system to adjust or change its characteristics or behaviour, so as to better cope with existing and future stresses. More specifically, adaptive capacity refers to ‘the ability of a socio-ecological system to cope with novelty without losing options for the future’ (Folke et al., 2002).
In order to achieve sustained progress, knowledge building and capacity development must be viewed as development objectives in and of themselves...

and ‘is an aspect of resilience that reflects learning, flexibility to experiment and adopt novel solutions, and development of generalized responses to broad classes of challenges’ (Walker et al., 2002). There is a need therefore to build into capacity development a concern that individuals have the skills to innovate when faced with a non-standard problem and a structural flexibility that does not penalize, but rather rewards and capitalizes on such innovation.

A new paradigm for water development has begun to emerge. It stresses the importance of country ownership and shifts the focus from passive knowledge transfer (e.g., from the North to the South) to knowledge acquisition and integration within the developing countries themselves. It does this by supporting home-grown processes for knowledge development - often using existing local and indigenous capacities - while also specifically including local participatory processes. In order to achieve sustained progress, knowledge building and capacity development must be viewed as specific development objectives, which command their own resources, management attention and evaluation standards, much along the lines of gender, poverty or environmental issues (Morgan, 2000).

The concept of capacity development implies that improved water services delivery and sustainable development are to be achieved as much through improving the enabling environment, the institutional frameworks and human resources as through the technocratic approach of investments in infrastructure. Capacities must be developed at all three levels while acknowledging that these layers of capacity are mutually interdependent – if one is pursued in isolation, development still remains skewed and inefficient (Fukuda-Parr et al., 2002). The right combination of actions depends on the local situation, which calls for extensive prior analysis and priority setting, for instance, by region or by river catchment (Alaerts et al., 1999).

1b. Identifying socio-economic benefits

While high-income countries have been able to couple large investments in infrastructure with human and institutional knowledge building many middle- and low-income nations lag behind in their ability to adapt to the ever-increasing pace of change in a complex world (Alaerts et al., 1999). Industrialized countries, for example, can afford to invest in better understanding and preparedness for the effects of climate change. Middle-income countries are generally characterized as having built sufficient infrastructure assets to provide adequate water services and prepare for the ‘conventional’ larger water-related risks such as floods. They may still however lack the necessary institutional and human knowledge base that is needed to reap a greater benefit from water resources development for more sustainable growth. Lower-income countries typically have

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**Figure 13.1: Capacity development: Levels, activities, outputs and goals**

not yet been able to invest in a minimum stock of water infrastructure, and often do not have the capacity to govern and manage these investments effectively once they are made. They thus have a strong incentive to invest their scarce resources in infrastructure that brings rapid returns. However, past experience shows that heavily investing in infrastructure without enhancing existing local capacities can result in dilapidated infrastructure, exacerbated water problems and increased debt.

Even though there exists in the world at large the know-how and knowledge to solve many, if not most, of the world’s pressing water problems, this knowledge is often slow to make an impact. National governments, often with overburdened and underpaid staff, possess only limited capability to acquire and interpret that knowledge, and turn it into practical action and realistic proposals. Vested interests often prevent the adoption of new approaches, and staff are forced to respond to short-term priorities.

While it is agreed that good governance and management require local government involvement, the devolution of responsibility for managing a range of water services from national to lower levels further raises the need to strengthen capacities. This is because local-government staff tend to have benefited less from proper education than their colleagues in central-government agencies, and because the local administrative procedures are even less geared to appreciate the value of sound knowledge. Similarly, better governance hinges on users and communities that are informed and have the capacity to access and use information with which they can hold government accountable.

Each country needs a development strategy that recognizes the balance between knowledge, capacity and infrastructure in order to adopt the most suitable governance strategy and utilize its water resources in line with sustainable development. Such a development strategy must acknowledge that radical social, environmental and technological changes are taking place at an increasing rate. As discussed throughout this Report, these include the burgeoning population growth in lower-income countries, the global consequences of climate change, the pervasive influences of globalization and the exponential growth in Internet-based communication.

The ability to predict the trends, measures and potential consequences of such complex systems depends on our capacity to understand and integrate information and knowledge, as well as on our assessment of the effectiveness of the knowledge economy both of which are fuelled by the new information and communication technologies (ICTs) that facilitate the collection, storage and sharing of data and information globally.

More than ever before, our increasingly interconnected world can enable more societies to identify opportunities and means for determining their own path to sustainable development. However, while the communication of lessons learned, and the sharing of experiences have allowed the international community to better articulate the objectives of water management in various sectors, the knowledge base and the development of capacity to implement and effectively achieve these objectives remain very much ‘work in progress’. Major constraints include the large sizes of the funds required to build these knowledge bases and capacity; the low sense of urgency at political levels; and, perhaps most importantly, the fact that people must first recognize the value of better knowledge and capacity, and that capacity-building is inevitably a long-term and continuous process.1

Yet because of the complexities faced in turning the social and economic benefits of research and development into knowledge generation and building capacity, economic returns are often overlooked, and there remains a strong reluctance to invest the necessary resources as a sustained initiative (see Box 13.1). Understanding and appreciating the need to change the approach to water development is the first step in overcoming deficiencies. The private sector has long since recognized the difficulties involved in designing and managing programmes of intentional change in corporations, and it has accepted occasional failures as normal episodes on a learning curve, spurring efforts to master change as a process (Pasmore, 1994; Senge et al., 1999; Kotter and Cohen, 2002). The response from development agencies, in contrast, has typically been to minimize risks and boost the apparent benefits to be achieved (Morgan et al., 2005). Without further intensive efforts to understand the dynamics of the complex processes of institutional change in international development, initiatives to enhance knowledge and capacity will fail to be properly targeted and will not produce the desired outcomes. Indeed, compared with other sectors, the water sector has been slow to seek out and internalize knowledge from other sectors, affecting issues such as climate change, and to investigate more deeply the longer-term scenarios needed for proper governance.

1. These long-term goals are gradually becoming recognized, and development banks like the World Bank, the Inter-American Development Bank, the Asian Development Bank, the African Development Bank and the international donor community are providing increasing support for capacity-building.
monitoring the physical and socio-economic systems of our water resources is the foundation on which we assess their state. Because of the high cost of data acquisition, data collection should be targeted at what is critically important. An examination of the current state of the data in the knowledge base on integrated water resources management (IWRM) reveals some distinct trends. On the one hand, due to political, institutional and economic instability, there has been a severe decline in basic hydrological monitoring for estimating sustainable water supplies (IAHS Ad Hoc Committee, 2001; Grabs, 2003). On the other hand, there have been considerable advances in the acquisition of data on water resources from remote sensing (Vörösmarty et al., 2005). These advances are due in part to the governments’ expectations of the availability and capabilities of remote sensing technology and its spatial coverage, in addition to the large costs and uncertainties involved in sustaining ground-based hydrological monitoring networks.

2a. Data acquisition

Faced with climate change and population growth, it is now more urgent than ever that measures be undertaken to improve the state of knowledge on water services and water resources for better management. The knowledge base of the water sector is very broad; it touches on health, agriculture/aquaculture, industry, energy and ecosystem issues and draws on skills and knowledge from technological, scientific, medical, economic, legal and social realms. In order to appreciate the complexity of the interaction between these different issues it is essential to have relevant and reliable data that relate to them and their connection to the water sector. The World Meteorological Organization (WMO) Global Runoff Data Centre reported that there has been a significant reduction in the data collected since mid-1980s. Agenda 21 (UN, 1992) states that the lack of data ‘seriously impairs the capacities of countries to make informed decisions concerning the environment and development’. Indeed, raw data from monitoring the physical and socio-economic systems of our water resources is the foundation on which we assess their state. Because of the high cost of data acquisition, data collection should be targeted at what is critically important. An examination of the current state of the data in the knowledge base on integrated water resources management (IWRM) reveals some distinct trends. On the one hand, due to political, institutional and economic instability, there has been a severe decline in basic hydrological monitoring for estimating sustainable water supplies (IAHS Ad Hoc Committee, 2001; Grabs, 2003). On the other hand, there have been considerable advances in the acquisition of data on water resources from remote sensing (Vörösmarty et al., 2005). These advances are due in part to the governments’ expectations of the availability and capabilities of remote sensing technology and its spatial coverage, in addition to the large costs and uncertainties involved in sustaining ground-based hydrological monitoring networks.

**Part 2. Enhancing the Knowledge Base**

An adequate knowledge base must be available to the water sector worldwide in order to understand and deal with current changes. Besides data describing the state of water resources and their management, there is an urgent need for good applied research to generate knowledge on the current challenges facing the water sector and to collect and share the existing experiences of communities as they develop capacity. Because the knowledge base must also address the socio-cultural and economic processes that feed into all three levels of capacity, factors related to collective learning processes, and democratic participation and empowerment must also be taken into account, requiring knowledge acquisition covering areas far beyond those concerned solely with the state of the resource.

**Box 13.1: Enhancing Education and Capacity: An Economic Proposition**

Conventional financial analyses of investment projects tend to calculate the rate of return based only on investment in physical assets. The capacity development component is typically treated as an appendix, to which no separate economic relevance is allocated. However, the methodological difficulty in determining the correlation between investment in capacity and improved sectoral performance is not proof that there is no return.

The Indonesian Government has gone through a period of intense institutional change since 1998. To improve its irrigation performance, it launched large-scale pilot programmes across the country where Farmer/Water User Associations (WUAs) were empowered through capacity-building and appropriate regulatory changes that created an enabling environment. As part of this, the local staff of the Irrigation Services were trained as ‘facilitators’. Because of the availability of comparative data, it was possible for the first time to separate out the value of investments in capacity-building as opposed to investments in physical assets. The analysis showed that conventional rehabilitation projects (to repair irrigation schemes after the recent economic crisis) would bring an economic rate of return (ERR) of 10 to 18 percent, depending on the state of the assets and the productivity of the scheme. However, when the enhanced knowledge and capacity of the WUAs was factored in, the ERR rose to 30 to 40 percent. The ERR over the incremental investment for the capacity-building component was approximately 32 percent. Thus, the larger benefits were created by the investment in the empowerment and training of the users, increasing the ‘social capital’ of the local communities and strengthening governance.

Ground monitoring systems

Ground-based monitoring systems are essential for characterizing a country’s water resources. Despite the spatial coverage of remote sensing, such data is generally still less accurate than that of ground-based monitoring, which is needed for confirming remote sensing data and for measuring parameters such as precipitation, discharges and sediment transport in rivers and groundwater levels. Today, however, there is a lack of ground-based hydrological station networks. In large parts of the world, basic networks have been seriously threatened in the last fifteen years as pressure on funding agencies and governmental organizations to reduce their size has often resulted in the elimination of the technical staff responsible for their operation (Box 13.2). It was mistakenly believed that the introduction of automation, among other reasons, would justify such staff reductions, resulting in widespread personnel removal, extremely low remuneration and little political support – the effects of which will only be felt in the mid to long term. Political decision-making has sometimes been in conflict with scientific research (see Chapter 1), even in countries with an advanced scientific capability, like the US: ‘There is a deep disconnection in American politics between scientific knowledge and political decisions’ (Sachs, 2005).

WMO’s World Hydrological Cycle Observing System\(^1\) (WHY COS) is making an important contribution to an overall assessment of the world’s water resources (see Map 13.1) by strengthening the technical and institutional capacities of the hydrological services to collect, transmit and store hydrological data and produce information responding to the needs of the end users. However, it is ironic that the dilapidation of ground-based monitoring networks is happening at a time when remote sensing coupled with geographic information systems can truly complement these traditional labour-intensive methods of data collection with better archiving, access and analysis of the data. Due to the uncertainties in their formulation and application, even sophisticated modelling systems are dependent on good ground-based data.

Today, in large part due to vast technological monitoring advances, the global and regional water balance (as well as water use statistics) has been estimated to a level of detail not achieved previously. However, in these estimates there are still significant uncertainties that need to be addressed by both the new technologies and the ground-based monitoring systems. It is a paradox that governments and agencies are willing to invest many millions of dollars in projects that have such fragile hydrological data foundations and may not be sustainable, but are unwilling to spend the much smaller sums needed to ensure that data are collected and processed to meet current and future needs and demonstrate the sustainability of projects (WMO/UNESCO, 1997a).

**Box 13.2: Hydrological Networks: The cases of India, Mexico and Venezuela**

In 1998, approximately 250 hydro-meteorological observer jobs (the technicians responsible for the operation and maintenance of the hydro-meteorological network) were eliminated in the National Hydrological Service of Venezuela, as part of the downsizing of the Ministry of Environment and Natural Resources. The plan, supported and encouraged by several development banks and financing institutions, was to fulfill responsibilities through a number of micro-enterprises that would be constituted by the same personnel who would be contracted on a need basis. Unfortunately, almost six years later, these enterprises have not yet been created, and as a result most of the stations of the original network are no longer operational.

In the case of Mexico, the river discharge network was traditionally operated by approximately 800 technicians, each living near one of the measuring stations (see Chapter 14). In the last six years, the policy of downsizing the public administration has meant that no new recruitment to replace retiring personnel has been authorized by the competent authorities. As a consequence, approximately 200 discharge stations were inoperative as of 2003, and more were expected to cease operating in the future.

In contrast to these cases, India built a huge Hydrology Information System covering nine states (1.7 million square kilometres) between 1996 and 2003, of which the main activities were to improve institutional and organizational arrangements, technical capabilities and physical facilities. Among others, 265 new river gauging stations were built and 650 stations upgraded, with 2,239 purpose built piezometres and thousands of digital water level recorders for groundwater monitoring. 14 water quality laboratories were upgraded with modern equipment and 9,000 employees were trained with 27,000 training units. In 2004, an additional phase was approved including enlarging the geographic scope to four additional states until 2011. The implementation of the project provides a quantum leap in the understanding of the state of the water resources in India.


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1. See www.wmo.ch/web/homs/

2. See also UNESCO’s World Commission on the Ethics of Scientific Knowledge and Technology (COMEST).

India is regarded as a world leader in using satellite data techniques for managing its natural resources and supporting rural development. However, most countries, including relatively developed ones, do not yet use these techniques on a day-to-day basis to support decision-making in water resources management. Because of this, the United Nations (UN) has made the enhancement of the capacity of countries to use and benefit from remote-sensing technologies a key focus for many space-related activities (UN, 2004). Of particular note is the TIGER Initiative led by the European Space Agency (ESA) in partnership with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Office for Outer Space Affairs (UNOOSA) and others, which

Remote sensing
In recent years, water resources management has benefited from the powerful assessment tools provided by remote sensing. Since the Rio Declaration on Environment and Development in 1992, a number of major developments have occurred. Over 100 new satellite sensors for sustainable development have been put into operation, and advanced warning for extreme storms and floods has increased in some instances to over 100 hours (UNESCAP, 2003). Remote sensing is used for the provision of simple qualitative observations, the mapping/detecting features of hydrological importance and the direct estimation of hydrological parameters and water quality (see Box 13.3).
of biophysical, socio-economic, hydrometric and remote sensing data with modelling now leads to the emergence of valuable new information on water stress at global, regional and local levels (see Box 13.5). The United States National Aeronautics and Space Administration (NASA) and ESA plan to launch special water management and hydrology-related satellites (see, for example, Alsdorf and Rodriguez, 2005), optimized for

**Box 13.3: Advances in the Practical Use of Satellite Remote Sensing for Water Resources**

Considerable improvements in the assessment of hydrological parameters for water resources management have been made during the last two decades using remote sensing from satellites (Schultz and Engman, 2000). Using a combination of radar and thermal sensors from weather satellites, the accuracy of precipitation estimates for crop forecasting, flooding and river flows over large areas and basins has improved considerably, as has the extent of snow cover and water equivalents. In addition, satellite data provide a unique means of assessing separately the actual evaporation over different areas, such as river basins, irrigated areas and wetlands, using the surface energy balance equation. This has led to methods for determining crop water efficiencies, water use by groundwater irrigation, and wetland water requirements. Another important hydrological parameter that is monitored using active or passive radar is the moisture of the uppermost soil layer.

Important progress has also been made in surveying the land surface. The Shuttle Radar mission has made freely available a worldwide coverage of digital terrain models, required for example, by rainfall-runoff modelling. Satellites, through radar altimetry, are now surveying water levels in lakes and large rivers within a few centimetres accuracy. This is particularly important for remote water bodies. Satellite images with resolution of 1 or 2 metres can be purchased, enabling the rapid preparation of maps through digital photogrammetry and showing terrain heights of floodplains or coastal areas, which are required for assessing flood risks and the propagation of floods. Land subsidence, often due to groundwater extraction, can also be measured with high precision by radar interferometry.

Imaging spectrometry (or hyperspectral remote sensing) provides information about the water quality of optically deep-water bodies. The first operational applications from airborne platforms were reported in the 1990s, and the first imaging spectrometry satellites were launched in 2000. The most successfully monitored water quality parameters are chlorophyll, a blue-green (or cyanobacterial) pigment, total suspended matter, vertical light attenuation coefficient and turbidity. The technique can be used in coastal waters for the assessment of the health of coral reefs and for bathymetric mapping.

**Sources:** Schultz and Engman, 2000; Dekker et al., 2001.

**Box 13.4: TIGER Initiative: Improving Water Systems Observation in Africa**

Established in 2003, the European Space Agency’s (ESA) TIGER Initiative aims to make earth observation services more accessible for developing countries, with particular focus on Africa. In 2005, there were four separate ESA projects operating under the TIGER umbrella:

- **GlobWetland:** provides land cover and land-use change maps on fifteen African wetland sites to support reporting obligations for the Ramsar Convention on Wetlands.
- **Global Monitoring for Food Security (GMFS):** maintains a continental-scale overview of sub-Saharan Africa in order to produce sub-national and selected high-resolution crop production forecasts.
- **Epidemio:** uses satellites to provide environmental information in the service of epidemiology, including the charting of water bodies in order to prepare malaria risk maps.
- **Aquifer:** generates land-use cover and land-use change charts, digital terrain maps, soil moisture mapping and subsidence monitoring, so that new aquifers can be identified and existing aquifers exploited in a sustainable manner.

The Envisat environmental satellite and European Remote Sensing satellite data are freely available for African hydrology research. TIGER also enhances capacities in space technologies in African regions, while supporting its integration within the user’s traditional working procedures to improve the sustainability of water resources management.

**Sources:** ESA, 2004; earth.esa.int/tiger/

aims to provide earth observation data, capacity-building and technical support services for IWRM in developing countries with a particular focus on Africa (Box 13.4).

The advantages of remote sensing lie in its ability to map conditions across regional, continental and even global scales on a repetitive basis at a relatively low cost compared to ground-based monitoring. The coupling of biophysical, socio-economic, hydrometric and remote sensing data with modelling now leads to the emergence of valuable new information on water stress at global, regional and local levels (see Box 13.5). The United States National Aeronautics and Space Administration (NASA) and ESA plan to launch special water management and hydrology-related satellites (see, for example, Alsdorf and Rodriguez, 2005), optimized for
Box 13.5: Advances in Remote Sensing Technologies

Research undertaken at the University of New Hampshire by Vörösmarty et al. has pioneered a means of coupling a range of different data types in order to generate new information, such as spatially discrete, high-resolution remote sensing data, model-generated climate change data, population density, growth and migration, and industrial development indicators (see global maps at the head of each section). Based on the integration of such datasets with appropriate modelling, the researchers have developed indices for local relative water use and reuse and water stress in order to assess the current state and future trends. They conclude that in 1995, 1.76 billion people were under severe water stress and that “rising water demands greatly outweigh greenhouse warming in defining the state of global water systems to 2025”. Such an analysis is carried out globally at a resolution of about 50 kilometres (km) but has also been done for Africa at 8 km resolution and for the river basins of Lake Victoria down to about 2.5 km resolution. Results show that chronic water stress is high for about 25 percent of the African population; 13 percent of the population experiences drought-related stress once each generation, 17 percent are without a renewable supply of water, and many are dependent on highly variable hydrological runoff from a far distant source.

Sources: Vörösmarty et al., 2000, 2005; wwdrii.sr.unh.edu/

Countries require organizations with individuals who are able to collect, store and analyse data in order to generate knowledge...

special measurements of water-related state variables, such as water levels and discharges in rivers. Research efforts have recently concentrated on developing methods that need limited in situ measurements, but a large number of applications still depend on correlation and/or combination with measurements from land-based monitoring systems. The usefulness of information will ultimately depend on its suitability for assimilation within hydrological forecasting.

Databases

Thanks to the establishment of water databases and monitoring guidelines, many countries have made strides since 2004 to set up and maintain national water databases. Still, 61 out of 239 countries have not supplied the necessary data to international repository centres, making it extremely difficult to establish the overall state of the world’s water resources, and in particular those of a particular region or river basin in a given year, month or day (GRDC, 2005). Such data is needed for inter-country comparisons in order to identify similarities, differences, strengths and weaknesses, to alert better governance and to improve management. The willingness to share data among countries remains a key obstacle to effective transboundary river management (see Chapter 11).

However, even when data is openly shared, differences in data characterization and record duration make it difficult to compare data from different databases. Often data collection is initiated by and limited to the duration of specific projects, and ongoing data collection is either ignored or grossly under-funded. These important problems need international attention. While a full assessment of global water database initiatives is beyond the scope of this report, given the scope and scale of the entire field of water data, the list of useful websites at the end of the chapter provides some key listings and some of the better examples of current databases in the water sector.

Modelling systems

It is one thing to acquire data from the real world, but it is another to interpret and utilize that data to better understand water-based processes and systems. The ability to extract, understand and interpret such data and information is crucial for taking advantage of the processes and systems in water management. Computer simulation models are now commonplace tools for assisting in such understanding and interpretation. Such models encapsulate scientific knowledge in their development and application, while operating with data to replicate real-world phenomena. In addition, when possible, the sophisticated use of graphics and video with Geographic Information System (GIS) provides opportunities for visualizing and anticipating new information and knowledge in order to understand complex phenomena.

Models are extremely important for effective water resources management, and the use of computer-based models has increased considerably in the last ten years; indeed, no major water-related project is undertaken without the use of models and corresponding decision-support tools. Centres such as the Institute of Water Modelling in Bangladesh have been established in order to capitalize on local expertise, while using advanced modelling tools for better water management.

A very important trend in modelling is the linking of hydrologic and hydrodynamic models to GIS, ground-based monitoring systems, remote sensing data, numerical weather prediction models and quantitative precipitation

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4. Those countries include Angola, Belize, Bhutan, Bosnia and Herzegovina, Botswana, Brunei, Cambodia, Djibouti, Eritrea, Gambia, Guinea Bissau, Haiti, Lebanon, Libya, Namibia, Qatar, Samoa and Yemen.

5. See www.iwmbd.org/ for more information.
forecasts. Such links, properly implemented using information and communication technologies, contribute to the building of integrated hydroinformatics systems leading to considerable improvements in predictive accuracy, especially important in the context of managing extreme events (see Chapter 10) and water resources management in transboundary river basins. OpenMI is a European project that is committed to developing a protocol that enables hydrological modelling software from different suppliers, to be linked so that the integrated software will support and assist the strategic planning and integrated catchment management required by the European Water Framework Directive.6 This opens up opportunities for a better management of transboundary rivers.

2b. Knowledge sharing and accessibility
Access to and sharing of knowledge by individuals and groups are critical to addressing water-related problems. In many developing countries, however, the water resources and services knowledge base has often been limited due to budget constraints, the emphasis on developing new infrastructure, and a lack of professional education and language barriers. This results in decreased capacity to translate available data into usable knowledge. Consequently, data collection has all but ceased in some countries. Countries require organizations with individuals who are able to collect, store and analyse data in order to generate knowledge, which requires first and foremost better education of these individuals.

In addition, the willingness to share information and the importance of building trust between parties is critical in the development of a shared vision for water management (UN, 2003b; Chapter 11).

New ICTs have facilitated the mechanisms and practices of sharing knowledge.7 ICTs have made an incomparable contribution to development in water-related sectors, from the rapid collection and exchange of hydrological information and the integration of advanced warning systems to virtual classrooms, video conferencing (see Box 13.6) and networking with GIS (see Box 13.10). While telecommunications still favour urban areas, the coverage in rural areas is growing rapidly in many developing countries. In Cambodia, for example, one year after the introduction of a mobile cellular phone network, mobile subscribers had already surpassed the number of fixed telephone lines in the country (UNESCAP, 2004). The media (newspapers, radio, television, films) also has an important role in disseminating information to the general public.

Better information management has repercussions at every level of society, whether on the development of national and international knowledge resources, the efficiency and effectiveness of government services, the focus of donor community programmes or project ownership by local stakeholders through participatory decision-making. Uganda provides an excellent example of this as indicated in the Uganda National Water Development Report (see Chapter 14). The Directorate of Water Development

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6. www.harmonit.org/
7. The UN Millennium Declaration includes a specific commitment to ensure that the benefits of new technologies, especially ICTs, notably the telephone, mobile phone, Internet and broadcast networks, are available to all.

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**BOX 13.6: THE GLOBAL DEVELOPMENT LEARNING NETWORK (GDLN)**

The Global Development Learning Network (GDLN) is a global network of learning centres that uses advanced information and communication technologies to connect people around the world working in development. Initiated by the World Bank in June 2000, this network has grown from eleven to over ninety affiliated centres, most of which are located in developing countries. In the future, the network is expected to grow dynamically. In middle-income countries across Latin America and Asia, emerging in-country networks are further increasing GDLN’s reach and use on a remarkable scale. GDLN facilitated more than 850 videoconference-based activities between July 2003 and June 2004, connecting an estimated 26,000 people around the world.

During 2004, the GDLN centre located at UNESCO-IHE Institute for Water Education hosted fifty water-related videoconferences, connecting 1,600 water experts worldwide.

Source: www.gdln.org
Assessment Methodology uses a series of relevant and widely available measures that can allow for a preliminary country comparison and the identification of strengths and weaknesses in order to focus policy attention or future investments in making the transition to the knowledge economy. The assessment tool is available online. The state of the global knowledge economy, weighted by population, is presented in Map 13.2.

The language barrier and quality assurance and control

Today, due to the ever-increasing speed with which technology can collect, store and disseminate data, we are possibly encountering for the first time a situation in which human individuals and their capacities are the primary bottleneck in the chain of information processing, making people the limiting factor for further understanding (Maurer, 2003). Knowledge has to be presented in a way that people can assimilate it. One barrier is that information and knowledge on water management and water use often uses terminology that only academicians, theoreticians and technical people can understand, or worse, in a language foreign to the end user. Language barriers constitute a critical obstacle to local information for literacy and education as well as a level playing field in the global digital knowledge economy.
With roughly 7,000 living languages in the world (Gordon, 2005), participatory approaches to water management immediately become more complex. SIL International, for example, works to develop community-level capacities to enable communities to carry out their own research, translation, and production of literature in their native tongue. In addition, with more than 90 percent of Internet content today existing in just twelve languages, UNESCO’s Initiative B@bel uses ICTs to support linguistic and cultural diversity, protect and preserve languages in danger of disappearing and facilitate access to this important communication medium. To further facilitate the use of software products and websites across multiple platforms, languages and countries, the Unicode Consortium has developed a standardized computer language. This could support the increasing trend in the development and use of online water information networks that can provide another means of surmounting the language barrier. This is particularly appropriate for the translation of technical terms that are peculiar to water development.

Another major problem that arises in using information or knowledge from elsewhere is assuring its quality. Information or knowledge can originate from a reputable source, such as a peer-reviewed journal or the website of a trusted organization, but this hardly accounts for the majority of information found on the Internet. Almost anyone can put anything online. In doing so, they bypass many of the benefits of traditional publications – issuance by an authoritative source, editorial or peer review, evaluation by experts, etc. Quality is still a matter of trust by the recipient in the trustworthiness of the supplier. Third-party confirmation of any information and knowledge is generally recognized as one of the best ways of assuring quality. Responsibility for the use and application of the data provided remains largely in the hands of the user, who has to rely on his or her education and experience to exercise discernment. Networking and involvement in professional associations largely stimulate quality assurance through continuous peer review, as in the case, for example, of the peer-reviewed web-based information service provided by FAO’s International Programme for Technology and Research in Irrigation and Drainage (IPTRID).

**Knowledge networks**

Networks of all kinds, representing all sectors, such as professional associations, are powerful tools for knowledge sharing and distribution. They offer a framework for resource optimization and knowledge combination, saving valuable financial and time resources, in addition to providing an excellent platform for peer discussions (see Box 13.7).

Networks for capacity-building in integrated water management are a relatively new phenomenon. The advantages of networking for scaling up capacity-building to reach the MDGs are gaining recognition in the international water community. The advantages are predominantly in providing a more coherent and coordinated approach to capacity-building, increased impact, relevance and sustainability from working with local institutions, improved sharing of knowledge and expertise and a platform for cross-disciplinary and cross-regional discussions.

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**BOX 13.7: FARMNET – FARMER INFORMATION NETWORK FOR RURAL DEVELOPMENT**

Since the early 1990s, the UN Food and Agriculture Organization (FAO) has assisted in the development of networks among rural farmers and supported intermediary organizations using ICTs and conventional communication media for capacity development. Operated by farmers, these FarmNets disseminate locally relevant information that is needed to improve livelihoods. FAO adopted a participatory approach to performing the preliminary assessment of needs and then provided the electronic network designs, some basic equipment, logistical support, coordination, technical backstopping and training to local extension and farm organization personnel. The impact of FarmNet has been significant. Transmitting price and market information through computer-based networks cost 40 percent less than using traditional extension methods. In one case, by using the market information provided by the network, a farmer association was able to sell cotton for US $82 per metric quintal as opposed to US $72, which was the price local buyers were trying to impose. Vegetable producers reported that the information on meteorological conditions informed them of climatic conditions faced by competitors in other regions and countries. This enabled them to plan their irrigation strategies and market their produce more successfully.

Local knowledge can lead to a better understanding of the water cycle and could play a vital role in providing solutions to the world’s water crisis.
Networks stimulate regional collaboration by addressing and solving water-related problems, and, as such, contribute to an increase in trust and stability throughout the world.

**Local and indigenous knowledge**

Local and indigenous knowledge refers to the cumulative and complex bodies of knowledge, know-how, practices and representations (including language, attachment to place, spirituality and worldview) as maintained and developed by peoples with extended histories of interaction with their natural environment. Despite the fact that such peoples number about 300 million, representing over 5,000 languages and living in more than 70 countries in all of the world’s regions (including 17 countries that are home to more than two-thirds of the Earth’s biological resources), they must still struggle for their rights over the water resources they have been using and protecting for generations (UNESCO, 2003a, 2003b). In fact this knowledge is typically dismissed by planners and still far from internationally recognized as vital to sustainable development and biodiversity management, particularly as it relates to the holistic approach so sought after in IWRM. Worse still, while knowledge development efforts today aim to empower local stakeholders in efforts to move towards effective IWRM (see Chapter 2) changing values, globalization and the drive for commercialism have all but extinguished these indigenous practices despite the vital role they could play in providing solutions to the global community’s water crisis (Box 13.8). And yet such knowledge and habits (constituting the ‘social capital’ of a community) can lead to a better understanding of the water cycle, of local seasonal effects and of their relationship with nature and agriculture. They also encompass social skills such as the resolution of water...
Indian communities have a long tradition of coping with the recurrent hot and dry seasons by constructing small to medium-sized reservoirs (or tanks). Villages in the past would each have their own tank(s), maintained by the villagers themselves. With the advent of modern technology, planners preferred to construct very large reservoirs that would serve a whole region and needed to be constructed and operated by a dedicated bureaucracy. As a consequence, many of the local tanks went out of use. Over time, however, it has become clear that the centralizing technocratic approach cannot address all local water shortages and a new movement has started to re-introduce the local tank system.

The island of Bali, Indonesia, has a sophisticated Hindust culture in which water and irrigation are central. Long before the government started to train and empower irrigators, and indeed started to construct large irrigation systems, the Balinese operated complex irrigation on hillside terraces (subak), including water allocation by rotational schedules, and sustainable maintenance procedures.

Many countries have learned how to cope with seasonal floods. In some countries houses are built on stilts; in others, such as Bangladesh, villages are built on artificial mounds for which the soil was taken from ‘borrow pits’ that in the dry season were neatly maintained to provide water for the household and for cattle. Transportation in the flood season took and still takes place by canoe. This approach proved effective, causing minimum disruption of daily life, allowing the floodwater to deposit fresh fertilizing silt on the fields, and sustaining large fisheries.

Part 3. Enhancing Local Capacities

When challenge areas discussed in this report describe deficiencies and propose goals for a better tomorrow, it is the enhancement of knowledge and local capacities that are needed to fill the gap between the current state and the desired sustainable solution. Success in water development can only be achieved when local capacities have been enhanced to address the water-related problem.

3a. Human resources development

Human resources development is a continuous process aimed at imparting knowledge, developing skills and changing attitudes and behaviours, which allow the maximization of the benefits of knowledge sharing and participatory processes. While all levels of capacity development – human resources, institutional capacity and the enabling environment – are ultimately of equal importance (see Box 13.9), adequately skilled staff to develop policy and legal frameworks and the necessary institutions are the starting point of any successful venture. In all capacity-building efforts, attitude, behaviour, education and training, as well as workforce incentives, career paths, and accountability mechanisms in the workplace all influence the capacity to make knowledge-based decisions, and are critical components of human resources development. Developing knowledge through effective sharing at and between each level of capacity development is one of the most important challenges in the water sector.

The many technocrats within the water sector generally do not have the skills to deal effectively with governance issues, such as conflict mediation, mobilization of communities, managing processes of stakeholder participation, etc. ‘Social facilitators’ can be introduced to complement the technocrats with skills to manage diverse and dynamic social and political processes that typically did not receive much attention in the past.

Basic education

People’s effectiveness in managing and using water is only brought about with the provision of a basic education on water, sanitation and hygiene. If children are taught proper hygiene, primary schooling can transform them into health educators for their families, thereby passing on vital information and skills that can reduce household vulnerability to deadly diarrhoeal diseases by at least 40 percent (see Chapter 6). This is particularly true for women and girls who are responsible for household hygiene, food and water, and who are, with the elderly, the most at risk from water-related hazards. Increased and safe access to primary education for girls will pave the way to more gender-balanced decision-making processes for water management (see Chapter 1), in line with MDG Goal 3 to promote gender equality and empower women.

BOX 13.9: IMPLEMENTING CAPACITY AT ALL LEVELS

Brazil is expected to achieve the Millennium Development Goals (MDGs) target in water supply and to come close to achieving the sanitation goal (see Chapter 14). According to a needs assessment undertaken in several Latin American countries, this is partly due to a sufficient number of professionals graduating from 120 water-related postgraduate programmes in the country. However, an unfavourable enabling environment has been one of the main reasons behind the underperformance of the water and sanitation sector in the last decades. For example, the Brazilian Congress approved a Water and Sanitation Policy in 1993, only to be revoked by the Government in 1994. It was not until 2005 that a new policy document to regulate the sector was put forward for discussion.

Contrary to the situation in Brazil, it is still uncertain whether the water and sanitation targets of the MDGs will be achieved in Mozambique (WHO/UNICEF, 2004). The country has implemented water sector reforms during the last decade, and implementation agencies have been strengthened, while robust policy, economic, legal and systems frameworks have been established. However, in accordance with a similar needs assessment, the country struggles with a lack of qualified human resources. Mozambique, with a population of about 20 million, has one university and about fifteen postgraduate professionals involved in water resources management and services provision.

Sources: Mejia-Velez and Rudic-Wiersma, 2005a; 2005b.
Higher education and training has an important role in knowledge transfer, not just as a one-time diploma course but also throughout the active professional life of the recipient.

As described in the Ethiopia National Water Development Report (see Chapter 14), 30 to 40 percent fewer girls than boys attended school at the national level. UNICEF’s report on gender parity and primary education (2005) indicated that girls make up most of the 115 million children currently out of school, and 80 percent of children not attending primary school in West/Central Africa, South Asia and Middle East/North Africa had mothers with no formal education at all (UNICEF, 2005a). Reasons for this include the need for girls and women to walk long distances to bring water to the home and/or lack of sanitation facilities in schools, forcing girls to seek refuge in the woods and risk sexual attack, ridicule and shame.

A recent study in Bangladesh indicated that a separate toilet could increase the number of girls in school by as much as 15 percent (UNICEF, 2005b). As Carol Bellamy, the former executive director of UNICEF, aptly noted: ‘We will only reap the rewards of investment in education if we safeguard children’s health while they learn’ (UNICEF, 2005b).

As part of its Water for African Cities Programme, UN-HABITAT has since 2003 embarked on an innovative Value-based Water Education campaign that seeks to impart information on water, sanitation and hygiene to children and communities, all the while inspiring and motivating learners to change their behaviour and adopt attitudes that promote hygienic living and wise and sustainable use of water.

Another interesting initiative is The Focusing Resources on Effective School Health (FRESH), an inter-agency collaboration between UNESCO, UNICEF, WHO, and the World Bank, which has produced a toolkit that offers information, resources, and tools that provide support to the preparation of Hygiene, Sanitation, and Water in Schools policies and projects (World Bank, 2000). Educational systems in general need to strengthen education and training delivery mechanisms through networking and the use of professional associations. Curricula, in addition to ensuring high scientific standards, must constantly adapt to concrete problems. An integrated and multidisciplinary competence in general problem solving rather than in purely technical subjects will prove valuable in many new fields. The use of GIS in support of mapping the sustainability of schools is a growing trend around the world, including education sectors in developing countries. In some cases, building geo-spatial databases and using GIS is becoming a standard and/or a requirement for funding (Al-Hanbali et al., 2004) (see Box 13.10).

**Higher education/training**

Higher education and training has an important role in knowledge transfer, not just as a one-time diploma course but also throughout the active professional life of the recipient. The value of such education and training is that appropriate knowledge on water can be packaged and even tailored for professionals and other stakeholders. New blended learning approaches encourage active and participatory learning. Peer-to-peer technology that links users in two-way communication enables collaborative working and distance learning. Whereas face-to-face communication is preferable, the increasing availability of distance learning facilities enlarges the possibilities and opportunities for lifelong learning and continued development of the knowledge and expertise of professionals. Online education has increased tremendously since the UN Conference on Environment and Development in 1992, but the challenge of educating the world’s population has never been greater, particularly at a time when over 40 percent of the global population is under twenty years old (van der Beken, 2004).

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**BOX 13.10: GIS FOR SCHOOL SANITATION AND HYGIENE EDUCATION: TAMIL NADU, INDIA**

GIS has been applied innovatively in Tamil Nadu for improving the school sanitation programme. With UNICEF assistance, GIS was used for the first time in India in the village of Panchayat to create water and sanitation facility mapping for schools focusing on five indicators: availability of drinking water, toilets, water for toilets, washing and school sanitation and hygiene education (SSHE). This triggered significant changes in planning for SSHE, especially the use of spatial data. When the first GIS maps were displayed during a regional workshop, they shocked the district officials, as they did not have any idea about the coverage of water and sanitation facilities in schools. They were drawn towards the GIS maps and started comparing coverage levels between different districts and decided to take up joint planning and use pooled resources. The data has been used to prepare district action plans for SSHE, jointly owned by the local governments. Higher officials in offices far away also became sensitized to local problems after looking at the GIS data.

Preliminary needs assessments indicate that nearly all countries lack the numbers of adequately trained individuals in order to meet the MDGs, and large numbers of technical and scientific personnel lack a holistic perspective on water management and use. Appropriate training programmes need to be designed and delivered in order to tackle the problems that affect people in their local realities. Adapted training and awareness raising must be provided to the myriad of professional perspectives that play a role in water sector development. This situation was made clear in a needs assessment carried out in 2001 in Bolivia (Lake Titicaca) (see Chapter 14 on case studies). The assessment showed how many managers already identified the need to combine knowledge and tools from social sciences with traditional engineering skills, and in a related survey, water resources management emerged as the most needed postgraduate programme, leading to the creation a Masters-level programme on sustainable water resources management. In Egypt, the activities of the Regional Centre for Training and Water Studies of Arid and Semi-arid Zones (RCTWS), working under the auspices of UNESCO as an international knowledge institution since January 2002, help to contribute to capacity building in the field of Integrated Water Resources Management specifically for the Arab and Nile Basin countries.

3b. Strengthening institutional capacity

Institutional capacity relates to the overall performance of the organization and its capability to function properly, as well as its ability to forecast and adapt to change. An organization’s personnel, facilities, technology, knowledge and funding constitute its ‘resource base’. Procedures and processes for managing its resources, programmes and external relationships determine its ‘management capacity’. Together, this resource base and the management capacity make up the overall capacity of the organization (Horton et al., 2003). Such capacities must be operational (day-to-day activities) and adaptive (response to changing circumstances). If the organizational structure within the water sector is conducive to efficient, effective and expedient decision making, it is likely that the country’s capacity to address water-related problems is strong. To ensure effectiveness in services delivery and efficiency in water use, the public sector needs to establish partnerships with local communities and user groups. By empowering and strengthening their capabilities, they can assume part of the management responsibility and authority over the infrastructure and the resource itself. Directly affected sectors or user groups, like water user associations, industrial estates, municipalities or wards, and irrigators, can be empowered by establishing and formalizing a platform that allows all interested water users to present their interests and have ‘voice and choice’ in the decision-making and management process of water services. This enhances transparency and accountability and fosters the local sense of ownership, while partially relieving the financial burden on the agencies. However, such user groups need also to have their capacities strengthened through training and access to information to allow them to take informed decisions and play their roles.

At the institutional level, three capacity development needs stand out in particular:

- a clear mandate for managing agencies, water providers and policy-making bodies that promote and enhance the institutionalization of good water management and water use throughout all levels of society
- an organizational system conducive to effective and efficient management decisions
- improved decision support mechanisms through research on lessons learned and indigenous knowledge.

Water management agencies continue to close the door on opportunities for effective integrated water management if they do not provide a voice to relatively powerless groups, such as women (Box 13.11), who are central in providing, managing and safeguarding water, and indigenous people (Box 13.8) who are custodians of sound, ancestral water management practices. As many ministries and non-governmental institutions deal with water within a country, a national apex body19 can play a crucial role in coordinating activities and disseminating responsibilities in the network of organizations operating on the ground within a river basin. By considering all stakeholders, a national apex body may adopt policies and laws, carry out institutional reforms and formulate a national water agenda (Asian Development Bank, 2004).

It is crucial to deal with employment issues in order to improve organizational performance. Both public and private sectors need to provide adequate salaries, as well as professional development opportunities and incentives. If the incentives for the staff as individuals and as an organization point in the wrong direction, the possession of other capacities is of little value (Alaerts et al., 1999). This is illustrated by a study of retention rates in a poorly performing public sector in Africa. It was found that the retention rates of trained individuals were much higher than expected for the perceivably low

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19. An apex body is a national organization that guides the water sector in water services and resource management.
Mid-career professionals receive on-the-job training by local experts in Indonesia

activities. In addition, the Gender and Water Alliance (GWA) was established at the World Water Forum in 2000.

The GWA has developed a training methodology geared towards building capacity to mainstream gender equity in integrated water resources management. The Vice Ministry of Basic Services and the Ministry of Agriculture of Bolivia have undertaken gender audits in both institutions, turning this unique research and analytical initiative into a ‘learning by doing gender’ experience. Although the audits indicated that the approach to gender equity is not reflected in sector policies – nor is the impact of programmes and projects on local women and men systematized with feedback to decision-making levels – issues related to gender responsiveness are becoming increasingly important.

BOX 13.11: THE NEED FOR GENDER BALANCE

Women produce between 60 and 80 percent of the food in most developing countries and provide up to 90 percent of the rural poor’s food intake. Women are major stakeholders in all development issues related to water. Yet they often remain on the periphery of management decisions and planning for water resources.

To overcome this deficiency, an inter-agency Task Force on Gender and Water was inaugurated to work towards the implementation of gender-sensitive water and sanitation policies. In addition, the Gender and Water Alliance (GWA) was established at the World Water Forum in 2000.

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It follows that an important aspect of good governance in stimulating capacity development is related to research and education. Governments have to provide incentives and mechanisms that stimulate education and research institutions to address the real societal issues and demand. This can be done through applied-oriented research funds and through activation of professional, commercial, civil society and political institutions in the development of education and research programmes. The European Union has provided instruments through its fifth and sixth framework programmes that support the development of such linkages in society and among education and research institutions.

A country may even have to modify its national laws and regulations to enable education institutions to adjust their curriculum in response to demands from society. One such example is the new law on higher education in Indonesia (2003). This law has opened up the possibility to include private education institutions with their linkages to professional organizations and the private sector. Moreover, the accreditation system has been changed from pre-approval of the curricula to post-approval by an accreditation board. This is a big step towards the development of dynamic and society responsive education and research environment.

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Capacity development is dependent on the government’s political will to change the existing policy, legal, management and economic frameworks and to implement reforms, as well as on the introduction of new governance systems and the familiarization of decision-makers and implementers with improved ways of managing water. This implies that capacity development actions have to include the political, social, economic and administrative dimensions of systems that may affect management of water resources and delivery of water services. This can go as far as the inclusion of policies in relation to organization of government, delegation of authority, career planning, salary and reward systems within the civil service and the creation of incentive mechanisms to enhance effective governance. It also implies development of policies that enhance access to finance for development and management of water infrastructure and services.

Until now capacity development has often been focused at the level of new utility management, communities or basin and water users associations. However, the decentralization and management transfer policies in many countries add a new dimension to capacity development: the development of new regulatory and governance systems at the decentralized levels. Unfortunately, the changing roles of government are not always accompanied with the associated capacity development and incentive systems required to effectuate the change. This is often due to a combination of a lack of knowledge on the implementation of these new roles, inherent resistance to innovation and a lack of appreciation of local capacity, knowledge and experience.

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...retention rates of trained individuals were much higher than expected for the perceivably low salaries, lack of equipment, demoralized environment and the bureaucratically inefficient management.

### Box 13.12: Initiatives to Enhance Access to Finance at Sub-sovereign Level

<table>
<thead>
<tr>
<th>The Municipal Fund that was established in May 2003 is a joint World Bank/International Finance Corporation (IFC) initiative to invest in projects at the state and municipal level - without taking sovereign guarantees.</th>
<th>supporting the delivery of basic services where policy concerns justify the use of public funding to complement or replace user fees. OBA approaches utilize targeted subsidies that are performance-based and paid largely after the delivery of specified outputs (e.g. water supply connections) and mobilize private capital and management. The most common form of OBA is subsidizing water supply connections for the poor. Some other initiatives are the European Union Water Facility for the African, Caribbean and Pacific Countries (ACP-EUWF) and the Asian Development Bank Water for All initiative.</th>
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<tr>
<td>The Department and International Development (DFID)/World Bank Global Partnership on Output-Based Aid (OBA) provides a strategy for</td>
<td></td>
</tr>
</tbody>
</table>

Source: Spicer, 2005; Weevers-Carter, 2005; van Hofwegen, 2005; www.ifc.org/municipalfund
Ensuring access to public information is yet another aspect of good governance. Unfortunately, the financial support to generate basic information especially in the domain of basic water quality and hydrological and meteorological data has been dwindling. A new discussion is needed on the meaning and implications of property rights, especially in the public domain, and the ethics around charging for information in the public domain, which should also include the international organizations.

Part 4. Identifying Knowledge and Capacity Needs

It is widely acknowledged that greater efforts are required to understand the complex processes of change within all levels of development. While case studies, working papers, reports, manuals, best practices, guidelines, and the like are all valuable sources of knowledge, comprehensive cross-country comparisons (regional, national and/or basin wide assessments) of existing knowledge and capacity are needed as are analyses of capacity development initiatives undertaken in the past. Today, little data is available to allow the identification of national capacities to address development problems specific to water.

Identifying methods to measure capacity and monitor development initiatives has proven to be difficult. National statistical agencies must improve and strengthen the collection, storage and analysis of information conducive to the knowledge base of water management. At the international level, such needs are being carried out in order to move the process of water assessments along, and the UN Statistical Commission’s Intersessional Working Group on Environment Statistics (IWG-ENV) is currently reviewing measures to improve the contribution of statistical work to the management of development in water-related sectors. Other organizations involved with enhancing capacity within national statistics agencies include Paris21, the World Bank, and UNESCO Statistics. Through discussions between the international statistics community, water experts and development agencies, it is expected that the existing sustainable development questionnaires could be adapted and new survey material created in order to segregate and better measure the capacity-enhancing initiatives specific to water development en route to meeting the MDGs. Thinking in terms of a non-traditional approach to capacity-development assessment will help to overcome limited international agreement on how to adequately measure such complex qualitative processes.

4a. Indicators

To date, indicators for measuring capacity are very much in their infancy. Rather than a final, easily measurable outcome or output, capacity development is a complex process that leads to more varying degrees of capacity in an ever-changing environment. Traditional measurement methods have often concentrated on ‘harder’ issues (e.g. systems improvements, equipment supply, training, organizational structuring, etc.), with a focus on a specific entity (societal, organizational or individual), rather than reflecting the broader system or environment in which they function and the ‘softer’ issues of learning, adaptation and changes in attitude. Under these circumstances, when output-based performance indicators conclude that the majority of capacity development projects implemented during the 1980s failed, we learn whether the capacities were ‘adequate’ or ‘good’ overall but gain little information about which aspects of the process were failing, where partial successes exist or whether or not the initiative was doomed to fail from the start (Mizrahi, 2004).

By only considering the barriers to capacity development without better assessing the causes of good and bad performance, the opportunity to identify and confirm strengths is forfeited. Because a number of indirect and...
unrelated inputs can contribute to the good performance of an institution, an excellent agricultural output in one country might be the result of a market collapse in another without any institutional reform or capacity enhancements being made.

Potential indicators for a global assessment might include the identification of users of the growing number of water-related databases or the human resource needs to meet specific water-related goals on the global agenda. However, while aggregated global indicators can make an important contribution to the awareness of global capacity gaps, they can oversimplify the complex processes involved in addressing the myriad of water-related problems and would therefore provide little information on accomplishments, needs or failures. Worse, such aggregated indicators could degenerate into a form of conditionality designed mainly for the reporting needs of the international community, thereby undermining a nation’s efforts to address the water-related challenges being assessed.

An effective global assessment demands that a bottom-up approach be undertaken, which endorses ownership, promotes participation and considers the contextual aspects of a sector’s objectives. The design and implementation of suitable strategies for change must adopt a focused approach based on region/nation/basin/community ownership. There is no panacea for assessing and enhancing capacity. When we ask ourselves, “What are the crucial capacity gaps?” We must also ask, “For what?” and “For whom?” The capacity for a nation to meet the MDGs water supply and sanitation targets will be different from that same nation’s capacity to monitor the resource for better risk management. The capacity required for a government to enable better agricultural trade will be different from the Farmers Association’s capacity needs for increasing pressure on the government to do so.

Capacity development is, by definition, a process leading to outcomes. As such, benchmarking is required to measure the degrees of capacity attained. However, identifying benchmarks is particularly difficult because a common understanding of the abstract notions of human knowledge, institutional performance and cultural change across the community, basin, national and international levels of society must be achieved among the various actors. Therefore, a participatory, locally oriented approach must be adopted when designing capacity assessment programmes. The ability to prioritize goals and improve self-evaluation methodologies can be strengthened through negotiation from the beginning of the capacity development initiative.

As each country faces its own water-related problems within the context of its own national priorities and agendas, it must choose its own methodological approach to identifying capacity needs while taking varying political, socio-economic and technical factors into account. It is essential that these assessments be entirely country-driven, undertaken by national institutions and experts to the fullest feasible extent, and responding to national situations and priorities. External agencies cannot effectively assess the capacity needs of a country, nor should they play any role other than that of facilitating the process of analysis and developing capacities to manage and implement change. It is therefore important that countries be self-sufficient in their ability to undertake capacity-needs assessments in water-related sectors, and it should be incumbent on those countries to be forthright in sharing the assessment information with the international community in order to gain from lessons learned, prove institutional strength or direct attention to their capacity needs.

By this approach, better clarity of the global capacity needs to address water-related problems will begin to be realized, and actions to address these needs can be undertaken. To enable some consistency in the regional and sector assessments, the general framework for capacity outlined in Table 13.1 could be used as guidance for indicator development. The framework provides a conceptual map that can be adapted and used to assess capacity related to specific development objectives and then reported within each of the challenge areas of the next UN World Water Development Report. This way, future assessments of the various challenge areas within this Report will inherently incorporate knowledge and capacity needs into their cross-country comparisons. For example, by viewing Chapter 7 on water for food through the lens of knowledge and capacity, future indicators may include the number of irrigation associations per capita or farmers’ access to meteorological information. These sector-based capacity assessments will contribute to the much-needed statistical data on existing capacity and associated initiatives. In addition, they will promote awareness of capacity gaps and be themselves a capacity-enhancing process to those involved.

The readiness of governments to undertake capacity-needs assessments in various water-related sectors would be self-sufficient in their ability to undertake capacity-needs assessments in water-related sectors...

It is important that countries be self-sufficient in their ability to undertake capacity-needs assessments in water-related sectors...
### Table 13.1: General framework for capacity development

<table>
<thead>
<tr>
<th><strong>Human Resources</strong></th>
<th>Refers to the process of changing attitudes and behaviours – imparting knowledge and developing skills while maximizing the benefits of participation, knowledge exchange and ownership.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Job requirements and skill levels</strong></td>
<td>Are jobs correctly defined and are the required skills available?</td>
</tr>
<tr>
<td><strong>Training/Retraining</strong></td>
<td>Is the appropriate learning taking place?</td>
</tr>
<tr>
<td><strong>Career Progression</strong></td>
<td>Are individuals able to advance and develop professionally?</td>
</tr>
<tr>
<td><strong>Accountability/Ethics</strong></td>
<td>Is responsibility effectively delegated and are individuals held accountable?</td>
</tr>
<tr>
<td><strong>Access to information</strong></td>
<td>Is there adequate access to needed information?</td>
</tr>
<tr>
<td><strong>Personal/Professional Networking</strong></td>
<td>Are individuals in contact and exchanging knowledge with peers?</td>
</tr>
<tr>
<td><strong>Performance/Conduct</strong></td>
<td>Is performance effectively measured?</td>
</tr>
<tr>
<td><strong>Incentives/Security</strong></td>
<td>Are these sufficient to promote excellence?</td>
</tr>
<tr>
<td><strong>Values, Integrity and Attitudes</strong></td>
<td>Are these in place and maintained?</td>
</tr>
<tr>
<td><strong>Morale and motivation</strong></td>
<td>Are these adequately maintained?</td>
</tr>
<tr>
<td><strong>Work Redeployment and Job Sharing</strong></td>
<td>Are there alternatives to the existing arrangements?</td>
</tr>
<tr>
<td><strong>Inter-relationships and teamwork</strong></td>
<td>Do individuals interact effectively and form functional teams?</td>
</tr>
<tr>
<td><strong>Interdependencies</strong></td>
<td>Are there appropriate levels of interdependence?</td>
</tr>
<tr>
<td><strong>Communications skills</strong></td>
<td>Are these effective?</td>
</tr>
</tbody>
</table>

**Institutional Capacity**

Focuses on the overall organizational performance and functioning capabilities as well as the ability of an organization to adapt to change.

| **Mission and strategy** | Do the institutions have clearly defined and understood missions and mandates? |
| **Culture/Structure/Competencies** | Are institutions effectively structured and managed? |
| **Process** | Do institutional processes such as planning, quality management, monitoring and evaluation work effectively? |
| **Human resources** | Are the human resources adequate, sufficiently skilled and appropriately deployed? |
| **Financial resources** | Are financial resources managed effectively and allocated appropriately to enable effective operation? |
| **Information resources** | Is required information available and effectively distributed and managed? |
| **Infrastructure** | Are material requirements such as building, offices, vehicles and computers allocated appropriately and managed effectively? |

**The Enabling Environment**

Focuses on the overall policy framework in which individuals and organizations operate and interact with the external environment.

| **Policy framework** | What are the strengths, weakness, opportunities and threats according to the socio-political, government/public sector, economic/technological and physical environment factors operating at the societal level? |
| **Legal/Regulatory framework** | Is the appropriate legislation in place, and are these laws effectively enforced? |
| **Management/Accountability framework** | Are institutional responsibilities clearly defined, and are responsible institutions held publicly accountable? |
| **Economic framework** | Do markets function effectively and efficiently? |
| **Systems-level framework** | Are the required human, financial and information resources available? |
| **Process and relationships** | Do the different institutions and processes interact and work together effectively? |

provide an indication of a government’s own capacity to appreciate and to adapt to change. The degree to which a participatory process is incorporated in performing the assessment and the utility of the assessment to identify capacity gaps and priorities could also be considered as a global indicator to assess countries in future editions of the UN World Water Development Report. Such information could be compiled in a map on countries’ readiness to meet the Johannesburg implementation plan target on IWRM Plan preparation by 2005. As presented in the case studies of this Report (Chapter 14), governments of some countries such as Ethiopia and Uganda have taken a positive first step in performing preliminary assessments of needs to operationalize IWRM and their foresight should be recognized in global country comparisons (see Chapter 14).

4b. The distribution of knowledge and capacity needs

The knowledge base that supports decision-making and the capacities of individuals, institutions and societies to perform functions, solve problems and set and achieve objectives pertain to all the challenge areas discussed in the preceding chapters. Lopes and Theisohn (2003) present a simple indication of the relative significance of different aspects of capacity development. Their work aims to arrest the ambivalence about capacity issues that remains within many international development agencies and partner countries by illustrating capacity development that does not only depend on individual training courses, but also on every aspect of a country’s ability to address water-related problems within all sectors of its development.

4c. Assessment tools and challenges

In recent years, a few examples of national capacity self-assessment handbooks have been created for various development objectives. Of particular note is WMO’s and UNESCO’s Water Resources Assessment - Handbook for Review of National Capabilities (WMO/UNESCO 1997b), which is designed to assess a country’s ability to measure and monitor effectively its water resources. The handbook specifically aims to provide guidance for reviewing levels of activity of the basic water resources assessment in the whole or part of a country or region. The activities are compared, when possible, with minimum acceptable requirements in terms of installation density, degree of computerization, skilled human-power and related management structure and education, training and research programmes. The comparisons then provide a basis for proposing actions considered necessary for achieving minimum requirements.

This methodology has been applied in Latin America and further expansion to other regions is desirable. The guidelines are not prescriptive in any sense and are not meant as a standard methodology that can be applied to all countries at all times under varying political, socio-economic and water resource conditions. Countries should use the water resource and capacity needs self-assessment guidelines to the extent that they consider them to be feasible, or they may choose other methodologies better suited to their national situations and preferences.

Though not widely available, assessments have been undertaken addressing specific sector needs that make them difficult to compare. Moreover, assessments undertaken have followed specific approaches intended to specifically address different levels of capacity development. At the regional level, assessments have been undertaken in Asia and Latin America to make inventories of the human capacities required and available to address the Millennium Development Goals in water and sanitation (Mejia-Velez and Rodic-Wiersma, 2005a; 2005b; Rodic-Wiersma and Sah, 2005). At the country level, some examples are included in Chapter 14 on case studies. Additional examples are the Mali Long Term Training and Capacity Building Needs Assessment (Academy for Educational Development, 2003), and the Capacity Building Project in the Water Resources Sector in Indonesia (Asian Development Bank, 2005). The first example concerns the individual human resources and the second the nature of the institutions. A brief description of the multilevel assessment and implementation of capacity development initiatives in Mexico is described in Capacity Building for the Water Sector in Mexico: An Analysis of Recent Efforts (Tortajada, 2001). Some key sources for information on how to perform capacity assessments are included in Table 13.2.

In addition, the Global Environment Facility (GEF) Secretariat and UNDP launched the Capacity Development Initiative (CDI), which produced a National Capacity Self-Assessment (NCSA) process. The primary goal of the NCSA is to identify, through a country-driven consultative process, priorities and needs for capacity-building, in order to identify, confirm or review priority issues for action within the GEF’s thematic areas of biodiversity, climate change and desertification/land degradation.
...the true test for any country will be its formulation of a strategic plan of action and the successful implementation of appropriate capacity development initiatives.

Country capacity needs and priorities to achieve goals related to conventions in these three areas are then documented globally (excluding high-income countries). This methodology provides a good direction for the implementation of global assessments in the various water-related sectors of the next World Water Development Report.

When assessing capacity needs, the true test for any country will be its formulation of a strategic plan of action and the successful implementation of appropriate capacity development initiatives. This assessment can help identify an entry point to initiate a capacity development programme under conditions of resistance to change (see Chapter 2). If the capacity development process starts through legal reforms, institutional strengthening or awareness-building is necessary, which entails the identification of a suitable entry point among the different levels of capacity. Principles summarizing the implementation of capacity development initiatives are beginning to be formulated (Lopes and Theisohn, 2003). An effective ongoing monitoring programme must accompany the process to improve the capacities of individuals and institutions, such that they can develop a culture of self-assessment and establish an approach to thinking strategically about capacity and performance. Since capacity development is a process, a monitoring system is necessary to understand changes in the process and to feed this information back to those managing it, so that they can enhance the efficiency and effectiveness of the intervention.

Table 13.2: Some capacity assessment tools

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The UNDP’s Capacity Development Resource Book</td>
<td>(available at magnet.undp.org/cdrb/Defaul.htm) is a collection of electronic documents assembled for capacity development practitioners.</td>
</tr>
<tr>
<td>UNDP website on capacity development</td>
<td><a href="http://www.capacity.undp.org/">www.capacity.undp.org/</a> includes key sources for generic information on how to perform capacity assessments. Additionally, it includes initiatives, networks, resources and tools. It offers access to the Capacity 2015 initiative developed to operationalize the MDGs.</td>
</tr>
<tr>
<td>The South African Capacity Initiative (SACI)</td>
<td><a href="http://www.undp-saci.co.za">www.undp-saci.co.za</a> developed a Capacity Mobilization Toolkit for Southern African countries, which takes into consideration the particularly complex human capacity challenges associated with the impacts of HIV and AIDS, poverty and recurring disasters on sustaining basic social services to the public at all levels of the Millennium Development Goals.</td>
</tr>
<tr>
<td>The European Centre for Development Policy Management’s Capacity Development website</td>
<td><a href="http://www.capacity.org">www.capacity.org</a> aims to look at policy and practice of capacity development within international development cooperation and provides a newsletter and a comprehensive material related to capacity development in all sectors.</td>
</tr>
<tr>
<td>The International Development Research Centre (IDRC), the International Institute of Rural Reconstruction (IIRR) and the International Service for National Agricultural Research (ISNAR)</td>
<td>Implemented a project to better understand how capacity development takes place and how its results can be evaluated. Further information is available at <a href="http://www.idrc.ca/en/ev-31556-201-1-00-TOPIC.html">www.idrc.ca/en/ev-31556-201-1-00-TOPIC.html</a>.</td>
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</tr>
<tr>
<td>The World Bank provides an online Capacity Development Resource Centre</td>
<td>which provides an overview of case studies, lessons learned, ‘how to’ approaches and good practices pertaining to capacity development. It is available at <a href="http://www.worldbank.org/capacity">www.worldbank.org/capacity</a>.</td>
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</tr>
<tr>
<td>A team of the German Technical Cooperation (GTZ)</td>
<td>supported the Indonesian Government in preparing guidelines on how to organize and manage a capacity-building needs assessment process in the regions, resulting in a medium-term regional capacity-building action plan. These very well structured guidelines, field-tested before they became final, are available at <a href="http://www.gtzsfhm.or.id/cb_nat_fr_work.htm">www.gtzsfhm.or.id/cb_nat_fr_work.htm</a>.</td>
</tr>
</tbody>
</table>
Part 5. The Way Forward

This chapter highlights the need for knowledge acquisition and integration to become the responsibility of the country concerned, supported on the one hand by participatory processes for knowledge development that capitalize on existing local and indigenous knowledge and on the other hand by the unprecedented access to the global knowledge base and professional networks in order to adopt a holistic and integrated approach to enhance all levels of existing capacities. As solutions are only found when problems are understood, comprehensive capacity assessments are urgently needed to identify where understanding is deficient and to meet water development objectives. To date, such assessments have not yet been done in developing countries. This trend should be reversed.

Comprehensive capacity assessments will set the baseline to gauge progress on locally owned strategies to address country-specific water-related problems. The information gained will stimulate the adaptive capacity of countries to anticipate and manage change by fostering a culture of self-assessment and by establishing a strategic approach to sustainable development. In this way the goal of sustainable development of water resources and services and the capacity to manage them effectively and efficiently can be achieved through a continuous renewal process that is at the heart of good governance.

It follows that there should be increased international commitment to statistical capacity-building in water with a focus on the three levels of capacity and their sub-components. Similarly, there should be greater emphasis on sharing knowledge, particularly amongst riparian nations of a transboundary basin, in order to build regional capacity to address water-related problems together.

That part of the knowledge base that concerns the data from monitoring the water resources and services performance is essential for both global comparison and local assessment. Further investment and better management of ground-based networks and remote sensing facilities are needed to ensure that adequate information is available to facilitate sound decision-making at all levels of a country’s capacity. At the same time emphasis should be placed on improving the human component of the knowledge base. This acknowledges that all staff and stakeholders, including the general public, require education and training about the pressing issues of water development in the region. Although there is a need for countries to create apex bodies at the basin level, the decentralization of responsibilities will require attention directed at strengthening local institutional capacities. In doing so, the roles of the local institutions must be clearly defined, and a culture of innovation should be encouraged that appreciates and takes advantage of local and indigenous knowledge and experience. Only by building upon the existing foundation can water development be effective.

If the Millennium Development Goals are to be met, in particular Goal 8 to develop a global partnership for development, it is incumbent upon donor nations to embrace the new paradigm for water development by providing the necessary support (increased aid and debt relief, opening of trade, accelerated transfer of technology and improved employment opportunities) to allow developing nations to expand their knowledge base and enhance their existing local capacities rather than transferring short-term solutions as was common in the past. Likewise, it is the responsibility of the leaders of developing countries to create an enabling environment to enhance the existing local capacities and the knowledge base on water, by setting policies, ensuring adequate funding, and empowering local institutions and stakeholders with decision-making responsibilities, and to monitor performance to ensure good governance and transparency.

In viewing the assessments and country comparisons for each of the challenge areas presented throughout this Report, we can identify the gap between the existing situation and the desired situation. These identified gaps are the deficiencies in knowledge and capacity within each of the associated sectors (i.e. food, health, energy, etc.). To continue to be ambivalent about enhancing the knowledge base, or to ignore the holistic approach to capacity development and view it simply as a one-off course for individual training would mean that countries will go on pouring untold resources and time into unsustainable solutions and these gaps will see little reduction in future World Water Development Reports.
References and Websites


eftner.vub.ac.be/ePUBLICATIONS21/watereducation.pdf

van Hofwegen, P. J. M. 2005. E-mail communication.

Mannesles, France. September, 2005


United Nations water-related portals

Earthwatch: earthwatch.unep.net

FAO Water Portals: www.fao.org/ag/agl/portals.stm

GEO-3 Data Portal: geodata.grid.unep.ch

International Year of Freshwater: www.wateryear2003.org

UNEP Freshwater Portal: freshwater.unep.net

UNESCO Water Portal: www.unesco.org/water

For a comprehensive list of Water-related UN programmes, portals, and databases see www.unesco.org/water/water_links/Type_of_Organization/United_Nations_System_Programmes_and_Agencies/
Some international water networks and professional associations

American Institute of Hydrology (AIH): www.aihydro.org/
Freshwater Action Network: www.freshwateraction.net
International Association of Hydraulic Engineering and Research (IAHR): www.iahr.org/
International Association of Hydrogeologists (IAH): www.iah.org/
International Association of Hydrological Sciences (IAHS): www.iahs-iahs.org
International Commission on Irrigation and Drainage (ICID): www.icid.org
International Network of Basin Organizations: www.inbo-news.org/
International Water Association (IWA): www.iwa.org.uk/
International Water Resources Association: www.iwra.org/
Streams of Knowledge: www.streams.net
Water Environment Federation (WEF): www.wef.org/
WaterNet: www.waterettionline.in

For additional professional associations see www.unesco.org/water/water_links/Type_of_Organization/Professional_Organizations/

Some international institutions for water education and research

UNESCO Centre for Water Hazard and Risk Management: www.unesco.org/water/
UNESCO-IHE Institute for Water Education: www.unesco-ihe.org
Water Virtual Learning Centre: www.wvlearn.org

For additional information on institutions for water-related training, education and research, visit www.unesco.org/water/water_links/Type_of_Organization/Educational_Training_and_Research_Institutions/.