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Sustainable water future with global implications: everyone's responsibility

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The current use and management of freshwater is not sustainable in many countries and regions of the world. If current trends are maintained, about two-thirds of the world's population will face moderate to severe water stress by 2025 compared to one-third at present. This water stress will hamper economic and social development unless action is taken to deal with the emerging problems. The Comprehensive Assessment of the Freshwater Resources of the World, prepared by the United Nations and the Stockholm Environment Institute, calls for immediate action to prevent further deterioration of freshwater resources. Although most problems related to water quantity and quality require national and regional solutions, only a global commitment can achieve the necessary agreement on principles, as well as financial means to attain sustainability. Due to the central and integrated role played by water in human activities, any measures taken need to incorporate a wide range of social, ecological and economic factors and needs. The Assessment thus addresses the many issues related to freshwater use, such as integrated land and water management at the watershed level, global food security, water supply and sanitation, ecosystem requirements, pollution, strengthening of major groups, and national water resource assessment capabilities and monitoring networks. Governments are urged to work towards a consensus regarding global principles and guidelines for integrated water management, and towards their implementation in local and regional water management situations. The alternative development options available to countries facing water stress, or the risk thereof, needs to be considered in all aspects of development planning. © 1997 United Nations. Published by Elsevier Science Ltd

This article summarizes the main findings of the Comprehensive Assessment of the Freshwater Resources of the World[1] (CFWA), and focuses on its recommendations for action, which are presented as policy options, and the practical implications of these recommendations on future development.

The CFWA describes and quantifies the occurrences of water on the planet from a hydrological cycle perspective (Figure 1) and further presents the uneven distribution of freshwater resources over the globe, resulting from the combination of many factors (Figure 2). They include global precipitation patterns and the rate of evapotranspiration, closely related to local climate conditions. This results in a range of hydrological environments, ranging from deserts to regions of extreme humidity. The availability per capita is dependent upon these factors, but also on population density. The fallacy of calculating "per capita availability" of freshwater over large regions, such as continents, or even countries, is demonstrated. An example is the Sahel region where in many studies, including the Assessment, this region is not characterized as having a high water stress, even though it is a semi-arid region well known for its poverty and other problems. One reason is that some countries in dry regions have relatively abundant water resources in parts of the country, such as a large river. This is the case in parts of Sahel where the Nile and Niger Rivers flow. In addition, abundant rainfall falls for parts of the year but with extreme inter-annual variability. Another reason is the relatively low population density (but with a high population growth rate). The main problem is, therefore, that the poor countries in this region lack the financial and technical

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[1]See Acknowledgement.

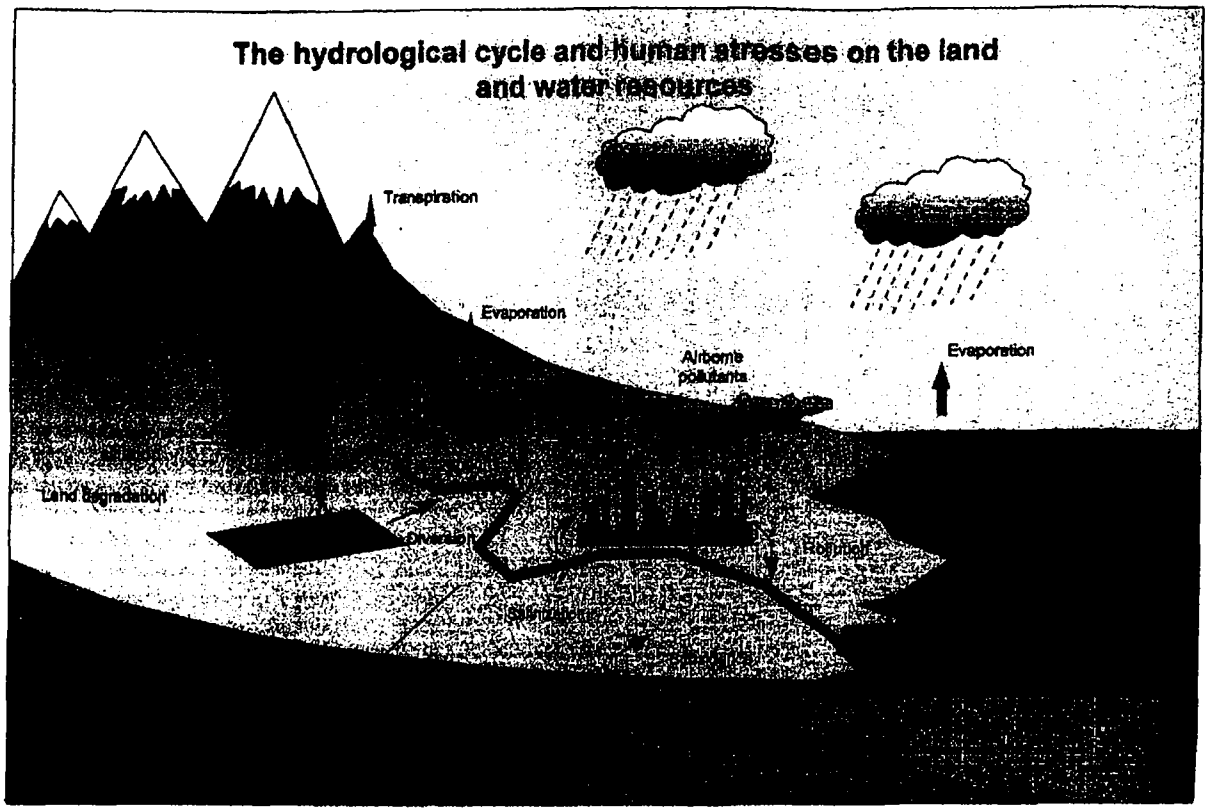

Figure 1 The hydrological cycle. Human activity interacts with—and pollutes—water at all stages of the cycle: lakes, rivers and groundwater aquifers; air pollution affects water trapped in the atmosphere. There is a close link between water management and land use: agriculture, forestry and urbanization cause changes in landscape which in turn alter the run-off and water storage capacity of the soils. (Source: After an original from the World Meteorological Organization presented in the Comprehensive Assessment; World Meteorological Organization and United Nations Environment Programme, 1996.)

means to use available water efficiently and to allocate water to the places where people live. The problems in this region are therefore strongly poverty linked.

Another difficulty in estimating "per capita availability" of freshwater resources is the unavailability or poor quality of data. Most of existing data on freshwater availability and withdrawals is presented at country level based on several studies (e.g. Shiklomanov, 1997). While noting the difficulties of data availability, the Assessment presents a series of maps (Figures 4 and 5) building on existing data on current water withdrawals (1995) in relation to availability, as well as a scenario for the situation in 2025 taking current demographic trends into account.

The CFWA goes on to discuss freshwater as a fundamental resource necessary for almost all aspects of human activity and for the maintenance of environmental integrity. Human interaction with water takes place at many levels. Man progressively interacts with all natural resources, giving rise to pollution of the aquatic environment from various activities, while the demand for an increasing amount of high quality water persists. Surface and groundwaters are being used for agriculture, industrial processes, household needs and to dilute and transport wastes (Figure 3). Pollution, including airborne pollution, alters the chemical and biological properties of ambient water; and landscape changes modify its natural flows. Attention has been mainly focused on quantifying human needs; however, minimum flows also need to be assessed for the maintenance of terrestrial and aquatic ecosystems.

The Assessment recognizes numerous problems that likely will face humanity over the next 30 years in connection with freshwater access and use. The quantitative implications of providing universal access to safe drinking water and sanitation are drawn out. The possible necessity for countries in arid regions to reorient their economies from food self-sufficiency (producing their own food, often based on irrigated agriculture) to food self-reliance, i.e. relying on world food markets for their domestic needs, are discussed.

The Assessment stresses that as water resources are indeed a finite resource, a "business-as-usual" approach to water allocation and management is not sustainable. Even projections of 30 years into the future based on present population growth rates, current observations of pollution, salinization, waterlogging and falling groundwater tables all indicate high increases in countries experiencing water stress and water scarcity (Figure 5). Measures to prevent further deterioration of water resources and thus reverse the ongoing negative trend include improvements in efficiency of use and distribution, recycling of waste

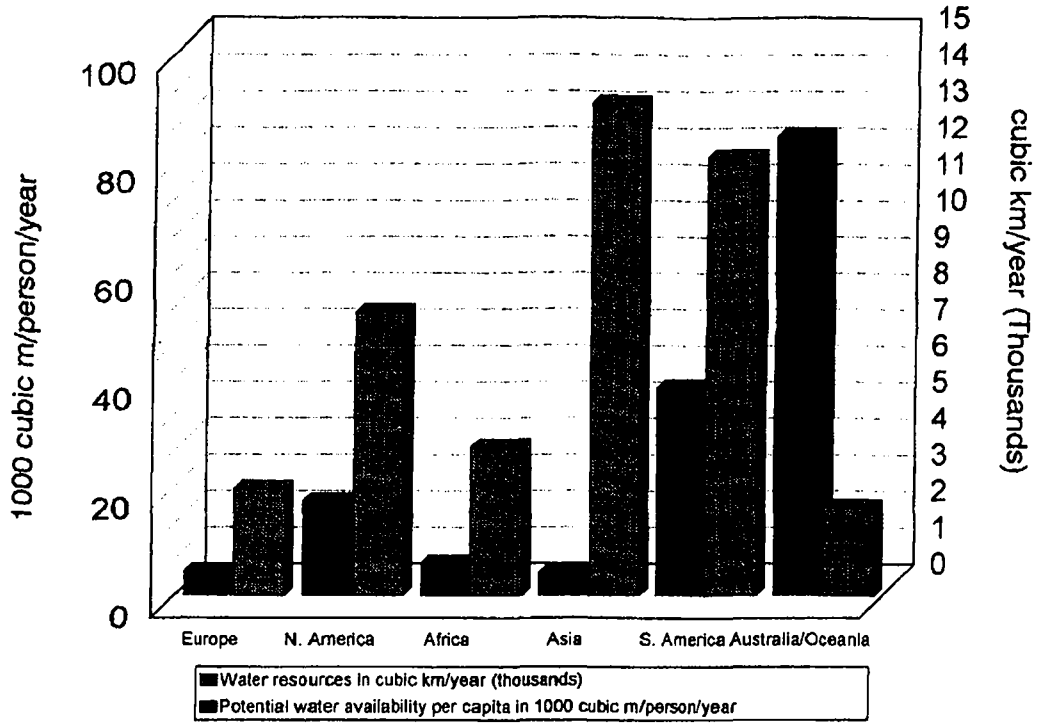

Figure 2 As is clearly demonstrated by comparing Asia and Australia/Oceania, average freshwater availability varies between continents; population size determines potential per capita availability. While Asia has the world's greatest run-off in volume, the per capita availability is the lowest of all continents due to the large population; in Australia/Oceania, the opposite is true (Shiklomanov, 1997).

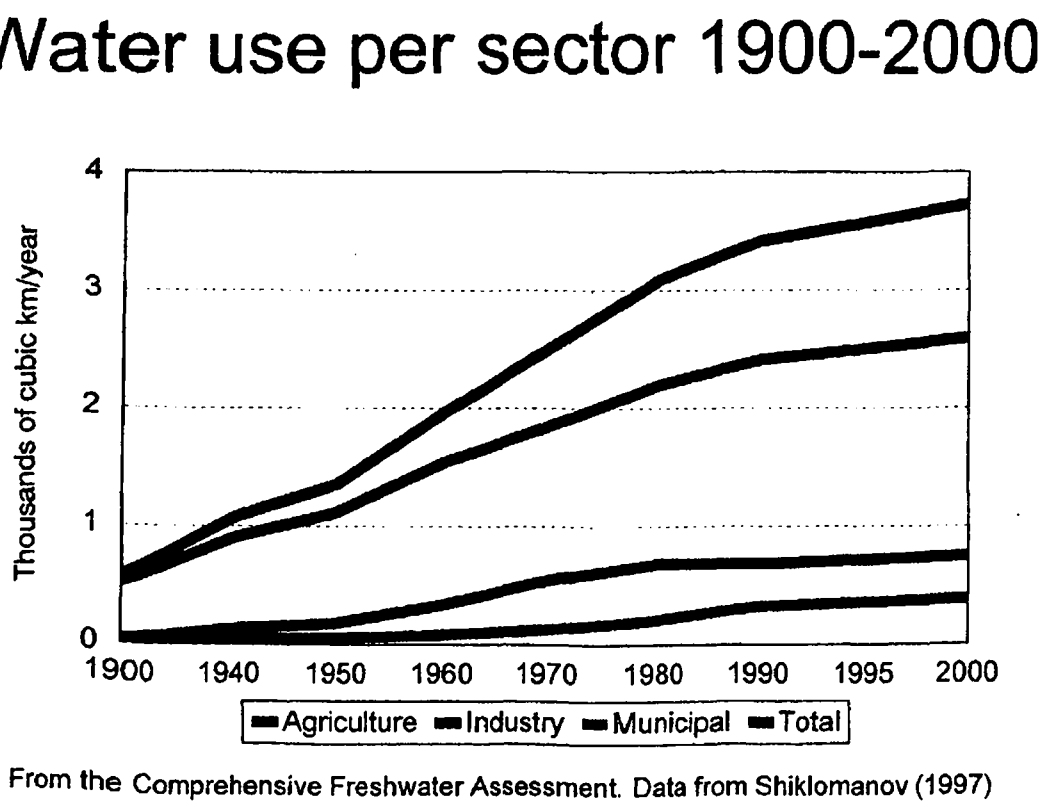

Figure 3 The use of freshwater has increased in all sectors but the increase is most dramatic in agriculture. This trend is likely to continue in the future—the question is how long it can be sustained (Shiklomanov, 1997).

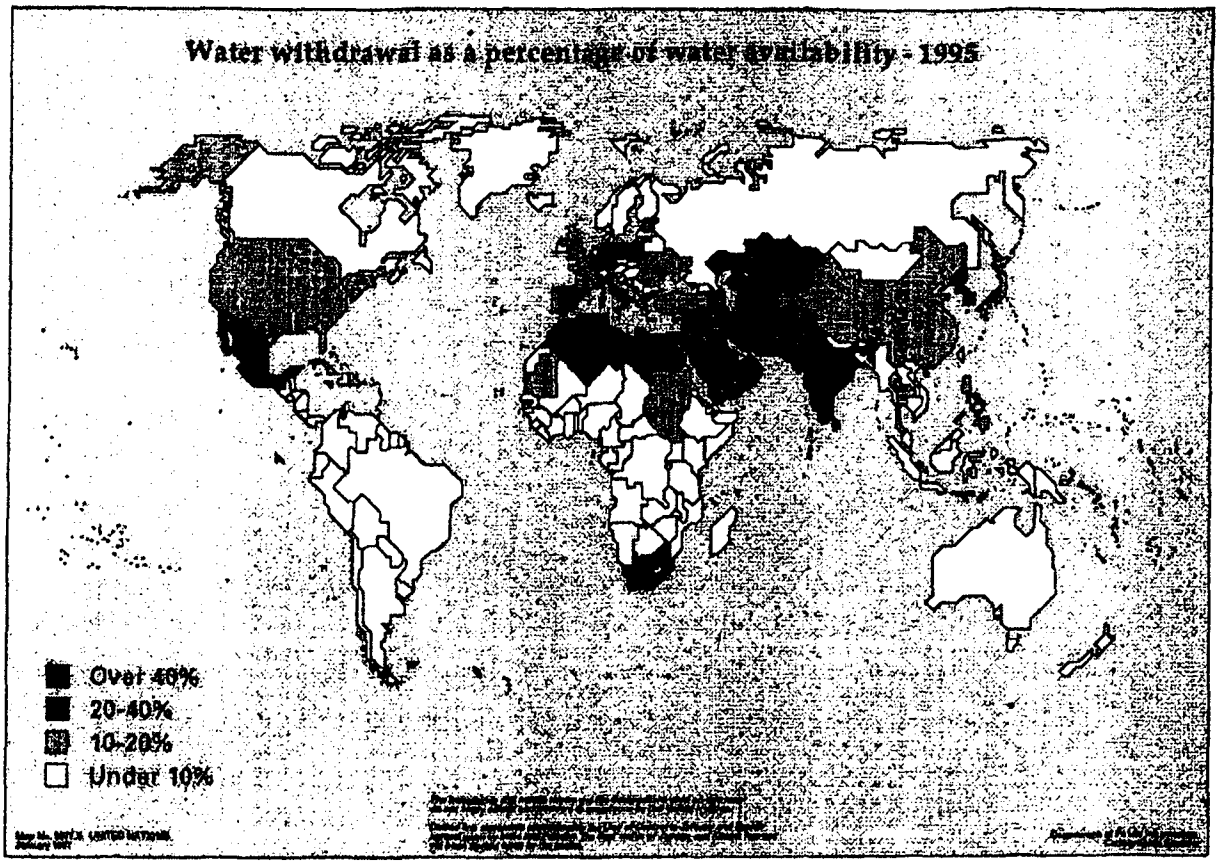

Figure 4 Water withdrawal as a percentage of water availability, based on both internal and external water resources. Statistics may mask the real situation, as in the Sahel region, which does not show high water stress although it is a dry region. This is due to the abundant water resources in one part of the country, as the Nile or Niger; sometimes a country may have abundant rainfall for part of the year, followed by long periods of drought. However, poor countries often lack the infrastructure to effectively allocate existing fresh water resources. Source: Map presented in the Comprehensive Freshwater Assessment (1997).

water and other measures. Such measures are seen as critical investment opportunities that cannot be ignored, since serious socio-economic problems arising from water insufficiency are already present, and projections into the future of current trends inevitably point to a deepening crisis.

Definition of the term "water stress"

The Assessment uses the terms "water stress" and "water scarcity" to describe conditions where lack of adequate amounts of water becomes a constraint to economic and social development, and where increased withdrawals may cause permanent damage to renewable freshwater resources (e.g. subsistence), and to other users. Withdrawals exceeding 10% of the renewable freshwater resources may, depending on coping capability, result in "water stress", a condition that will become more pronounced as withdrawals increase to 20–40%. However, the percentage indicator is a basic reference, as conditions may vary tremendously over space and time. Many countries already use more than 20% of their water resources (Figure 4), however, and do not have adequate economic means and well-developed infrastructure (including effective systems for sewage treatment and pollution containment) to deal with this situation. In those countries, once the withdrawals pass this threshold, there is a clear risk that water levels in lakes and rivers fall to a point where other users, including ecosystems, will be harmed. Already, about one third of the world's population is living in areas that suffer from moderate to severe water stress, i.e. where lack of access to water limits the possibilities of economic and social development. Unless action is taken, up to two-thirds of the world population, or close to 5.5 billion people, will be at risk of facing such a situation by 2025 (Figure 5).

The issues covered by the CFWA are to a large extent well known to professionals in the field. What has been, and partly still is lacking, both by scientists and policy makers is an integrated approach to water issues. Socio-economic factors interact with physical factors, which need to be reflected both within scientific modelling and political planning. The purpose of the endeavour is to bring water-related factors, such as hydrological, sociological and ecological parameters, together into the political arena. It is hoped that the CFWA will bring warnings to the level of political

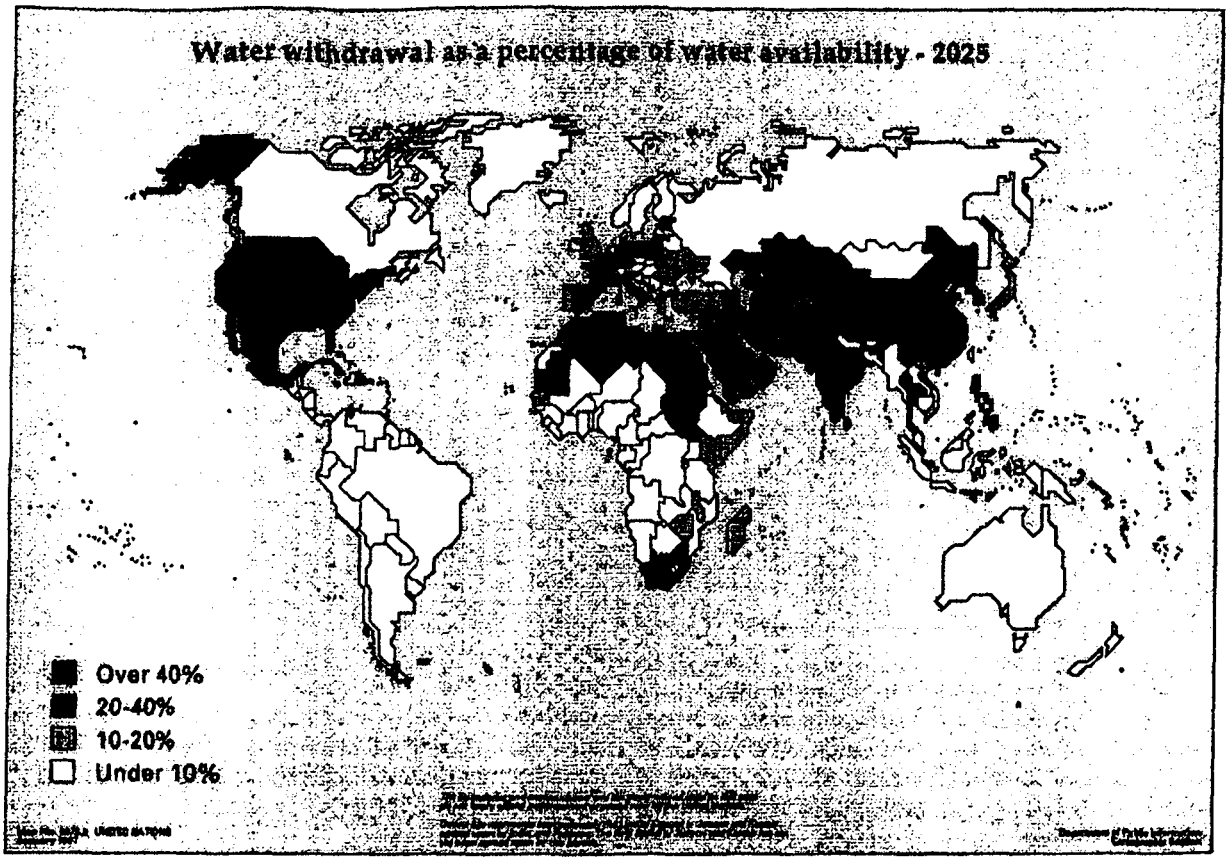

Figure 5 Impact of projected population growth on water usage by 2025, based on UN mid-range population projection and current water use rate per person. Probable increases in water use patterns, as a consequence of economic growth, or improvements in efficiency are not taken into account. Source: Map presented in the Comprehensive Freshwater Assessment (1997).

action, based on knowledge that has been gathered, compiled and voiced by scientists and technicians in the field for many decades, and the implications of which—in the absence of appropriate measures, particularly in an integrated approach—are rising to alarming levels.

While numerous warnings have been sounded over the past decades, "business-as-usual" practices are still prevalent among administrators and politicians, and no fundamental integration at the planning and conceptual levels has been achieved. While the goal of providing sufficient freshwater to all and at the same time maintaining natural ecosystems, appears technologically and scientifically possible, political divisions, and lack of necessary interlinkages in administration and management constitute the real obstacles to progress towards integrated river basin management.

Expected water use over the next 30 years and emerging problems

Water use will increase in the future, but exactly how much is a matter of debate. Serageldin (1995) predicts an increase in water use of about 650% over the next 30 years based on population growth, future per capita income and income elasticity. However, it is important to note here that projections based on current demand are not necessarily matched by the availability of additional supply, and increased withdrawals may not always be feasible (Falkenmark and Lundqvist, 1997). Projected changes in water use in the Assessment are based on estimates of population growth, one of the few factors in future modelling that are considered fairly reliable. While it is not possible to predict accurately the situation with regard to freshwater availability at any particular point in the future, the driving forces that are currently shaping the development can be identified.

Driving forces that will influence future water use

(i) Population growth/increased food needs. Population growth has the dual implication of increased direct household consumption, and increased freshwater needs for irrigation to produce the additional food required. The mid-range projection by the United Nations shows that world population will increase from 5.7 billion in 1995 to about 8.3 billion in 2025. A great deal of this increase will occur in rapidly growing

urban areas of developing countries, many of which are already experiencing serious water stress.

(ii) Technological development. Improved technology and better water distribution infrastructure (e.g. water is piped into the house, instead of being carried, mostly by women, over long distances) will initially lead to increased withdrawals for domestic purposes. However, with rising levels of socio-economic development, important savings in freshwater consumption also become possible through improved management and efficiency, and advanced technologies, e.g.

- use of drip-irrigation
- minimizing leaks in pipes and distribution systems
- reduction of evaporation from reservoirs
- recycling of wastewater
- desalination.

(iii) Trade policies. A large portion of the increase in world food demand is projected to come from the arid and semi-arid developing countries, currently showing high population growth rates. Owing to limited water resources, countries may have to choose between using their water to maintain food self-sufficiency, or to use the water to produce high value products that can be exported to pay for food products. If countries are to abandon their food self-sufficiency policies, they must be able to rely on the world market for agricultural products for their domestic needs.

(iv) Socio-economic development. The level of economic and social development is the main driving force determining a country's ability to address emerging water stress and scarcity. The current situation in the Sahel may serve as an example. As discussed above, this region in many studies, including the Assessment, does not register as having high water stress, as local conditions are masked by aggregate statistics for the region. Although water is sufficient region wide, the poor countries lack the financial and technical means, and the infrastructure, to use available resources efficiently or to allocate them to where people live.

(v) Trends in urban and rural development. Rapid urbanization especially will be strongly felt in developing countries. Many large cities already experience severe constraints in providing water supply and sanitation services. Industrial and urban development will divert both people and water supplies from agriculture to urban areas and radical improvement in water supply and sanitation systems are urgently needed.

(vi) Human induced climate change. Although the topic of much heated debate, the climate change effect of increased atmospheric CO_2 are not believed to show a calculable effect until some time after 2025. According to the Intergovernmental Panel on Climate Change (see for instance 1996), the increased concentration of "greenhouse gases" may result in temperature increases, precipitation changes and sea level rise, with impacts on the availability of fresh water around the world. Computer models of possible future climate patterns are not yet detailed enough to forecast changes at local or basin level. However, current indications show that the impacts of climate change on the hydrological cycle may be only minor in 30 years, but are predicted to become more strongly felt during the decades after 2025.

(vii) Demand management and restrictions on use. Until recently, water demand was accepted as such, and supply was thought of simply as a matter of installing more pipes, pumps, dams, etc. However, under conditions of limited availability, the situation is reversed. Supply cannot be created to fill demand, but demand has to be tailored to fit existing supply. Demand management measures are enacted to curtail and control demand to ensure that limited water resources are distributed equitably and that critical needs are met. Measures include progressive water tariffs, with low fees for basic domestic needs, rising steeply for non-essential uses. Measures may also entail regulations on use, and rationing, in extreme situations. Wastewater recycling, "cascading" utilization, and a variety of water saving devices are often combined with demand management strategies.

Integrated water management: options for action

The CFWA concurs with other studies (see e.g. Falkenmark and Lundqvist, 1996), that current level of freshwater withdrawals as well as current styles of management of freshwater resources in many parts of the world are not sustainable. The present situation does not primarily result from excess demand and pollution—severe as such problems may be, in both developing and developed countries. The problem lies more on the administrative side, in the lack of integrated management of issues closely related to freshwater needs, such as land use. Other dimensions also contribute to water stress, e.g. increased competition among different water uses; poverty; low levels of social and economic development; lack of infrastructure, etc. Integration is badly needed not only between regions and countries, but between different sectors in local administrations and governments.

Local and regional water crises result mainly from inefficient management and poor water allocation. If present trends in water use and pollution are projected into the future, the situation in 2025 will not be sustainable in many regions. While the CFWA stresses that a "business as usual" approach to freshwater use cannot be maintained, alternative paths of development are conceivable, along which further economic and social development is indeed possible.

Cross-sectoral approach

To achieve a cross-sectoral integrated approach requires establishing linkages between water related sectors and areas such as land management, coastal zone

management, agriculture, forestry etc. The linkages between freshwater issues and international conventions on desertification, biodiversity and climate change as well as the forest principles are and should be kept strong. It is equally important to link freshwater and economic and social development. Economic planning still often neglects water as a fundamental resource for all economic and social development. Only an integrated approach in planning will enable a shift toward sustainable use of freshwater resources. National efforts must be supported by non-governmental organizations, the private sector and in some cases by international, regional and national external support.

As shown in Figure 6, there is no clear correlation between per capita income and per capita water consumption in the world today. This demonstrates that each country needs to assess its unique development options, taking into consideration available resources, not least water resources. For water-scarce countries, this implies that economies based on food self sufficiency may have to be reoriented towards manufacturing and trade, securing food needs from world markets.

Capacity building for sustainable planning

To maximize future development options, water resources management must be given a high priority in all planning, including socio-economic. Governments must strive to reduce fragmentation of institutional responsibility for water issues and achieve clear separation of functions. National efforts in water planning have in some cases been successful, leading to improvements in water availability and water quality. Recent developments in Latin America show numerous examples of successful water strategies, both at local and national levels, including institutional coordination for a more integrated approach; and new legislation to better address water resources management (ECLAC, 1996).

The Assessment stresses that capacity building is essential to bring sustainable water use practices into national and regional planning. This may involve changes to legal frameworks, and existing institutions. People living in poverty, struggling to secure daily basic food needs, do not always regard environmental concerns as a priority. But in a long-term perspective, education and information may provide knowledge and skills in order to find better local solutions to problems and to improve a sustainable management of their resources, including water. Governments, all over the world, need to give high priority to institution building and legislation and human resources development. Professionals from different backgrounds working in different sectors of society must be trained in the skills necessary for effective participation in intersectoral planning, design and construction relating to water resource use. Other means of improving public awareness/training also need to be brought into play, such as education, public information and awareness-raising campaigns, and provision of an

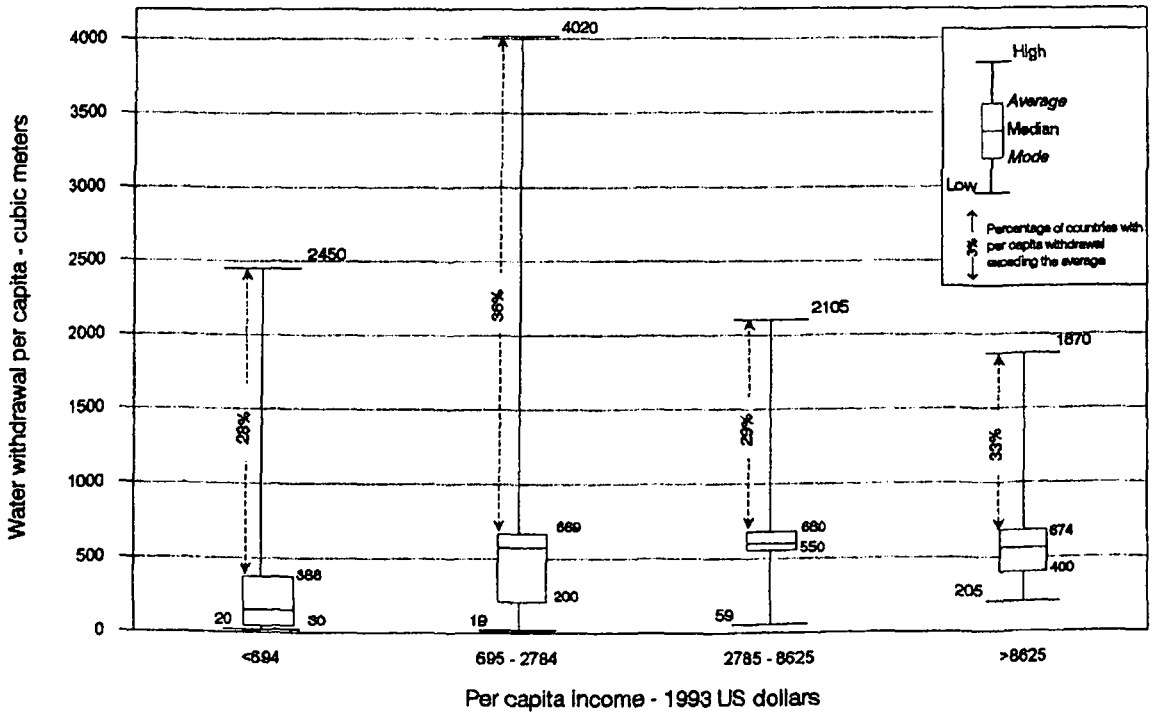

Figure 6 Comparisons between per capita income and water use show no clear correlation. Other factors are more relevant, such as type of agriculture (irrigated or rain-fed), industrial development, life style, etc. The figure shows that economic development can take place even with limited water resources; economic and social planners need to take existing water resources into consideration, and a development path chosen accordingly.

environment that enables people to take well-informed decisions. Major groups, including non-governmental organizations and women, need to participate in the decision-making process. Decisions should be taken at the lowest appropriate level.

Reliable information systems

In all planning, access to reliable and easily available information is vital. Although monitoring systems exist at the national level, different types of data (e.g. pertaining to water use, land use, demographic and economic development) are not readily comparable throughout regions and are generally not adapted to a watershed approach. This is especially true of information not directly related to the hydrological environment, i.e. social and economic data, since this type of information has not traditionally been used for this purpose. Therefore, socio-economic data must be coordinated and obtainable at the same spatial scale (river basin) as hydrological, climatological and ecological data as well as land use data in order to achieve an efficient integrated management of the resources. The ability of many countries to assess their water resources (and other resources for that matter) has decreased during the past decade due to financial constraints, but rapid development of new techniques, e.g. remote sensing and Geographical Information Systems (GIS), can increase the capacity for environmental monitoring at a moderate price.

Despite several important monitoring and assessment programmes by agencies of the United Nations as well as government and non-government organizations, international support efforts concerning information management remain fragmented and incomplete.

Water and global food security—the global food market

One main aspect of water use is water supply for agriculture, since this sector currently accounts for about 80% of the total use. The CFWA addresses the important link between global food security and poverty alleviation. According to data presented at the FAO World Food Summit (Food and Agriculture Organization of the United Nations, 1996), 800 million people still lack food to meet their basic nutritional needs. Countries striving to achieve national food security often incur problems of mismanagement and overuse of water resources, as well as ecological damage from fertilizers and pesticides. The outcome of the World Food Summit, the Rome Declaration on World Food Security and World Food Summit Plan of Action, state that production increases in the future should be achieved without jeopardizing the sustainable management of natural resources and the protection of the environment.

In considering a transition from food self-sufficiency to food self-reliance, it is also important to take into account the impacts of such a transition on the poor. Unless properly orchestrated and managed, many small farmers will have difficulties to compete with large food producers and industries when water pricing is introduced. This could lead to increased income discrepancies among people and further shift benefits to urban areas at the expense of rural communities, i.e. rural poverty may become worse.

Globally, little new land remains to be exploited for agricultural production. In terms of feeding increased population, current projections therefore tend towards more efficient management of existing land and water resources. The CFWA discusses comparative improvements available with drip irrigation techniques (see e.g. Shiklomanov, 1997).

Drinking water supply and sanitation

The CFWA discusses the ongoing struggle to provide all people with safe drinking water and access to adequate sanitation, which has been high on the international agenda since the United Nations Water Conference in Mar del Plata, Argentina, 1977. It further emphasized at the Global Consultation on Safe Water and Sanitation for the 1990s in New Delhi, India, in 1990 and at the Interministerial Conference on Drinking Water Supply and Environmental Sanitation in Noordwijk, The Netherlands in 1994. Despite these efforts, supplying millions of people during the last decades, current data presented in the Assessment show that 20% of the world's population still lacked access to safe water and 50% to adequate sanitation in 1995. This alarming failure to keep pace with rapid population growth and increased pollution is considered to be closely related to poverty and rooted in the inability of Governments to invest in proper systems and maintain water distribution networks.

The CFWA urges top priority for water and sanitation to be accorded to Africa, South-East Asia and Latin America, especially regarding the escalating problems of fast growing urban areas, which often have a large proportion of poor people and insufficient infrastructure. Demand management and cost recovery are also advocated. The private sector is thought likely to play a key role as a supplier of services, but governments need to provide an enabling financial environment to promote interest in this sector as well as a contractual and regulatory structure that: (i) minimizes uncertainty; (ii) provides flexibility in renegotiation and operational autonomy; and (iii) protects consumer interests.

Water pollution control

The CFWA urges governments to attend to all forms of water pollution, still an increasing problem in many areas of the world. The issue of deteriorating groundwater quality should also be addressed, due to the increasing importance of renewable groundwater as a source of domestic water supply.

Since groundwater contamination is mainly caused by non-point sources of pollution (agriculture, cities, land-use changes), an integrated land and water management approach is especially important. Actions to solve the problem will often require changes with a more long-term perspective. The problems related to groundwater use and management are rapidly increasing in many parts of the world and will need increased attention in the future. Groundwater is an

"invisible" resource, and basic knowledge about its functions is still lacking among many policy makers and planners.

The CFWA supports the "Polluter Pays" principle, now applied in many countries, and advises that pollution prevention is cheaper than post-damage clean-ups in the long run, despite high initial costs. Therefore, efforts should be made to turn away from "end of the pipe" solutions and address problems earlier in the (industrial) process.

International co-operation for effective freshwater management

A set of principles, reflected in chapter 18 of Agenda 21, for water planning and management have emerged and are gaining wide acceptance. The Dublin principles (elaborated at the International Conference on Water and the Environment held in Dublin, January 1992) state that: (i) freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment; (ii) water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels; (iii) women play a central role in the provision, management and safeguarding of water and (iv) water has an economic value in all its competing uses and should be recognized as an economic good.

The concept of water as an economic good needs to be recognized, taking into account the provision of water to meet basic human and ecosystem needs. Water use has a cost in terms both of its development and of its foregone opportunities. The misuse of water will be paid for either by the community at large or through the depletion of the existing natural capital. Water demands will continue to increase and it will be important to make sure that water is put to high value economic uses. Some progress has been achieved in a number of countries, but wider acceptance and commitment toward the implementation of these principles is needed worldwide to achieve sustainable water use.

Water markets and pricing mechanisms in general will encourage the private sector to play a more active role in development of water resources. In order to do so, this sector must be able to rely on Governments to agree on laws and regulations that promote fair market conditions. The distribution of responsibilities among the Government, local communities and the private sector needs to be decided in many countries. An example of a successful process is in Uganda, where water reforms have brought decentralization, leading to communities taking a greater responsibility for providing water services that are more closely related to local economic conditions and needs (Kahangire, 1997). Future development of water markets will require further attention and successes as well as failures in national implementations must be carefully studied and evaluated.

The need for a comprehensive legal instrument for international water bodies has been voiced by several countries. The draft articles of the law of the non-navigational uses of international watercourses[2] were adopted by the International Law Commission in 1994. A special Working Group of the 6th Committee of the General Assembly has debated the formulation of an international framework convention; the Working Group adopted the draft Convention as a whole, by a vote in April 1997, and later adopted by the fifty-first session of the General Assembly. The convention does, however, only apply to water courses (including groundwater) and not to the land from which the water, to a large extent, originally springs.

Even in the absence of a universally ratified comprehensive legal convention, similar principles—and often more stringent standards or cooperation—have been applied by countries in specific agreements. A good example of regional cooperation is the Protocol signed by the eight heads of member Governments of the Southern African Development Community on regionally shared watercourses in 1995. In this Protocol, member states recognized that a failure to develop water resources in a sustainable manner could hamper economic productivity and social development in the entire region. The agreement promotes the equitable use of shared water resources, including the development of integrated water resource development plans.

Other examples are: the Rhine Action Plan aiming at reducing pollution, not only in the river but also in the North Sea, to the point where sensitive species once again can survive in the Rhine River and coastal areas; and the 1909 Boundary Waters Treaty between Canada and the U.S. leading to a series of agreements over the sharing of waters and controls on pollution, particularly in the Great Lakes.

Concluding remarks

There is a need to take an integrated approach to water issues, thus including land, ocean and coastal zone, habitat, health and economic aspects, when managing water. There is also a need to recognize that, although human beings as well as the environment should have a right to adequate amount of water to sustain life, those using water have a responsibility to use the water wisely and sustainably. To obtain a sustainable water future, with water to sustain life, there is a need to cooperate over water. Governments need to reach a consensus on guiding principles for an integrated water future and on actions needed to reach such a future. In this endeavour, international and national co-operation among all stakeholders is urgently needed.

Acknowledgements

The Commission on Sustainable Development of the United Nation in 1994 requested the preparation of a Comprehensive Assessment of the Freshwater Resources of the World, to be presented to the fifth session of the Commission in April 1997 and to the Special Session of the United Nations General

[2]See United Nations document A/49/10, chapter III, section D.

Assembly in June 1997. Since freshwater issues are multi-disciplinary, a Steering Committee consisting of representatives from United Nations Organizations dealing with water issues and the Stockholm Environment Institute, was established. As scientific base, a number of comprehensive background documents and commissioned papers were prepared by experts with various professional backgrounds (Brismar, 1997; Falkenmark and Lundqvist, 1997; Kjellén and McGranahan, 1997; Lundqvist and Gleick, 1997; Raskin *et al.*, 1997; Shiklomanov, 1997; Wallensteen and Swain, 1997).

The Assessment is primarily based on inputs from the background documents and from the members of the Steering Committee and others; therefore, references have not been given according to proper scientific practice. The authors would like to emphasize that all those taking part in the preparation of the background documents, as well as the members of the Steering Committee, have contributed greatly to making the Assessment a reality. The Assessment was prepared by a number of United Nations departments and agencies: the Department for Policy Coordination and Sustainable Development and the Department for Development Support and Management Services of the United Nations Secretariat; the Food and Agriculture Organization of the United Nations (FAO); the United Nations Development Programme (UNDP); the United Nations Environment Programme (UNEP); the United Nations Educational, Scientific and Cultural Organization (UNESCO); the United Nations Industrial Development Organization (UNIDO); the World Bank; the World Health Organization (WHO); and the World Meteorological Organization (WMO) working in collaboration with the Stockholm Environment Institute. We also like to mention Dr Frederico Neto, Ms Marcia Brewster and Dr Jacob Burke who made valuable comments on this manuscript, and Ms Linda Hale for improving the language.

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