# EUROPEAN PARLIAMENT

**Directorate General for Research**

**WORKING PAPER**

# WATER AND DEVELOPMENT IN THE DEVELOPING COUNTRIES

***Development Series***

**DEVE 100 EN**

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**10-2000**

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# EXECUTIVE SUMMARY

The aim of the study is to assist the European Parliament in formulating long term strategies and short term policies to aid developing countries to prepare and implement policies leading to efficient, equitable and ecologically sound water resources management. A policy and strategy must be possible to translate into feasible programmes and projects that can be executed.

**I. Work to support awareness raising, information sharing, capacity development, education, etc.**

- The EU should contribute towards increased awareness and capacity through education and training in land and water management and for different kinds of water use, and for implementation of integrated water resources management.

- The EU should support measures towards increased confidence building between riparians, for instance, by establishing or strengthening "regional support groups" that could assist in data and information sharing, networking, and exchange of experience linked to the application of different regulatory and institutional systems, etc.

**II. Work to support development of management strategies.**

- The EU should contribute towards establishing and strengthening management strategies and policies through integration of relevant management strategies such as demand management, strategies for "Best Possible Use of Water", and inter-linked management of water quality and quantity.

**III. Work to support co-operative arrangements and conflict prevention.**

- The EU should support the application of appropriate regulatory measures and institutions at international and national levels by different kinds of structural changes, co-operative arrangements between riparians/stakeholders for legal and formal regulations and institutions.

- The EU should provide support aiming at conflict prevention and mitigation in shared water areas by supporting high-level political networks of relevant ministries, providing management support, providing "third party" assistance, etc.

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The EU should provide specific assistance to the selected regions in accordance with these principles and with the countries', regions' or river basins' priorities as described.

***Chapter one*** is an introduction and definition chapter. It stresses the need for recognition of the significant role water plays both in society and in the natural systems in the landscape. In dry climate regions, access to water is in fact a critical precondition for development. The availability of water is, particularly in arid and semi-arid countries, highly variable both seasonally and inter-annually, making water storage imperative. To meet current and future demands and to safeguard vital life-support functions in the landscape, it is essential to balance social, economic and environmental objectives. Water needs and demands are driven by population growth, urbanisation and industrialisation, and therefore tend to change with time.

The chapter defines some fundamental issues needed to be recognised in managing water resources:
- It is essential to recognise that an important part of the water falling on the ground as rainwater is returning to the atmosphere by evaporation from wet surfaces and by the plant production process, forming a water vapour flow, *the green water flow*. The surplus produces run-off in rivers, lakes and groundwater aquifers, *the blue water flow*. Together, the 'green' and 'blue water' serve two major functions: they sustain natural and man-made ecosystems, and, when made accessible, they are an essential, non-substitutional resource for various social and economic functions in society. In particular, agriculture is a highly water consuming sector that turns a large quantity of the water used into 'green water'.
- Water is said to be *scarce* if there are problems to meet the water needs due to availability constraints. Hydro-climatologically, water is scarce when the annual rainfall is lower than the evaporative demand of the atmosphere. Plant production is constrained when the plant requirements are higher than water available in the soil. Water stress tends to develop when there are problems to meet demands for blue water, either due to "water crowding", i.e. high population pressure on the available water, or due to difficulties to mobilise a larger share of what is available, i.e. increase the use-to-availability ratio further. The people per flow unit of water is an indicator of dispute proneness and the number of people polluting each flow unit of water.
- *A land use decision is also a water decision*. An integrated land and water management should thus be inevitable. This is particularly true in warm climates with a high evaporative demand where changes in land use and vegetation will have clear land- and water implications.

Key challenges in water management in order to sustain water security are linked to various *trade offs*: choices in allocation between competing sectors and demands, in upstream/downstream water sharing, and in allocation of water between societal uses and ecosystems. To meet the increasing demand on water, different, increasingly sophisticated water management systems need to be applied.

***Chapter two*** concentrates on regulatory measures, water sharing and conflict prevention from a national perspective. With increasing demand on a given amount of water, which is climatically determined, it is necessary to make sure that each unit of water is used in the best possible manner, at the least possible cost. Since water is a necessary and non-substitutional resource for life and basic human welfare, food production, industrial development and ecosystem functions, it is imperative to develop regulatory measures and management procedures which, together, address the various aspects related to water, notably its role in socio-economic development, social stability and environmental sustainability.

The common and overriding challenge for all countries is to formulate a water policy which provides guidelines for what is the *'Best Possible Use of Water - BPUW'* with respect to societal development objectives and with due regard to environmental considerations. Achievements of the objectives, which presumably refer to alleviation of poverty, income generation and employment creation activities, conflict prevention, etc., will depend on three basic criteria for *BPUW*, namely *Efficiency*, *Equity* and *Environmentally Sound Use* - the three '*E's*'.

Facilitating or promoting the three *'E's'* will require application of a combination of incentives and sanctions, among which legal and regulatory measures, institutional reforms and economic measures are crucial.

The aim of ***chapter three*** is to suggest measures for facilitating the co-operative management of international fresh water resources. In an attempt to articulate these measures, the chapter first examines the present situation regarding water scarcity and its implications for the international community. Today, 261 river basins are shared by two or more countries. The increasing scarcity of water and the unequal and multilateral distribution of this resource paves the way for a greater number of water conflicts. It is illustrated that though the possibility of water-related disputes erupting increases every day, episodes of violent conflict are not inevitable.

In the face of mutual dependence on the same fresh water resource, the withdrawal or pollution of one riparian state can potentially not only lead to the disputes but also bring co-operation in the basin. In several cases, competing and disputing riparian countries are now moving towards signing river water sharing agreements. However, water-sharing arrangements among the riparian states cannot last if the latter do interact with and gain support from proper water management institutions. In spite of the recent emergence of a number of international organisations and agreements regarding this global issue, the international community still lacks sufficient and comprehensive solutions to the international freshwater sharing issues.

Thus, it is recommended that the riparian states should adopt a basin-based approach to avoid possible armed conflict over shared water resources and to build a lasting co-operative scheme for water management in the future. These basin-based initiatives need to be augmented and supported by suitable nation-state and international measures.

***Chapter four*** examines strategies and policies in Water and Development work in different international processes: the UN system and its organisations and agencies, the Guidelines for Water Resources Development Co-operation prepared for the European Commission, and the World Water Vision and the Framework for Action, the Hague-process. Further, the chapter develops principal strategies and policies which the European Parliament should recommend the EU to adopt for awareness raising, capacity development and information sharing; for developing management strategies and policies; for the application of regulatory measures and institutions; and for support towards conflict prevention and mitigation in shared water situations. The chapter also briefly discusses policies and strategies to be applied at regional levels.

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***Appendix I*** describes water availability and use, water and environment, and the challenges related to those for selected regions. Already today more than 8% of the world's population live in areas of water scarcity, a proportion that is rapidly increasing. The main parts of those areas are situated in Southern Africa, Northern Africa, Middle East, and South-western Asia. In many of those areas water quality deterioration is causing health problems to human beings as well as to the environment. Human activities in the landscape are imperative in order to satisfy societal needs but may have side effects such as land productivity deterioration, deterioration of wetland functioning, water quality deterioration by pollution, and downstream effects from upstream consumptive use changing the balance between evapotranspiration, 'green water (vapour) flow', and run-off, 'blue water flow', or from upstream water quality depletion. This calls for co-operation between stakeholders/riparians over the water resource and for a management structure that includes considerations of physical resources, ecological resources and livelihood systems.

The key challenges for some of the African regions such as North-western Africa and Sahel, where more than 90% of the land is either desert or arid lands that are using 80-

90% of the available blue water for irrigated agriculture, are the preservation and sustainable use of land and water. Particularly in Northern Africa, water resources management that enables more efficient present use of water is needed. This should emphasise that innovative and traditional small-scale solutions to water resources management is needed. Parts of West and Central Africa, although being humid and sub-humid, are depending on rainfed agriculture. Integrated water/land management, including to secure water for the environment, is necessary to enhance the quality of life for the people concerned. A participatory approach to management that includes all stakeholders is important.

The countries of the Horn of Africa, Southern Africa, the Ganges-Brahmaputra area, the Mekong area, the Aral Sea area, the Euphrates-Tigris area and the Jordan River area are all countries where the water resources to a large extent are transboundary resources. The Mekong area and the upstream parts of the Ganges, and in particular the Brahmaputra, are humid regions; for Ganges and Brahmaputra, the rainfall is very erratic. The other areas are arid and the dependence on the blue water in the river systems is high. For these regions the main challenge is co-operation over the water resource, among stakeholders and among riparians. Such co-operation needs to be in place to establish projects and programmes for sustainable use of water for people and for the environment, within an integrated water resources management.

***Appendix II*** concerns the application of different techniques and practices to improve water availability, accessibility and the quality of water. Before any water and development project is launched, investigations should be made to assess and evaluate *existing* techniques and practices for water extraction, storage, distribution, use and recycling. To the extent possible, productive and non-productive water-related practices and techniques should be distinguished. Also, competitive water demands and avoidable and unavoidable tradeoffs should be identified. New, complementary or alternative techniques and practices should be identified with consideration to recommended management principles. While unproductive water losses should be kept at a minimum, efforts should also be made to maximise productive water uses, wastewater recycling, and non-harmful material return flows.

The chapter has been divided into two main parts: (i) measures to enhance water availability, and (ii) measures to enhance water quality. To enhance water availability, the chapter discusses different measures for water extraction and use. These measures include wise use and management of groundwater resources; rainwater harvesting to supplement irrigation and for small-scale water uses; drip irrigation to reduce unproductive water losses; desalination methods; mitigation of soil salinisation by drainage and effective irrigation; and reparation of cisterns and pipes and to reduce leakage. Different waste and wastewater practices could also enhance water availability.

These include the handling of human waste according to ecological sanitation; promotion of dual pipe systems; low-cost treatment of industrial and municipal wastewater; irrigation with urine and greywater; reclamation of potable water; different local water and sewage systems; and artificial groundwater recharge. Furthermore, measures to adapt land use practices and techniques to prevailing climate and soil preconditions, for example in agricultural, forestry and livestock management, could reduce unproductive water losses and enhance water availability. Measures to enhance water availability should be applied with the aim of ensuring 'best possible use' of available water resources. Water should be allocated so that maximum societal and environmental returns can be generated with minimum volumes of water invested.

Among measures to enhance water quality there are measures to turn wastes into resources by recycling of nutrients in human and livestock excreta, recycling of industrial and municipal wastes and recycling of wastes with livestock and aquaculture. Enhancing water quality can also be done by preventing spreading of pollutants through handling of wastes with on-site separation, recycling of wastes and improvement of wastewater transportation. Water quality can further be enhanced by minimising the use of non-degradable harmful chemicals by improvement of agricultural and domestic practices (pesticide and fertiliser use, etc.), and of industrial practices such as application of cleaner technologies and eco-technologies. Application of measures to enhance water quality should improve the possibility for policymakers to meet a central concern to provide water of usable quality for human beings as well as for the environment.

## SUMMARY OF RECOMMENDATIONS

By investing in key areas, the EU would be able to assist in tackling urgent water priorities such as to achieve water and food security, to extend sanitation coverage and hygiene education, to meet the challenge of urbanisation and to protect and restore water resources and ecosystems in order for the assisted countries to achieve sustainable development. This will require interventions for increased water security centred on the following themes:

- **Work to support awareness raising, information sharing, capacity development, education, etc.;**
- **Work to support development of management strategies;**
- **Work to support co-operative arrangements and conflict prevention.**

Based on background information for the different regions, and on different techniques (as presented in Appendix I and II) and on different aspects of regulatory measures, water sharing and conflict prevention, both in a national and an international perspective, it is suggested that the European Parliament make the following recommendations to the European Union:

- the European Parliament should recommend the EU to co-ordinate its activities within the UN entities working with water issues in a development perspective;

- the European Parliament should recommend the EU to support the Integrated Water Resources Management approach, integration between land and water, integration within the river basin between the upstream and downstream areas, integration between water quantity and water quality aspects, and integration between social and environmental aspects, and facilitate provisions needed for its implementation. The EU should also support training of personnel to implement the Integrated Water Resources Management;

- the European Parliament should recommend the EU to support countries in their efforts to recognise all aspects including ecosystem values within the integrated approach to land and water management;

- the European Parliament should recommend that this understanding of Integrated Water Resources Management be applicable also to internationally shared waters and should be guiding the EU work in shared waters' areas;

- the European Parliament should recommend the EU to carefully review the outcome of the World Water Forum process in order to incorporate relevant parts of these strategies and policies in its own 'Water and Development' strategy;

- the European Parliament should recommend the EU to support awareness initiatives, and to assist in enhancing the sharing of information and data, among stakeholders, including between riparians of a river basin, and in a transparent process. In such a process it is important to include not only water specialists but also economists, planners, etc. The EU's support might assist in building confidence and trust among the riparian states;

- the European Parliament should recommend the EU to contribute to a better understanding of the processes linked to unwise industrial and agricultural systems and domestic use, and to training in techniques to combat such threats, including by application of changes in processes. The EU might also, by information sharing and education, help in establishing Early Warning Systems to develop increased preparedness towards hazards such as floods and droughts. In all types of awareness raising and capacity building, participation by target groups at relevant levels, including by women, needs to be ensured;

- the European Parliament should recommend the EU to support water scarce countries with increasingly complex water demands in their efforts towards demand management. In these areas increased water supply through intercontinental water transfer can only be a short-term solution, although other types of water transfer solutions might be needed;

- the European Parliament should recommend the EU to support the application of "Best Possible Use of Water" within all water management, within countries and regions and within national and international river basin or aquifer management;

- the European Parliament should recommend the EU to support the application of an integrated management of water quantity and quality for a sustained water security – the sooner in a development process, the cheaper and the more resource efficient in the long run;

- the European Parliament should recommend the EU to support structural changes such as policy changes and legal changes, establishment and promotion of formal and informal institutions, with participation of all stakeholders that would contribute towards improved water management. The EU should encourage and support this kind of improved governance structure at national and international/regional levels to ensure best possible co-operation in Integrated Water Resources Management of an aquifer or a river basin area. In such work different types of co-operative arrangements or "support groups" could be established supported by the EU;

- the European Parliament should recommend the EU to offer its experiences in multilateral co-operation over larger lake and river basins to developing regions and encourage network building on all levels between national and local authorities as well as different kinds of organisations, governmental and non-governmental. Partners in such networks could also be private sector entities;

- the European Parliament should recommend the EU to assist in establishing or, where existing, developing such regional "support groups" where relevant knowledge available within the region, both on land- and water-use, on management systems and on good governance, would exist. These groups could serve as a platform where, upon request, exchange of experience of application of different regulatory and institutional systems, etc., could assist countries in their efforts towards an improved governance system and could also develop methodologies for successful information exchange to secure enhanced confidence building between the riparians;

- the European Parliament should recommend the EU to assist by supporting the establishment of high-level political networks of relevant ministries. The EU or its member states could also assist as a "third party" in peace talks over water within a shared water area, for instance by establishing regional platforms for facilitation/mediation, where neutral EU-countries or representatives may be of assistance. Such platforms could be linked with the "support groups" as suggested earlier;

- the European Parliament should recommend the EU to provide specific assistance to the selected regions in accordance with these principles and with the countries, regions or river basins' priorities as described. Such assistance should include:

- for *North Africa and Sahel*: that the EU, in co-operation with the governments in the region, should support policies that would ensure key inputs also from poor and marginal groups in water managing, and make markets more accessible in order for the poor to get better livelihoods. In a longer time perspective the attention needs to be devoted towards land- and water-use in an overall integrated perspective;

- for the *Horn of Africa* area: that the EU should support work within the framework of the Nile Basin Initiative, which would enhance the political will and commitment among the countries, technology transfer to and between the countries, and which might result in increased confidence and trust among riparians. Such work may also result in institutionalisation and harmonisation of legal aspects to set up monitoring systems for use of water resources and generate exchange of information and data between the countries. Co-operation between the countries of the Nile Basin could also optimise water use efficiency between the countries and improve potentials for integrated water management including water for crop production and farmer participation;

- for *West and Central Africa*: that the EU should direct its support towards actions at both national and transboundary levels in order to promote co-operation between the countries. It might provide support to enhance good governance at all levels in order for the countries to be able to develop integrated water resources management. The EU might also support improvement of land and water resources planning, allocation and regulation of water abstraction;

- for the *SADC Countries*: that the EU should provide assistance for the efforts to implement the SADC protocol and bilateral agreements. It could also support efforts towards integrated water resources development and management within a framework of co-operation in the region. The EU could also support efforts towards shared management of international water basins to stimulate mutual regional economic development and for ensuring adequate water for life-supporting ecosystems;

- for the *Ganges and Brahmaputra River Basins*: that the EU should gear its support to the area towards provision of adequate technologies for water saving irrigation, crop development, water treatment and desalinisation, protection of the quality of surface and ground water, etc. Any support should be provided within an integrated water management framework where equity is a major consideration in resource management and service provision;

- for the *Mekong River Area*: that the EU should continue or intensify its support works within the framework of the Mekong River Commission. The parties to the Commission have agreed to co-operate in all fields of sustainable development, management, utilisation and conservation of the water and related resources of the Mekong River Basin, including irrigation, hydropower, navigation, flood control, fisheries, timber floating, recreation and tourism. This kind of support should promote international co-operation;

- for the *Aral Sea Area*: that the EU should increase its support for technical and scientific co-operation within the area. Increased support for all purposes is needed to avert the negative trend in the region and to provide acceptable living conditions for the people living in the area. A complex GEF-project is operating in the area. Increased EU co-operation within that framework would ensure improved health conditions through food and drinking water and sanitation provision. It does also integrate environmental aspects where the EU might provide assistance;

- for the *Euphrates-Tigris Area*: that the EU should, from a pure technical point of view, provide technical assistance and co-operation to prevent the build up of and/or recuperate salinised areas and areas with high degree of waterlogging. Any EU support to the area has to be evaluated from a political point of view. The EU might also play a role in facilitating provisions for a joint plan of action or a development framework for the whole river basin-area;

- for the *Jordan River Area*: that the EU should provide its support within the political framework. The EU may provide technical support, for instance, for the provision of efficient irrigated agriculture or safe drinking water supply and sanitation to the area or for different water management projects.

# 1 WATER IN FOCUS - DEFINITIONS AND CHALLENGES

The aim of the study is to assist the European Parliament in formulating long term strategies and short term policies to aid developing countries to prepare and implement policies leading to efficient, equitable and ecologically sound water resources management. A policy/strategy must be possible to translate into feasible programmes and projects that can be executed.

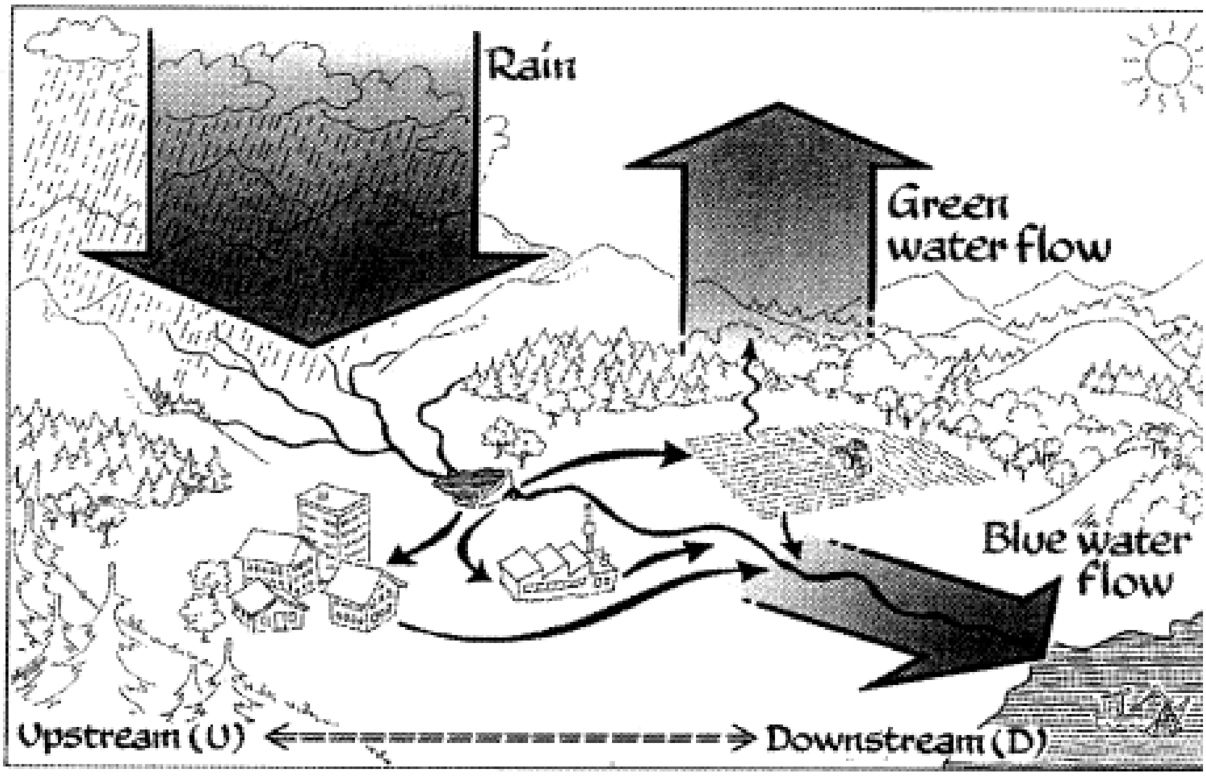
Water plays a significant role both in society and in the natural systems in the landscape. Hydrological features and human interventions in natural water pathways influence vital parameters in society, like human health, food production, industrial opportunities, etc. They also have implications for composition and functioning of terrestrial and aquatic ecosystems. To meet current and future demands and to safeguard vital life-support functions in the landscape, it is imperative to balance social, economic and environmental objectives. Socio-economic progress is a primary objective in all countries. During recent decades and for the 21st century, the awareness to combine socio-economic objectives with environmental sustainability is noticeable.

## 1.1. Water resources and use - the modern view

The basic water resource of a catchment/drainage basin is derived from the rainfall. When hitting the ground, water is partitioned between the evaporating part, i.e. the *green water flow*, from wet surfaces and the plant production process, and the liquid part, i.e.

the *blue water flow*. Blue water refers to the water that is available when it flows through the landscape, from the water divide to the river mouth via rivers, lakes and aquifers, i.e. above and below ground. Together, the green and blue water flows serve two major functions: they sustain natural and man-made ecosystems and, when made accessible, they are an essential, non-substitutional resource for various social and economic functions in society.

It is primarily blue water which society has focused upon in its endeavours to satisfy societal needs. Rivers, lakes and groundwater aquifers are the very sources from where water is withdrawn. For practical reasons, it is not possible to withdraw green water. The omission to include green water flows in water policy and, indeed, in water resources assessments is, however, unfortunate for two major reasons. First, the size of these flows is quite significant (they are much larger than the blue water flows). Second, changes in green water flows have a direct consequence for the size and variation of blue water flows.


Rain
Green water flow
Blue water flow
Upstream (U)
Downstream (D)

## 1.2. Water use and what happens to water after use

Water needs and demands are driven by population growth, urbanisation and industrialisation. Reduction of poverty is mirrored in increasing expectations for quality of life and therefore for more water. Water provision to meet needs and demands involves the bringing of water from where it is available in the landscape to where it is to be used. The return flow goes back either untreated and disposed of on the land or into a water course, or it goes to a treatment plant for pollution load reduction.

Water is used in households, municipalities, industries and irrigation. For the three former, use is mainly *non-consumptive*, i.e. most of the water returns after use to various recipients in the landscape. In irrigation contexts, the situation is quite different. If efficient, irrigation will “transform“ the provided blue water to green water that returns to the atmosphere as evapotranspiration. Irrigation is thus characterised by a *consumptive use* of water.

A common denominator for virtually all kinds of land and water use is that *pollutants* are picked up by and dissolved in the water. For instance, pit latrines may be leached into the ground during the wet season, polluting the groundwater. Furthermore, the return flow of water after use consists of water whose quality is more or less degraded. In semi-arid and arid regions, where the base flow in water courses is low, the dilution capacity is limited and the consequences of letting polluted waste water into recipients could be hazardous. Needless to say, the consequences are most discernible in downstream areas.

## 1.3. Making water accessible for use

From the discussion above, it is clear that the amounts of (blue) water that are available in the landscape are the result of climatic and bio-physical circumstances, while the amounts of water that are accessible for intended purposes in society primarily depend upon the capacity in society to regulate, store, withdraw and provide water. In many places, the provision of water that is safe to use requires, moreover, that hazardous substances in the raw water are minimised or eliminated.

Although the *distinction between natural availability and accessibility* in many respects is crucial, it is rarely discussed or comprehended  It may sound as a paradox, that, while we have indisputable evidence of an increasing water scarcity - i.e. a rapidly growing number of people per flow unit of available water - it is also true that the accessibility to water for large segments of the world population has improved.

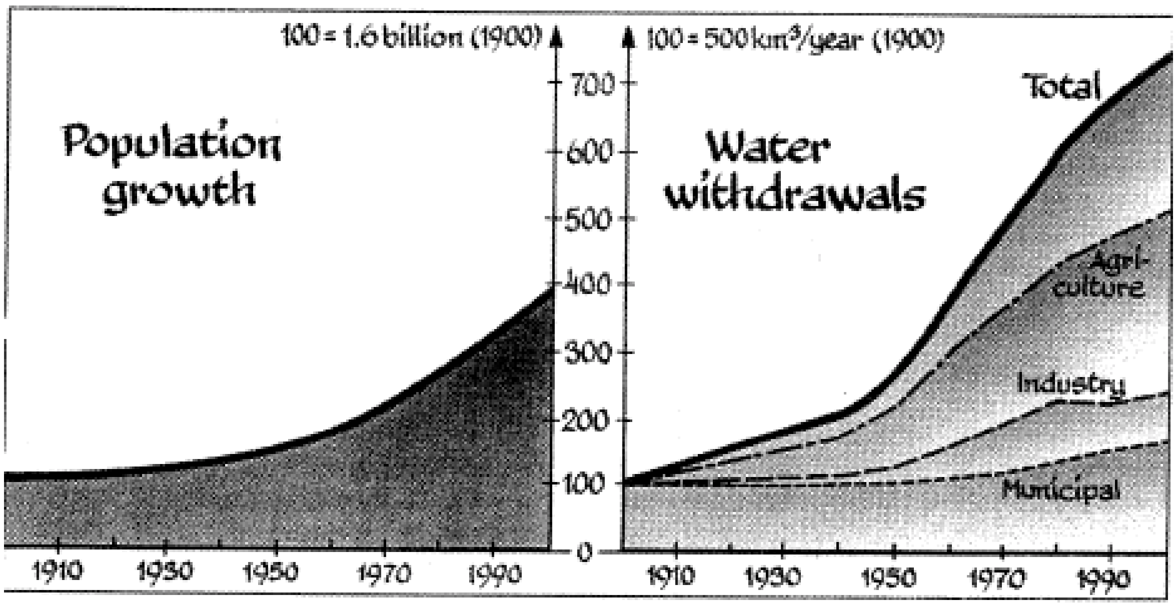


***Figure 1.2.*** *Water withdrawal is increasing much more rapidly than the population.*

During the 20$^{th}$ century, humans have been quite successful in building dams and other structures through which seasonal and interannual variations have been regulated and water stored in reservoirs. From reservoirs and other natural sources, water has been supplied and subsequently used in society. During this century, the rate of additional withdrawals has, on average, been about two to two and half times faster as compared to population growth (see figure 1.2).
The transformation of the water from being naturally available into a comparatively time-stable resource, that can be supplied in required quantities, for intended purposes, at the time and place desired is, no doubt, a significant achievement and something that has made development, in a wide sense, possible. An increasing dependence on water provided through technical and institutional arrangements is obvious. A successful urban growth, for instance, is inconceivable and impossible in the absence of safe and dependable water provisions, among other things. In terms of quantity, the largest share of provided (blue) water is, however, to boost food production through irrigated agriculture.

## 1.4. Water scarcity - three perspectives

Water is said to be scarce if there are problems to meet the water needs due to water availability constraints. Three perspectives may be applied:

- *aridity* refers to the hydroclimate: when the annual rainfall is lower than the evaporative demand of the atmosphere. When even the wet season is arid the natural way of life is nomadic and/or pastoral;
- *water scarcity in the soil* refers to plant production: when plant requirements are higher than the water available in the soil, plant production is constrained;
- *water scarcity in rivers and aquifers* refers to societal production. Water stress may be spoken of in different senses. In the sense of difficulties to mobilise more water, i.e. limited degrees of freedom, water stress is discussed by referring to the *use-to-availability ratio* or percent of blue water availability that is already being withdrawn. Water stress in the sense of high population pressure on water availability or water-related "crowding" is discussed by the *people per flow unit of water* (often expressed as the inverse, i.e. per capita water availability). The latter type is an indicator of dispute proneness and the number of people polluting each flow unit of water.

## 1.5. Availability problems

Most of the regions selected by the European Parliament, presented in Appendix I, are in the arid areas of the world and have monsoon type climate with a wet and a dry season. This means that water availability is subject to large seasonal fluctuations. In response to the rainfall variability, the runoff is also highly variable:

- *seasonally* with short duration floods and dry season low flow. In semiarid climates, many small rivers go empty during the dry season.
- *interannually* due to intervening drought years. Flow differences may be large between wet years and dry years.

Regardless if water use is seasonal (as in the case of food production) or perennial (as is the case in municipalities and industries), *water storages are imperative* to counter the negative consequences of seasonality of rainfall – which usually do not correspond to cropping seasons – and erraticness. The size of a potential reservoir depends, among other things, on river flow and its variations and topography. In a small river, small ponds can catch the flood flow while in large rivers like the Nile, the size of Lake Nasser is needed to catch the wet season flow to make it accessible during later dry years.

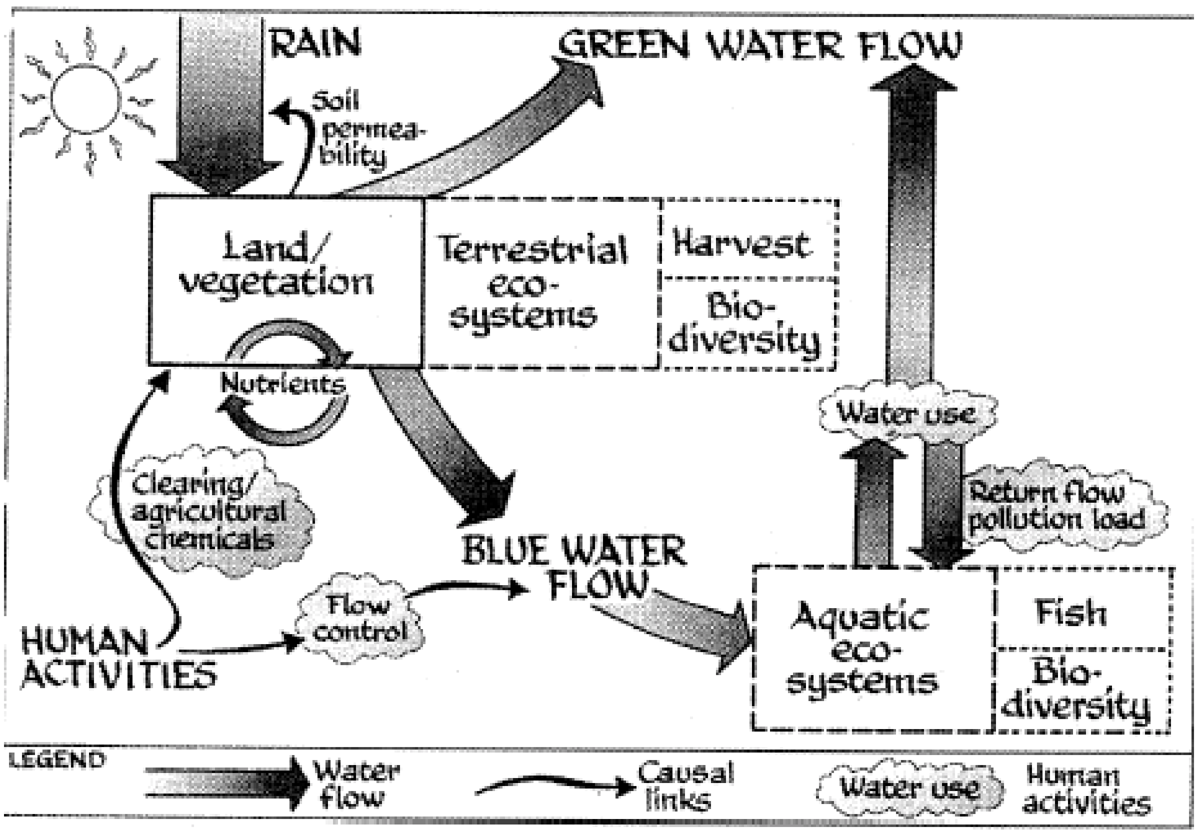
In semiarid regions, water becomes a critical pre-condition to development. Surface water is often insufficient. There are basically three water sources that society may benefit from for direct uses:

- groundwater accessible through pumping in wells
- surface water accessible in the water courses;
- rainwater harvested on roof tops and impermeable plots and stored in house cisterns or as local groundwater.

Where the water courses are non-perennial, groundwater is an essential source in the dry season. But groundwater recharge is often very limited in a dry climate.

Overexploitation is a reality and a serious threat. Documentation from various countries





shows a sinking ground water table. Deepening of wells step by step is one way to cope with the challenge, but gradually this solution is not feasible.

***Figure 1.3*** *visualises water-related causal chains between key ecosystem goods and services in the target end, and human activities in the landscape related to food, water and energy supply etc., in the disturbance end.*

## 1.6. Water-related environmental problems

Human activities in the landscape are imperative in order to satisfy societal needs. They involve manipulation of both soil, vegetation and water flows. Due to the linkages between land/water/ecosystems (See figure 1.3) a whole set of side effects tends to develop, generally discussed under the integrative term *environmental problems or impacts.*

First of all *a land use decision is also a water decision.* The links between the various components of water flows are particularly obvious in tropical climates. In areas where the evaporative demand of the atmosphere is high and where rainfall is concentrated to a short season, the water partitioning and, thus, the generation of runoff is easily modified by changes in land-use and vegetation. Land use plays a vital role in influencing blue water flows, both in terms of amount and seasonality (high flow/low flow).

*Food production is highly water consuming*, whether rainfed or irrigated: some 600 $m^3$/ton grain in humid situations, at least some 3000 in hot, arid situations. In arid surroundings rainfed crop production is subject to many problems: yields on the farmers field are often far below 1 ton/ha due to a whole set of deficiencies: lack of rain (aridity), lack of infiltrability and poor water holding capacity (crusted degraded soils), plant deficiencies due to lack of nutrients and root damage during intermittent dry spells. Irrigation is a way to compensate for lack of rainfall, soil conservation a way to minimise soil deficiencies, and fertilisation and informal on-farm irrigation a way to reduce plant damages.

Water's mobility makes human activities upstream impact on downstream opportunities of water use. *Upstream vegetation changes* influence the runoff production, especially in hot climate regions. This is the bitter lesson learned by Australia and South Africa, where land clearing the European way turned out to present massive water problems in terms of rising water table, waterlogging and salinisation. On the other hand, increased consumptive use upstream through *irrigation expansion* may deplete the river, causing problems for water-dependent downstream activities and aquatic ecosystems. The Aral Sea problematic is an example of a combination of both. Upstream reforestation also reduces the runoff but may improve the low flow by facilitating groundwater recharge. *Pollution loads added upstream* reduce the water usability and the health of aquatic ecosystems downstream.

## 1.7. Key challenges

A basic water management challenge is to find ways to satisfy human needs while coping with hydroclimatic and topographic preconditions and protecting the water resource from long term deterioration either by depletion due to consumptive use or by quality degradation due to pollution load and/or leakage of agricultural chemicals. There has also to be enough water in the river of an adequate quality in order to protect aquatic ecosystems from deterioration.

Strategies and policies to deal with these challenges need to be developed by the countries and regions in order to sustain water security. Such strategies and policies need to take into account the following aspects:

- the first one refers to *allocation challenges* when growing and incompatible water demands claim for more water: Choices will have to be made in terms of how should the water withdrawn be allocated between competing sectors and demands;
- the second one refers to *upstream/downstream water sharing*, a sharing with clear political dimensions;
- the third one refers to the *allocation of water between societal uses and terrestrial and aquatic ecosystem* for which a minimum flow would have to be left untouched in the river.

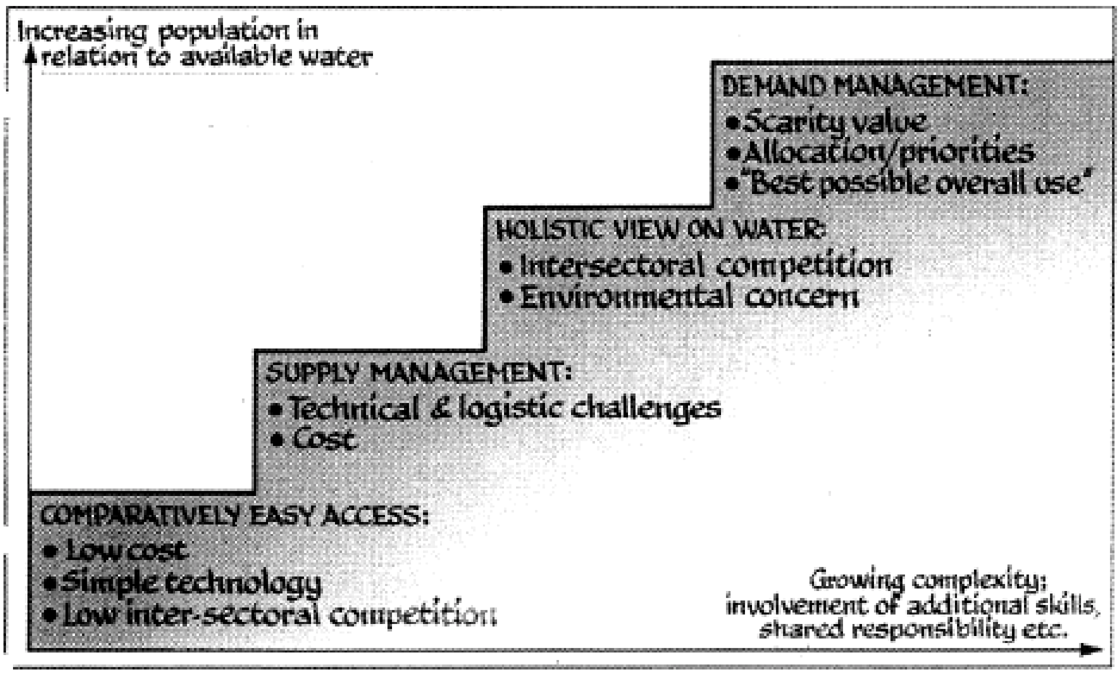


***Figure 1.4.*** *Development under conditions of growing water scarcity must be based on a strategy where the best possible use of available resources will be stimulated, probably alongside with a scrutiny of the need for additional withdrawals.*
*A combination of supply side and demand side management will be natural as countries climb "the management ladder".*

Making water accessible hinges, initially, on a combination of technical skills and financial resources. Gradually, the challenge becomes more complex. Apart from decisions concerning how much water that should be developed, policy makers must also ensure that water is reaching those who should have access to it. Incompatible claims for water from various sectors, from urban and rural areas and from upstream-downstream interests are currently quite common.

In addition, the claims for more water to sectors in society clash with interests that promote environmental values. An increased ability to deal with water management from an integrated perspective is thus necessary. In this work co-operation and co-operative arrangements are needed. This report indicates against descriptions of the challenges for the different regions, techniques and practices, regulatory measures at national and international level, strategies and policies that the European Parliament should suggest the European Union to regard in its work on Water and Development in the regions identified. Such strategic work would enhance possibilities for conflict prevention, thus resulting in increased water security.

# 2 - REGULATORY MEASURES, WATER SHARING AND CONFLICT PREVENTION - THE NATIONAL PERSPECTIVE

## 2.1. Three basic challenges in current and future water policy

From what has been discussed in previous chapters of this report, it is obvious that the increase in overall demand for water cannot be met in terms of corresponding increases in water supply in many, if not most, countries. Supply will most probably increase, but not at the same pace as hitherto. An increase of total supply to the main sectors of society, i.e. irrigation, industry and households, means that more water will have to be withdrawn from rivers, lakes and the ground. Since the amount of water in these sources is more or less constant over time, it is increasingly difficult and expensive to augment supply. In terms of water policy, the new situation implies three basic challenges.

### 2.1.1. The allocation challenge

The first challenge, which is probably the most obvious one, refers to the growing and incompatible claims for more water for irrigation, industry and households in each municipality or region of a country. If supply can not increase at the same rate as demand increases, choices have to be made as to what activity should get water on a priority basis, how much and on what terms. In some areas, the choice may eventually entail re-allocation from one sector to another.

### 2.1.2. The upstream - downstream water sharing challenge

In a number of river basins it has been dramatically illuminated in recent times that the possibilities to meet both upstream and downstream demands represent a most difficult and conflict laden equation to solve. The same principle problem is experienced in a national context as in international river basins. If water utilisation intensifies in upstream segments of a river basin, the amount of water that is available to downstream areas is reduced. In addition, an intensified use of water, and/or land, will almost inevitably result in a deterioration of water quality (cf. regional examples in Appendix I). In both the quantity and quality dimensions – the “Q & Q connection” - the upstream/downstream interrelationships are clearly illustrated. In the absence of a well functioning management system, the consequences for the societies concerned are significant.

### 2.1.3. The society - environment interface challenge

In the past, development thinking has, by and large, overlooked the environmental implications for water development and use. Water, like air and other “landscape commons”, has been taken for granted in a development perspective. Water, in particular, has been perceived as a technical supply problem. Today, this perception is gradually giving way to an understanding of water as a finite and vulnerable resource. Debate and experience have repeatedly shown that it is of mounting importance for human wellbeing, and a sustained economic growth, to consider the potential discord between societal development and what happens to the resource base and the state of the environment. If more and more water is withdrawn from streams, lakes and the ground, there will be comparatively less stream-flow and the quality is affected, as already mentioned. The in-stream and estuary ecological systems/functions will most likely be affected. To what extent and for whom the impact on the environment is negative, acceptable - or even environmentally benign - is certainly a complicated issue. But this is an issue that has to be raised in areas where claims from society on water are mounting, particularly in areas where the overall availability is limited.

Increasing competition and the incompatible claims (i) *within* and (ii) *between societies* and (iii) *between society-environment*, must be handled through a combination of regulatory measurers and management principles. Such efforts are vital both in order to reduce the risk of conflict *and* to generate the socio-economic benefits which citizens expect. If basic components of human welfare and a "reasonable" socio-economic development are not achieved, it is futile to expect that conflict prevention measures will bear fruit. Similarly, rational resource management practices will hardly be adopted. Development and conflict prevention and/or mitigation are closely related phenomena.

There is thus a need to consider inter-sector *allocation* of water between the various sectors of society demanding more water in each locality and also to consider the upstream-downstream *sharing* of the water that is available in a river basin as a whole. In addition, the demands for development of society must be balanced with a consideration for environmental sustainability. Regulatory measures must consequently address conflicting demands for water use in society as well as how to deal with the issue of reservations of certain fraction of stream-flow for in-stream functions and/or how to minimise adverse impacts from reservations as such.

## 2.2. Regulation of supply and the need for new, additional regulatory measures

Constraints to meet escalating demands can be seen both in terms of physical circumstances and in terms of resource constraints in society. Concerning physical circumstances, it is illuminating to ponder over the fact that in some parts of the world, the conventional water sources (streams, lakes and aquifers) are already exploited to such a degree that additional withdrawals are simply not feasible. In the Middle East, where the number of people in relation to the available amount of water is very high, both in an absolute sense and in an international comparison, the withdrawal ratio is close to 100%, or even much higher in individual cases. This means that all the water that is available in stream and lakes (there are very few lakes in the region!) and the amounts of water, which are replenishing groundwater aquifers, are withdrawn and supplied to various sectors of society. A withdrawal ratio in excess of 100% means that more water is withdrawn as compared to what is renewed through rainfall. In Libya, huge volumes of water from fossil groundwater sources are lifted. Instead of rains, which are minimal in the area, this fossil water is the source of man-made rivers. A combination of technical solutions, use of substantial amounts of energy to lift the water and heavy investments have made this kind water supply strategy possible. Needless to say, this is a strategy that is neither possible in most other countries nor sustainable in a long time perspective.

Water regulation and storage is an important management task in most countries, and rates of withdrawal have been quite high during recent decades. A continuation of this trend is not possible and a reduced rate of withdrawal is currently noticeable. The challenge today and for the future is thus to meet a continued growth in demand while the options to increase supply have been reduced.

Societal constraints are frequently alluded to in terms of skyrocketing financial costs associated with the building of additional storage and conveyance capacity. On average, the cost in real terms to supply an additional unit of water may be about two to three times the cost of the supply that has already been arranged. Apart from problems to secure funding of expensive technical arrangements in a tightening budgetary situation, the building of new structures is often associated with contested environmental and social consequences in terms of, for instance, eviction of people from a new dam site.

In an era during which the awareness of environmental and social values has surfaced in the general debate and become mandatory in connection with many development projects it is, of course, politically complicated to go ahead with new water development schemes. Generally, this poses a dilemma. On the one hand, strong interests in society demand more water - many claims are certainly justified - and, on the other, there are problems of how to finance additional structures combined with a noticeable reluctance or negative attitude to new projects, as just indicated. Although these kind of opposing views, in general, have not escalated into tangible conflicts, they must nevertheless be taken seriously in water policy and in the development and implementation of regulatory measurers. As will be elaborated below, the best conceivable strategy in this regard is to develop and implement a demand management strategy as an important component in the overall policy.

## 2.3. Water supply management is more than building new structures

It is most important to note that technical and institutional arrangements for water supply will continue to be an important and basic component in water management. However, building of new structures is only one aspect in this regard. Maintenance and rehabilitation of existing structures must also be seen as increasingly important tasks. Currently and for the future, supply management must probably be much more oriented to these kinds of tasks rather than concentrating on building new structures alone. Repair of old conveyance systems, for instance, may augment water supply of a system and could be both cost-effective and would reduce the pressure on natural water sources and/or postpone the perceived need for additional withdrawals. Similarly, the upgrading of old structures in irrigation systems may facilitate a much more efficient utilisation of

water and, at the same time, reduce the negative consequences of seepage and other water losses, which are common in irrigation systems.
Taking care of existing structures makes much more sense than building new structures in situations where the existing ones are in a state a decay and/or where funds for new structures may be difficult to mobilise. Conventionally, it seems unfortunately more easy to mobilise funds for new structures than for operation and maintenance purposes to old (and new) structures. Political perceptions may favour new schemes rather than the old ones – which might have been built by a previous government or which, initially, might have been supported by some other agent.

## 2.4. Key principles of a feasible water policy

In a situation where conventional strategy to meet increasing demand by augmenting supply in terms of increasing withdrawals can no longer be pursued as the sole and dominant management strategy, the most feasible strategy is to analyse and manage the demand side. In addition, the O&M tasks should be considered. Expressed in simplified terms, the focus in water management will have to shift from a consideration of how to best arrange additional water supply to a concern about how water is actually being used and what kind of benefits and costs that are associated with water withdrawal and maintenance as well as with actual water use. It is an important and challenging task *to reduce excessive demand on water while increasing output per unit of water*. In many cases, the challenge is to “produce more out of comparatively less”.  It would, of course, be a political failure and most problematic for the inhabitants of society, if a water policy would not be conducive to what might be called “reasonable and realistic” development aspirations of society. The opposite is equally true; it is necessary to formulate a development strategy that is based on a proper consideration of the water resources situation of the country. In other words, the water resources situation and water policy must be an integral component of a development *cum* conflict prevention strategy.

The ensuing discussion refers to the regulatory measures oriented to the demand side and more particularly to what kind of regulatory measures that may stimulate what might be referred to as a desirable water use. Regulatory measures refer to a wide range of efforts aimed at facilitating “best possible use of water” (BPUW). We will first discuss what could be considered as “best possible use of water” and then provide an overview of the various regulatory measures that could be applied in efforts to achieve BPUW.

## 2.5. Best Possible Use of Water (BPUW)

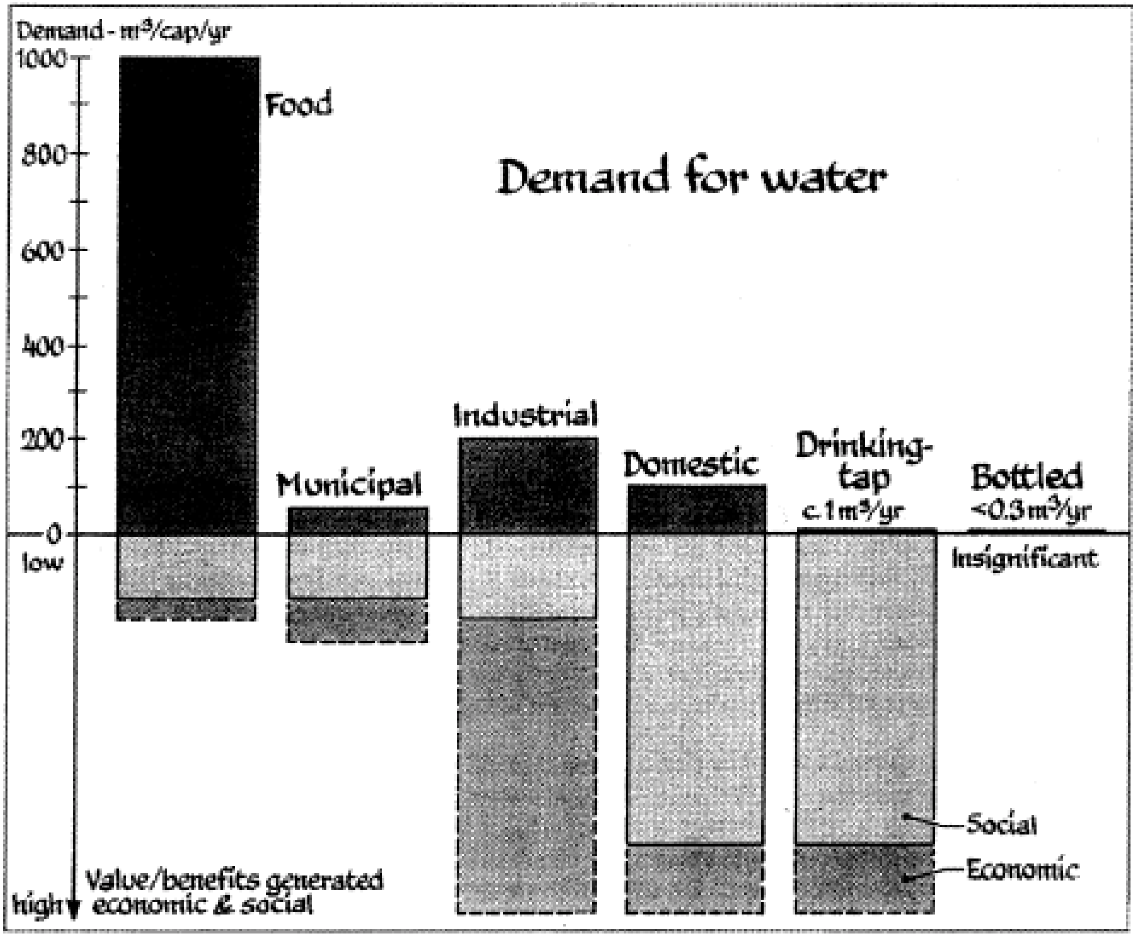
BPUW refers to three interrelated sets of objectives:

- **Efficiency ($E_1$)**. When a growing number of people need to use and benefit from finite and vulnerable water resources, it is imperative that the use of water must be such that the social and economic benefits are optimised per unit of water used. The need to promote an efficient utilisation of limited water resources is particularly noted in connection with food production since huge volumes of water are consumed by way of evaporation and transpiration from crops and fields. Notions such as “more crop per drop” illuminate that the challenge to feed a rapidly growing world population, in a context where the available amounts of water are more or less constant, cannot be successfully dealt with unless more food can be produced from each unit of water input. It is, however, not only food production that is under stress. Inter-sector competition will put increasing pressure on each sector to ensure that the amounts of water that are provided will be utilised as efficiently as feasible.

- **Equity ($E_2$)**. Efforts to increase efficiency in water use, i.e. to increase the return per unit of water may, or may not, be compatible with equity considerations, regional development objectives and similar. Achieving the twin objective of social and economic development may be more difficult in a short term as compared to a long-term perspective. In “pure” economic terms, the allocation of water to, for instance, a certain industry in a booming area may generate a quicker and higher rate of return as compared to a situation where the same amount of water would have been allocated to a poor region with a lack of basic infrastructure. Still, the allocation to the latter type of area may be warranted for various reasons: to stimulate regional development, to up-lift the living conditions of disadvantaged people, etc. A too strong emphasis on the first objective, **($E_1$)**, may therefore conflict with certain social objectives such as satisfaction of basic human requirements, alleviation of mass poverty and similar aspects.

- **Environmental sustainability ($E_3$)**. The achievement of social and economic objectives tends to be at odds with environmental considerations, at least in a strict sense. Satisfaction of social and economic objectives generally presume that more water is being exploited and withdrawn from natural water courses, thus leaving less water in natural water courses, and that more pollutants, nutrients and other substances are reaching water recipients and "the environment". Human intervention in the landscape is necessary to satisfy various needs and wants but it will also contribute to an environmental change. The sustainability of environmental objectives like in-stream functions, bio-diversity and maintenance of estuaries, presumes that abstractions are comparatively modest and that quality of the water flowing through the landscape is not appreciably degraded.

BPUW is a complex objective which will look different in different climatic contexts and which will also vary with socio-economic and political contexts. With regard to the two first components of BPUW, i.e. efficiency **($E_1$)** and equity **($E_2$)**, it is illuminating to ponder over the differences in social and economic benefits that may be generated per unit of water in the various sectors of a society. In Figure 2.1, a schematic attempt is made to illustrate the economic and social benefits, respectively, from water use in the main sectors of society. The upper part of the diagram shows a rather characteristic situation in terms of the various amounts of water that are required for the various sectors of an economy. Agriculture is, by far, the most water intensive sector. It is to be noted that most of the water that is used in the agricultural sector is actually consumed since the evaporation and transpiration from large fields and from crops is significant. As compared to urban sectors and to the households where water may be re-circulated and re-used, it is not possible to re-use most of the water that is supplied to the fields and to the crops.


Demand for water
Demand - m³/cap/yr
1000
800
600
400
200
0
low
high
Value/benefits generated economic & social
Food
Municipal
Industrial
Domestic
Drinking-tap
c.1m³/yr
Bottled
<0.3m³/yr
Insignificant
Social
Economic

In semi-arid countries, where the amounts of water are limited and in cases where the financial resources also are limited, it is increasingly difficult to mobilise enough resources to cater for the water requirement of agriculture. In other words, it might be difficult to supply the roughly 1,000 m3/person and year of water to the agricultural sector that would be required to produce the amount of food that the inhabitants require for a reasonable diet. (Part of the water will, of course, be available as rainwater. But in semi-arid regions, the reliance on water supply for irrigation is a typical pre-condition for a successful agriculture).
In terms of water policy, the pertinent question is not only if it is possible to supply water from a hydrological, technical and financial point of view. A more important query is how much water should be withdrawn altogether and what amounts should be allocated to the various sectors to achieve a best possible overall use of limited and vulnerable water resources in society and in an environmental sense. In addition to the problems of securing adequate amounts of water for food production in semi-arid regions and the substantial financial expenditure that is required, it is therefore relevant to look at the relative contribution to social and economic benefits that may be generated in the various sectors of an economy. As implied by the lower part of the diagram, the social and economic significance of the various sectors looks quite different. Generally, the agricultural sector generates a low rate of return, in economic terms, per unit of water as compared to the industrial sector. This is not to deny the reliance on the agricultural sector and the fact that its is strong in many countries. Its significance in

terms of contribution to GDP, employment and income is substantial in many of the countries in the South. A high GDP per capita is, however, usually correlated with a comparatively low contribution from the agricultural sector.
The urban expansion is quite noticeable and water supplies must be arranged to cater for the various functions of a city. Apart from drinking water supplies, attention must also be given to the potential role of the industrial sector. In cases where the urban sectors are able to produce goods and services that are demanded, either domestically or internationally, water policy must address the issue of how to best allocate limited amounts between the rural, agricultural sector or the urban sectors. It is important to note that for most countries, the agricultural sector will continue to be the most viable sector since the pre-conditions for a successful industrial expansion are not at hand. It is also of vital importance to consider the implications for world food security if an increasing number of countries would re-allocate water from the agricultural sector to the urban, non-food producing sectors.

## 2.6. An overview of regulatory measures – the old and the new ones

For a long period of time, the public sector has been the major agent for water management in most countries. The principle regulatory measure has been related to water supply, as discussed above. Typically, there was no deliberate attempt to regulate demand as such. The provision of water to the various sectors was often based on some crude and standardised assumptions concerning per capita need, per acre water demand, or similar. In most countries, the provisions to household sector had top priority. It still has. In terms of volume, the irrigation sector has clearly been the most favoured sector. The provision of water was heavily subsidised both to households and to the irrigation sector. Since water was supplied for free or at a highly subsidised rate, the incentive to use water sparingly was missing. In the absence of a monitoring system concerning whom received water, how much, at what time, etc., and with scant attention to the performance of water development schemes and water use, the mis-management and mis-use of water has become a common result. Efficiency in the use of water was low and, in spite of widespread endorsement of equity considerations, a large number of poor and disadvantaged sections of society are yet to receive adequate supplies, while very few, if any, of the affluent segments of society lack water services – at highly subsidised rates.

The conventional regulatory system is consequently under increasing stress in many countries. As elaborated above, the new context requires a much closer look at the demand side. Above, it has also been emphasised that the new management strategy is, to some extent, supplementary to existing management. A major task in this regard, however, is to improve and upgrade management structures that have existed but which, for various reasons, have functioned poorly. In the new context, it is imperative that the regulatory system addresses the three criteria for BPUW as discussed above. In the following, it is assumed that the three objectives of BPUW may be reached through a combination of the following major regulatory measures:

1. **Legal and formal regulations**. In all countries, it is essential to have a set of clear rules and regulations concerning, for instance, water rights and what kind of obligations are necessary with regard to environmental sustainability, third party interests, etc. Many countries have laws which are intended to regulate various aspects of water provision and use, but the tools and the actual implementation and enforcement of the laws and legal/regulatory provisions are still fairly weak.

2. **Institutions**. A second component refers to the attempts in many countries to improve management and implementation of rules and regulations through institutional reforms. The noticeable compartmentalisation of water management tasks within the framework of sectors and formal Ministries represents one challenge in efforts to promote an integrated water resources management (IWRM). Creation of river basin commissions and attempts to promote a national water policy represent examples of emerging institutional structures. At a lower level, the formation of water users' associations, "river parliaments", etc., is an important step in efforts to mobilise users' in efforts to make better use of water. Mobilisation of people in the civil society is an important component in the building of new water management institutions. Institutional reforms refer to a review of existing formal institutions but also to attempts to facilitate the creation of and support to informal ones.

3. **Market-oriented and economic reforms**. A third component refers to a greater reliance on the market forces in water management and also to use economic incentives and sanctions. In principle, this measure is another kind of regulation as compared to the regulation that is carried out by formal, government institutions. As implied from Figure 2.2, the market-oriented measures cannot, however, be seen as independent from the two other measures.

It is important to recognise that the three measures listed above are related to each other to a greater or lesser extent. Most colleagues would also emphasise that the market is in itself an institution. Incentives and sanctions will form common tools in all the three measures. Economic incentives and sanctions in terms of water fees, licenses, etc., for instance, are important in connection with the employment of institutional reforms and they are a natural component in connection with market oriented measures. Similarly, the legal framework may recommend fees, for instance, in connection with licensing and in relation to effluent emissions to recipients.

Concerning the seemingly different character of the market oriented measures vis-à-vis the two other measures, it is of paramount importance to emphasise that a market can never function well in the absence of strong and transparent institutions and a proper legal, regulatory framework. Transactions between people who want to sell water (rights) and people who are interested in buying, are not likely to function unless the trade is carried out in a context where the seller is able to show that (s)he has water rights that can be transferred. If transactions are carried out in the void of such a framework, there are uncertainties that are likely to offset the potential benefits that could be reaped from a market system.

A common pre-condition for the effectiveness of all regulatory measures is obviously related to the degree of awareness among decision-makers and the public at large concerning the challenges that society as a whole is facing with regard to water. The formulation of laws and the building of formal and informal water management institutions, for instance, is important to facilitate an improvement in water resources management. But unless a basic understanding of key hydrological features is shared among the people involved, it is not likely that the regulatory measures will be adhered to nor be effective. Education programmes aiming at reducing the presumably widespread “water illiteracy” and, generally, a “natural resource illiteracy” is consequently of primary concern in efforts to promote and facilitate improved water management. Education and awareness campaigns are also of outmost importance in efforts to mobilise human effort and ingenuity and to make water “everybody’s business”.

The relationships between overall development objectives of society and how they relate to water policy and strategy are portrayed in Table 2.1. In this an attempt is also made to illustrate that the three criteria for BPUW may be approached though various regulatory measures. Finally, Figure 2.2 illustrates that the various regulatory measures are interrelated and that there are now sharp boundaries between them.

**Overall societal development objectives**

- Alleviation of (mass) poverty
- Social and economic progress (income, literacy, employment, etc.).
- Conflict prevention and mitigation

**The role of water in societal development**

| | |
|---|---|
| Water development (withdrawal and supply); the old regulatory measure | Water use (allocation and actual utilisation); the focus of the new regulatory measures |

**Table 2.1**. The criteria for best possible use of water (BPUW) and the regulatory measures that are possible to apply to reach BPUW. One “X” means that the likelihood of achieving a good result in the criteria is comparatively modest, while “XXX” refers to a regulatory measure that is likely to have a relatively stronger effect.

| Best possible use<br>Regulatory measure | Efficiency | Equity | Environmental sustainability |
|---|---|---|---|
| **Legal & formal regulatory measures** | X | X | XX |
| **Institutional reforms** | XX | XXX | XXX |
| **Market oriented measures and economic reforms** | XXX | ? | X |

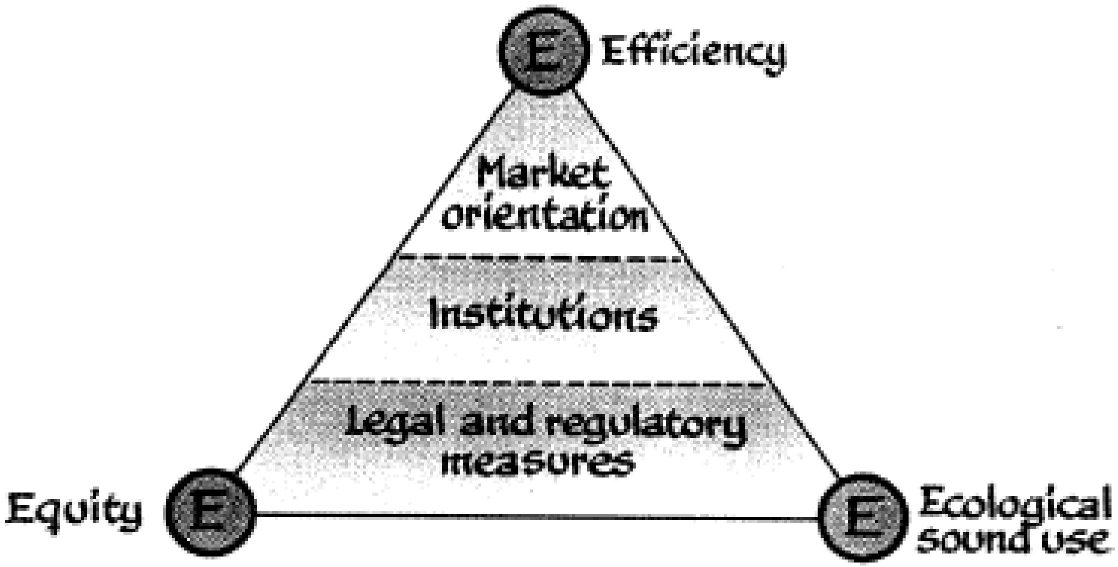



***Figure 2.2***. *A schematic figure illustrating the three objectives of water policy and the three major regulatory measures are interrelated. It is implied that the legal and regulatory measures are of basic importance and that they will be indispensable for the institutional reform and also for the market oriented measures.*

# 3 INTERNATIONAL FRESHWATER BASINS: PREVENTING CONFLICT AND STRENGTHENING CO-OPERATION

The aim of this chapter is to suggest measures for facilitating the co-operative management of international fresh water resources. In an attempt to articulate these measures, the chapter will first examine the present situation regarding water scarcity and its implications for the international community. It will illustrate that though the possibility of water-related disputes erupting increases every day, such episodes of violent conflict are not inevitable. The chapter will then focus upon existing international institutions and current legal principles. It will be argued that in spite of the recent emergence of a number of international organisations and agreements regarding this global issue, the international community still lacks sufficient and comprehensive solutions. Thus, we recommend other measures which basin states and international organisations could, and perhaps should, implement in order both to avoid possible armed conflict over shared water resources and to build a lasting co-operative scheme for water management in the future.

Within 25 years some three billion people will be living in countries facing water stress. Water tables are falling increasingly on every continent. Many developing countries already face serious problems in meeting rapidly increasing water demands. In order to meet such demands, further pressure is being placed on these ‘blue’ water resources, this over-exploitation resulting in acute shortages. Faced with such scarcity, water has increasingly become a source of social tension, bringing further competition and creating conflict which, together, have the potential to destroy those present arrangements for water distribution. Even though such tensions are omnipresent, they tend to be more complex and difficult when concerning international rivers, lakes and aquifers. A number of commentators believe that the dependence of many developing countries on an external water supply may force them to re-orientate their national security concerns in order to protect or preserve such availability. Several countries are currently in dispute over the sharing of their common water.

**Table 3.1. Some of the Countries Heavily Dependent on Imported Surface Water**

| Country | Import Component of Renewable Water Resources (%) |
|---|---|
| Turkmenistan | 98 |
| Egypt | 97 |
| Hungary | 95 |
| Mauritania | 95 |
| Botswana | 94 |
| Bulgaria | 91 |
| Uzbekistan | 91 |
| Netherlands | 89 |
| Gambia | 86 |
| Cambodia | 82 |
| Romania | 82 |
| Luxembourg | 80 |
| Syria | 80 |
| Congo | 77 |
| Sudan | 77 |
| Paraguay | 70 |
| Niger | 68 |
| Iraq | 66 |
| Albania | 53 |
| Uruguay | 52 |
| Germany | 51 |
| Portugal | 48 |
| Bangladesh | 42 |
| Thailand | 39 |

| | |
|---|---|
| Austria | 38 |
| Pakistan | 36 |
| Jordan | 36 |
| Venezuela | 35 |
| Senegal | 34 |
| Belgium | 33 |

Sources: Peter H. Gleick, “Water and Conflict: Fresh Water Resources and International Security”, *International Security*, vol. 18, no. 1, Summer 1993; David R. Smith, “Environmental Security and Shared Water Resources in Post-Soviet Central Asia”, *Post-Soviet Geography*, no. 36, 1995.

## 3.1. Conflicts over shared waters

When more than one country are jointly dependent on the same freshwater system, one’s withdrawal and pollution can potentially lead to conflicts. Today, 261 river basins are shared by two or more countries. The increasing scarcity of water and the unequal and multilateral distribution of this resource paves the way for a greater number of water conflicts. Not only does the prognostication of future water conflicts project a gloomy picture, but the present number of these conflicts has also become a matter of serious concern.

The most publicised water conflict has centred on the control of the Jordan River basin among the riparian parties, Israel, Jordan, Lebanon, Syria and West Bank. The disagreement over the waters of the Jordan, Litani, Orontes, Yarmuk and other rivers was one of the reasons of the Arab-Israeli War in 1967, and it also partly influenced Israel's decision to invade Lebanon in 1982. Massive population increase in the basin has brought further pressure on the scarce river water. The peace agreements between Israel and Jordan in 1994 and Israel and the Palestinians in 1995 have recognised the water needs and rights of the riparians, but the implementation of these agreements faces a number of road blocks. The disagreement over water sharing has also become a serious hindrance in the on-going negotiations between Israel and Syria.

Since the 1920s, Egypt and Sudan have shared Nile River water by mutual agreement between the two governments. Sudan now wants to revise the last agreement, which was signed in 1959, to acquire a larger share of the water. However, the major threat to Egypt's water supply comes from Ethiopia, which contributes more than 80% of the Nile's water entering Egypt. Not being a party to the legal agreement between Egypt and Sudan, Ethiopia unilaterally plans to divert part of Nile's water for its own irrigation projects. Not only Ethiopia and Sudan, other upstream riparian countries are also planning to develop the Nile tributaries to meet increase demand for water.

Turkey is now implementing its plan to construct over twenty hydroelectric and irrigation facilities on the upper reaches of the Euphrates River. This huge 'GAP Project' has brought water shortages for downstream users, mainly in Syria. When all the planned Turkish projects are completed (probably by 2006), the flow of the Euphrates to Syria could be reduced by up to 40% and to Iraq by up to 80%. The GAP Project has not only strained relations between Turkey and Syria but also Syria’s relations with Iraq.

Population growth, increased agricultural activities, and high rates of evaporation add to the increased demand for water in the basin. Lack of any existing legal water sharing agreements among the three major riparian countries increases the chances of deepening the conflict over the river water.

In recent years, Hungary and Slovakia have seriously disagreed over the construction and operation of the Gabcikovo/Nagymaros project on the Danube River, further complicating the fragile security of Central Europe. The construction of a large dam on the Han River by North Korea in the late 1980s has added another layer to the long-standing dispute between North and South Korea. The conflict over the distribution of the Ganges water between India and Bangladesh predates the creation of Bangladesh itself. The list of international water conflicts does not end here. There are reported disputes among the riparians over the Indus, Mahakali, Salween/Nu Jiang, Mekong, Parana, Lauca, Great Lakes, Colorado, Rio Grande, Lake Chad, Orange, Zambezi, Okavango, Senegal, Lake Victoria, Amu Dar'ya and Syr Dar'ya, and Szamos. In some cases, there are existing agreements to regulate the water distribution among the riparian states, but the increasing scarcity is threatening their continuance.

Fortunately, these water conflicts have, thus far, not developed into violent episodes. In this century, water scarcity has caused few (seven) minor skirmishes but no war has yet been fought. Few possible reasons can explain why the 'water war' has not taken place, in spite of many threats and many predictions in this direction.

1. *Time Factor*: Threat does not necessarily reduce water supply to the other users of the basin. To carry out the threat of water diversion and /or withdrawal, a long period of

time is needed to construct the infrastructure. Long intervals between the ‘expression of threat’ and ‘execution of threat’ provides opportunities for negotiated settlement. The time factor can also help the parties to prepare themselves to face the possible water scarcity situation.

2. *Aid Factor*: Most of the developing countries need financial and technical aid and assistance to undertake large water projects. Very few who can do on their own do it with a heavy economic and political price tag (e.g. GAP project in Turkey, Three Gorges Project in China and Narmada Project in India). In recent years, it is becoming increasingly difficult to receive external support for a disputed project in the international basin (e.g., World Bank’s OP 7.50 in October 1994). The end of the Cold War has also stopped the alternative source of borrowing (e.g., Soviet assistance to Aswan Dam Project in 1950s and 1960s). In spite of increasing water demand, this new development restricts many (e.g., Ethiopia in the Nile basin) to undertake new projects, which might become the source of violent conflict in the basin.

3. *Risk Factor*: Many international rivers and lakes are the source of livelihood for a large number of people in the basin. Any violent conflict over the water issue might disrupt the water supply and bring damage to the water storage and distribution system. This can bring misery to a large number of civilian populations on the both sides. The massive adverse consequence deters many disputing riparian states to wage ‘water war’ (e.g., sharing of Indus between India and Pakistan).

In the face of mutual dependence on the same freshwater resource, the withdrawal or pollution of one riparian state can potentially not only lead to the disputes but also bring co-operation in the basin. In several cases, competing and disputing riparian countries are now moving towards co-operation. As Shira B. Yoffe and Aaron T. Wolf point out, 145 water-related treaties have been signed in the last century. Growing competition over the waters of the Mekong, Jordan, Ganges, Mahakali and Zambezi rivers have resulted in co-operative sharing arrangements in the 1990s. In spite of retaliatory nuclear tests and virtual war in the Kashmir mountains, India and Pakistan are continuing their co-operative sharing of the Indus water since 1960. Within the Nile Basin Initiative, a Council of Ministers of Water Affairs of the Nile Basin countries are co-ordinating towards establishment of a Nile River Commission. Even in the Euphrates-Tigris basin, a Technical Committee is in operation where all three major riparians are the members.

**Table 3.2. Freshwater Basins of Conflict and Co-operation**

| **International Freshwater Basins** | **Disputing Riparian Countries** | **Incompatibility** | **Basin Based Institutions** |
|---|---|---|---|
| Jordan | Israel, Jordan, Syria, Lebanon, Palestine | Water Scarcity and control | Yarmouk Comm. (Jordan, Syria) Orontes & South Cebir Comm. (Syria, Lebanon) |
| Gaza, West Bank Aquifers | Israel, Palestine | Water Scarcity | |
| Euphrates-Tigris | Turkey, Syria, Iraq | Water Scarcity and Control of water | Tigris and Euphrates Joint Technical Committee |
| Amu Dar’ya & Syr Dar’ya | Uzbekistan, Kyrgyzstan, | Water Scarcity and Storage | Int. Coordination Comm. for Water-Supply (Concerning the Aral Sea |

| | | | |
|---|---|---|---|
| | Kazakhstan | | and Tadzjikistanian Rivers) |
| Minho, Douro, Tejo, Guadiana | Portugal, Spain | Water scarcity | Int. Comm. Between Portugal and Spain |
| Rhine | France, Germany, the Netherlands | Pollution | Int. Comm. for the Protection of Rhine against Pollution (ICPR) |
| Danube | Hungary, Slovakia | Control (diversion) of water | Danube Comm.; Int. Comm. for the Protection of the Danube River |
| Szamos | Hungary, Romania | Pollution | Romania-Hungary Hydrotechnical Commission |
| Salwan /Nu Jiang | Myanmar (Burma), China | Water Scarcity | |
| Mekong | China, Myanmar, Thailand, Laos, Cambodia, Vietnam | Scarcity and control of water | Mekong River Comm. (Thailand, Laos, Cambodia, Vietnam) |
| Han | North Korea, South Korea | Control of water | |
| Ganges | India, Bangladesh | Water Scarcity, Diversion | Indo-Bangladesh Joint River Comm. |
| Mahakali | India, Nepal | Scarcity and Control of water | |
| Indus | India, Pakistan | Scarcity of Water | |
| Parana | Argentina, Brazil, Paraguay | Control of water | Programme Paraguay-Parana |
| Lauca | Bolivia, Chile | Control of water | |
| Great Lakes | USA, Canada | Pollution | International Joint Comm. (IJC) |
| Rio Grande | USA, Mexico | Pollution | Int. Boundary and Water Comm. |

| | | | |
|---|---|---|---|
| | | | (IBWC) Rio Grande |
| Colorado | USA, Mexico | Pollution | |
| Nile | Egypt, Sudan, Ethiopia | Water Scarcity | Council of Ministers of Water Affairs of the Nile Basin Countries (COM) |
| Sahara Aquifer | Libya, Egypt, Sudan | Water Scarcity | |
| Lake Chad | Nigeria, Chad, Cameroon | Water Sharing | Lake Chad Basin Comm. (LCBC) |
| Orange | South Africa, Lesotho | Water Scarcity, Diversion | SADC-Orange River Basin Comm. |
| Zambezi | Zambia, Zimbabwe, Mozambique, South Africa | Water Scarcity, Diversion | SADC-Joint River Basin Comm.; Zambezi River Authority (Zambia, Zimbabwe) |
| Okavango | Namibia, Botswana, Angola | Water Scarcity | Okavango River basin Comm. (OKACOM) |
| Senegal | Senegal, Mauritania | Water Scarcity | Senegal River Development Organisation |
| Lake Victoria | Uganda, Kenya, Tanzania | Water sharing | Lake Victoria Environmental Management Programme |

Competition results, in most cases, in co-operation to maximise the benefits of water use in order to meet growing demand. However, evidence suggests that co-operative arrangements among the riparian states cannot last if the latter do not interact with and gain support from such institutions for proper water management at the basin level.

When the matter of contention is over the quantity of water, the challenge for long term water sharing agreement is much higher. With the help of financial and technological resources, it is relatively easier to address the water quality problem. The success of 1972 agreements between the USA and Mexico over addressing the salinity problem in Colorado River water and the 1976 (became operative in 1985) agreement among France, Germany, Netherlands and Switzerland to reduce Chlorides pollution in the Rhine, testify to this fact.

However, when the issue is quantity, the solution is not that easy. Signing of a sharing agreement might solve the water scarcity problem for a short period of time, but it does not provide a long-term solution. The recent threats to the survival of the Indus River Agreement of 1960, Nile River Agreement of 1959, Euphrates River Agreement of 1987 and Ganges River Agreement of 1996 confirm this apprehension.

Allocated water in the sharing agreement is unable to meet the increasing demand. The scope of further augmentation of river water in many parts of the world is getting limited due to financial, technical and more importantly environmental reasons. There are very few international basins left that can provide a certain hope for feasible further exploitation. Most of the rivers have been exploited to a large extent. In many cases, the augmentation can be only possible at the cost of others. So, these schemes receive opposition from the affected people (e.g., Jonglei Project in the Nile Basin). Time has come to realise the fact that the addressing supply side alone cannot find a lasting solution to the quantity question of the sharing of the international rivers. Thus, the water sharing issue is needed to be addressed from the demand side as well.

For the appropriate and competent management of shared freshwater systems, it is vital to build upon institutions at the basin level. Some of the international organisations and legal principles are aiming at providing guidelines for the basin-based arrangements to emerge.

## 3.2. International organisations and legal principles

There have been numerous endeavours to establish and strengthen international organisations and create an international legal framework for the management of international freshwater resources.

### 3.2.1. International organisations

The World Water Council (WWC) and the Global Water Partnership (GWP) are two major international 'water institutions' which have been established in the 1990s. The WWC, created in 1996 and with its secretariat in Marseilles, aims to promote an awareness of water issues and works in favour of efficient, sustainable conservation and management of freshwater. This non-governmental organisation provides an independent forum for exchanging views and information, for sharing experience and concerns, and for recommending actions on water management. While the WWC is essentially a forum for discussion, the GWP comprises organisations with financial powers to implement various programmes. In August 1995, the World Bank and the

United Nations Development Programme (UNDP) proposed the creation of this organisation and it is open to all parties involved in water resource management. The GWP brings together a large number of organisations, including aid agencies in an informal partnership. The GWP promotes integrated programmes at the regional and national levels and helps capacity building and sustainable investment across national boundaries.
These global initiatives to address the issue of freshwater have brought the international freshwater sharing problem to the fore. There have also been numerous individual attempts, for instance by the Global Environmental Facility (GEF), World Bank, UNDP, UNEP, Food and Agricultural Organisation (FAO), and World Meteorological Organisation/United Nations Educational, Scientific, and Cultural Organisation (WMO/UNESCO) to find ways of successfully sharing the international watercourses among states.

### 3.2.2. International law

Besides such institutional support for the freshwater resource management, there is a clear move towards establishing a common legal framework for the sharing of international watercourses at the global level.
The International Law Association (ILA) has made several attempts since 1956 to establish a ‘principle of equitability’ in the sharing of international river waters. The ‘principle of equitability’ advocates reaping maximum benefits to all riparian countries,

bearing in mind their economic and social needs. When the ILA compiled a set of rules on non-navigational uses of international rivers (Helsinki Rules) and placed it before the UN General Assembly, it was not approved as a model for sharing international rivers by the member-states, particularly given opposition from the upstream nations.
Instead the UN General Assembly recommended that the International Law Commission (ILC) take up the study of the law of the non-navigational uses of international watercourses with a view to its progressive development and codification. After 25 years of deliberations, the ILC submitted its draft in 1996 for consideration by the UN General Assembly. Finally, the Convention on the Law of the Non-Navigational Uses of International Watercourses, adopted by the United General Assembly on 21 May 1997, was submitted to the member-states for their ratification. Nevertheless, the process is moving along at a very slow pace, which has raised the fear that the Convention is unlikely to be ratified by enough countries to enter into force. Many governments are finding it either too strong or too weak, with positions often coinciding with whether the nation is upstream (too strong) or downstream (too weak) in international basins. It has been signed by only twelve countries and ratified by six countries thus far. This Convention will remain open for ratification until 21 May 2000.

**Table 3.3. List of Participant countries (1 March 2000) in the Convention on the Law of the Non-Navigational Uses of International Watercourses**

| Participant | Signature | Ratification, Acceptance (A), Accession (a), Approval (AA) |
|---|---|---|

| | | |
|---|---|---|
| Côte d'Ivoire | 25 Sep 1998 | |
| Finland | 31 Oct 1997 | 23 Jan 1998 A |
| Germany | 13 Aug 1998 | |
| Hungary | 20 Jul 1999 | |
| Jordan | 17 Apr 1998 | 22 Jun 1999 |
| Lebanon | | 25 May 1999 a |
| Luxembourg | 14 Oct 1997 | |
| Norway | 30 Sep 1998 | 30 Sep 1998 |
| Paraguay | 25 Aug 1998 | |
| Portugal | 11 Nov 1997 | |
| South Africa | 13 Aug 1997 | 26 Oct 1998 |
| Syrian Arab Republic | 11 Aug 1997 | 2 Apr 1998 |
| Venezuela | 22 Sep 1997 | |

By having both the principles of ‘equitable utilisation’ and ‘not to cause significant harm’ in the text, the UN Convention was able to obtain a majority support in the UNGA (103 'for', 3 'against' and 27 abstentions). Some commentators describe the Convention as “a basket of Halloween Candy: there is something in it for everyone.” However, whether it will be able to address the issues over the sharing of specific international rivers remains questionable. The major problem may arise in defining the ‘equitable use’ and also, its conflict with the ‘no-harm principle’. Even if this Convention is ratified by member states and becomes a legal framework, it will not be sufficient to address the problem of water sharing in different parts of the world. The sharing of international freshwaters among the riparian countries in different geographical regions is a problem of huge magnitude. In the presence of strong regional variance over the availability, need and perception of the freshwater, establishing an internationally acceptable legal principle may not itself bring the solution. Complex water disputes can only be solved by co-operation and compromise, not by a strict insistence on rules of law.

## 3.3. Imperative for a comprehensive endeavour

For a fruitful and long lasting co-operation on shared waters, there is need for a comprehensive approach to address the water scarcity issue. This comprehensive approach includes a series of measures to be taken at the basin level. These basin-based initiatives are needed to be augmented and supported by nation-state and international measures.

### 3.3.1. Measures to be taken at the basin level

*3.3.1.1 Treating international watercourses as a single unit*

An international river, lake or aquifer does not, by definition, respect national boundaries and as such, shared water systems should be treated as single units as regards the maximum utilisation of their resources. The development of these shared water occurs most optimally at the basin-wide level and the whole basin should be regarded as one economic, ecological and political unit irrespective of state boundaries. Under an integrated programme of basin based development, water projects should be located at optimum locations. The benefits of these projects should be allocated taking into account the needs of riparian countries as well as who have made the sacrifices to realise these projects. This approach includes joint planning, joint construction, joint management and cost sharing. The regulation and management of basin organisations should be entrusted to an independent body, who is outside the political control of any single riparian states. Management of international freshwater systems should grow beyond the sphere of national sovereignty to achieve the best possible use of water (BPUW), i.e., efficiency, equity and environmental sustainability (see Ch. 2).

*3.3.1.2 Involving both State and Non-State actors*

Not only states, but also non-state water users, must be eligible to participate as decision-makers in the basin based organisations. The recognition of water user associations and 'river parliaments' as eligible decision-makers provides an essential democratic channel, mitigating the construction and maintenance of water management through the establishment of legitimacy and mutual trust. The sustainable use of fresh water requires user participation in all aspects of water policy and management in the basin. In addition, when identifying the relevant actors for participation in the management of the water resource, one needs to move beyond identifying actors at various institutional levels. Social groups, such as women and other less empowered groups, should be given special attention. In particular, women's rights and roles should be considered as they often manage water-related activities such as irrigation and food production.

*3.3.1.3 Recognition of the social and cultural contexts*

In order to construct sustainable basin-based water management institutions, contextual considerations are of the utmost importance. The complexity associated with institutions for sustainable management does not only stem from technical and geographic conditions; essential is a consideration of the social and cultural institutions at hand. Policies recognising contextual institutions in the region should match enduring patterns of behaviour that have developed from people's own organisation as individuals, groups or classes, to utilise and exploit scarce materials and social resources. Existing traditions of rainwater harvesting, water storing practices and agricultural pattern are some of issues to be taken into serious consideration while formulating basin management policy.

*3.3.1.4 Clear rules on appropriation*

It is necessary to have a set of clear rules and regulatory measures in the basin regarding water rights and environmental obligation. Appropriation principles in the basin must restrict when, how, where and how much an appropriator can withdraw from the river. The demand for water includes a combination of basic 'needs' and a larger set of 'wants'. Basic needs for water must be identified and given priority. These allocation rules must take into account particular variations due to weather conditions and other local physical characteristics.

*3.3.1.5 Functioning information sharing network*

In several cases, riparian countries have unequal access to data and information due to differing data accessibility and asymmetric competence to process data. This asymmetric information can be scientific and/or strategic. For the smooth running of a river-basin management regime, a functional information sharing framework is required. The data on water availability, its need and use should be freely available and also be subjected to mutual monitoring. This would foster mutual trust in the available information. For the better understanding, the compatible data gather methods should be used in the basin.

### 3.3.2. Measures to be taken at the Nation-State level

*3.3.2.1 Import, and not export, 'virtual water'*

Most of the developing countries are exposed to water stress or even water scarcity. The adoption of a supply management strategy addressing only water shortage in the region is not nearly sufficient. To meet growing demand there is a need to minimise water use, particularly in the agricultural sector. This can be achieved in two ways: by ceasing to export 'virtual water' and starting to import 'virtual water' in the case of water deficient regions. 'Virtual water' denotes agricultural products that have been produced with large amounts of water. Following these two principles, ceasing the production of water-intensive agricultural products for export purposes and importing water-intensive agricultural products from water abundant regions, would both decrease water demands in the basin.

Countries in Northern Africa use their scarce water resource for producing agricultural products like pepper and tomato in order to export to water affluent regions in Europe. Israel exports oranges to Europe by using its meager water supply. Some Middle Eastern countries like Saudi Arabia spend massive resources to produce wheat in the desert, which they can easily import from water abundant regions in much cheaper price. For many developing countries, achieving self-sufficiency in food production is the most important national agenda. There is nothing wrong in achieving this. It provides a sense of food security as well as strengthens the legitimacy of the state and regime. But, the self-sufficiency in food production is always an on-going struggle in order to satisfy the increasing demand of the growing population. Moreover, in most of the cases, the temporary and limited self-sufficiency comes with the high unsustainable use of scarce water resource. Riparian states may opt for a planned allocation of agricultural activities to improve the productivity of the water in their various regions in order to meet the future demand for food.

*3.3.2.2 Pricing the water*

There is a need to restrict and regularise the demand for the increasingly scarce water resource in the basin. The full-cost pricing of the water will create quantity restrictions for the competing users. It will force consumers to use water more efficiently than if there would be no price tag on it or is available at highly subsidised prices. In recent years, the construction of the water projects demand greater investment. This is partly due to fact that the new sites for dams and storages are increasingly available only at greater economic and environmental cost. It is not only the construction of the projects, but also the proper management of the water storage and its distribution which is needed for efficient use of water. The water distribution systems, particularly in the developing countries, are not self sustaining, because the price charged for the water has been kept very low. This huge cost-benefit difference has reduced the performance of many irrigation and water distribution systems.

Pricing of the water is not a politically sound act for the leaders of the developing countries. For a politician, political interest is invariably more important than economics or environment. Taxing the water might cost the political leaders their major “vote banks”. Farmers constitute the most important voting bloc in the South. Thus, there is a need to distance politics from technical, economic and environmental criteria in decision-making regarding the basins. Greater awareness is needed about the water scarcity among the common people, which can help to depoliticise the water pricing to a large extent. Education can certainly help to bring this awareness.

The enactment of pricing the water is not sufficient in itself. There is a need to make effective institutional arrangements to collect the ‘water tax’. The law must be simple but strong enough to compel the people to pay their tax. Water Courts may be created to facilitate speedy justice on disagreement over water sharing and also disputes over water taxation. By strengthening institutions, a single chain of authority is required to carry out policy making, planning and management of water issues. Moreover, with the price, the state should offer some tangible benefits. Reliable and timely water supply, universal applicability of the rules and regulations under a democratic and efficient system, and rational allocation of water among various competing sectors are some of the prerequisites for the smooth implementation of the water pricing.

### 3.3.3. External support

*3.3.3.1 Facilitating negotiation "honest broker"*
External intervention and assistance can sometimes facilitate the negotiation of water resource sharing agreements. The Indus River Agreement between India and Pakistan is one of the success stories of such external intervention. The World Bank played a significant role in bringing these two hostile countries to an agreement in 1960, to share and develop the Indus River. Recently, the Bank has also facilitated two international river agreements: on the Orange River between Lesotho and South Africa; and on the Incomati between Swaziland and South Africa with the concurrence of a third riparian, Mozambique. The role of the Asian Development Bank in recently bringing the four lower riparian countries of the Mekong River basin into co-operative agreement should also be mentioned. Where riparian countries have been able to establish co-operative arrangements, successful and sustainable development programs follow. In many cases, however, riparian countries in the South are unable to establish institutional co-operative arrangements because of their concern regarding existing and future water rights. Mutual

suspicion and uncertainties of reciprocal action obstruct constructive engagement. To overcome such obstacles, EU/EP can possibly provide credible and impartial international assistance to start the process of co-operation. Gradually, it will help to increase mutual trust and confidence among the basin riparians in order to achieve collective action.

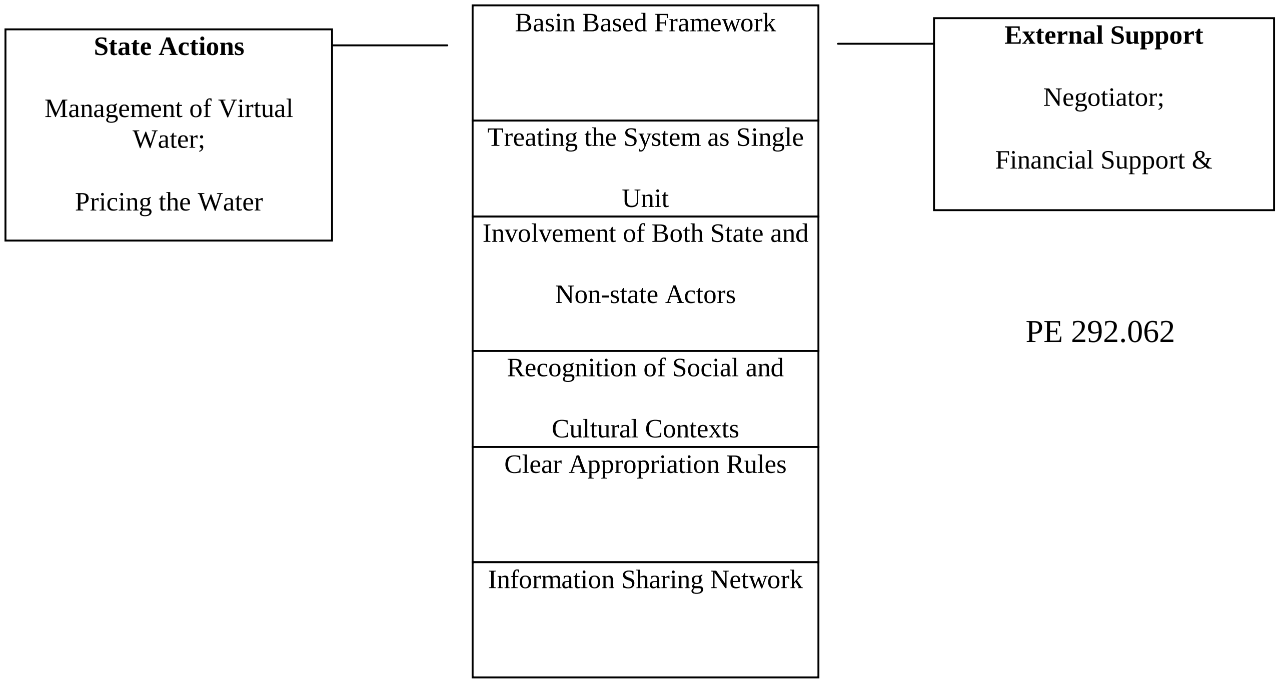
*3.3.3.2 Financial and technical assistance*

Formation of river basin organisation encourages international collaboration and assistance for the river water development. As constraints on the resource grow, the opportunity cost for not co-operating is becoming clearer. The increasing scarcity of available freshwater per capita and lack of financial strength in the developing countries may gradually encourage the basin countries to co-operate in order to achieve optimal benefit of the shared water. Basin-based development of irrigation, hydro-power, water diversion or flood control projects can provide riparian countries greater net benefits than they could have achieved through purely state-centric development. Incentives for riparian co-operation for the basin level development can come from the EU/EP and bilateral aid programmes. EU/EP and member countries can play the facilitator role in encouraging collaborative efforts among the basin states. European and international financial institutions may even become critical to encouraging and leading new incentives.

## 3.4. Conclusions

The primary aim of this chapter has been to suggest some practical policy measures which basin states as well as the international community might be in a position to take, with a view to easing tension over shared water resources, facilitating co-operation among co-riparian states -- and, in the long run, avoiding tomorrow's potential conflict over the world's water. It is true that the measures proposed here would be far from easy to implement; some would prove highly difficult to secure into place. Challenging as they may be, however, such comprehensive measures are of primordial importance: they represent the crucial core of initiatives aimed at overcoming the institutional deficiencies within existing international organisations and rules, in an effort to build and strengthen water-regulatory institutions both at the national and basin-wide levels. Only then will greater co-operation be possible.

***Figure 3.1.*** *Comprehensive Approach for Lasting Co-operation on Shared Basins*



# 4 STRATEGIES AND POLICIES IN "WATER AND DEVELOPMENT"

## 4.1. Strategy and policy as pronounced in international processes

Strategic discussions and negotiations on water in development have been on the international agenda for several years but more pronounced since the initiation of the process leading up to the Rio-conference, where Environment and Development were interlinked. Since 1992 several processes in different settings have been and are bringing water higher up on the international and intergovernmental agenda. Such processes exist at intergovernmental and UN levels, within the European Commission, and as processes initiated within the framework of the new International entities Global Water Partnership and World Water Council. The strategic work within all these entities is of course very much depending of the mandate and organisation of the entity.

### 4.1.1. The UN-system and its committees

The UN system includes UN-organisations and agencies as well as different UN-committees and commissions with water on their agenda. *The Commission for Sustainable Development, CSD,* which is the intergovernmental commission to follow up the Rio-process, and the *Administrative Co-ordinating Committee, ACC,* and *its Sub-*

*committee on Water*, which is to co-ordinate the UN entities working with water issues, are the most important commissions and committees. An other important committee is *the UN Committee on Energy and Natural Resources for Development, CENRD,* consisting of governmental designated experts, including water experts.

Within the Rio-process the integrated approach to water management was emphasised, even though the integration of water and land management was almost non-existing. In the process leading up to Rio, the Dublin conference was the international conference to prepare water issues. The most important outcome of the Dublin conference were the Dublin principles:

- "Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment;
- Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels;
- Women play a central part in the provision, management and safeguarding of water; and
- Water has an economic value in all its competing uses and should be recognised as an economic good."

Agenda 21, the action programme from the Rio-process, is a politically negotiated document and as such "as appropriate" to be accepted by all governments. Within the follow-up to Rio, in the CSD, freshwater has been on the agenda in 1994, 1997 and 1998. In 1997 a *Comprehensive Assessment of the Freshwater Resources of the World*, a Swedish initiative, undertaken by eight UN-agencies in co-operation with the Stockholm

Environment Institute, SEI, and with scientific expertise, presented a strategy in which the linkage between water and food security was one of the key issues. It managed to raise freshwater on the international agenda but has so far not resulted in any increase in concrete actions.

In the Dublin process it was recognised that about 20 UN entities had some aspect of freshwater issues on their agenda, but no single UN organisation covers all aspects. This was the reason why the *ACC Subcommittee on Water* was assigned task manager for freshwater in the Rio-process.

Strategies for work undertaken by the different UN agencies are, of course, depending on their respective mandates. As poverty eradication is the main objective for the *UNDP* work, the main strategy includes to secure safe water for the poor. *FAO* and its water unit are responsible for issues related to water for food security. Both *WHO* and *UNICEF* are mainly working with issues related to the provision of safe drinking water supply and sanitation, where for *UNICEF*, in particular, access to safe water for the children is a priority. *UNEP's* mandate includes issues related to safeguarding of water for the environment within a sustainable water management. Within the *UNESCO* mandate education and scientific aspects of freshwater are important. Within the *WMO* mandate the hydrological cycle perspective, including meteorologic, climatologic, oceanographic and hydrologic aspects, is important. The *UN Habitat* is mandated to work with water issues from an urban and mega-city perspective, while *UNIDO's* mandate covers the industrial sector.

The different Rio-conventions, the *UN Framework Convention on Climate Change*, the *UN Convention on Biological Diversity* and the *UN Convention to Combat Desertification* all apply different perspectives in accordance with their respective mandates, as do the *UN Regional commissions*. The *World Bank*, having the broadest mandate, as defined in its Water Strategy of 1993, is granting loans to eligible countries for programmes within all the different sectors.
Co-operation between UN organisations and agencies is becoming increasingly developed. Still, the fragmented structure of responsibilities linked to water issues within the UN system makes the co-ordination role for *the ACC Subcommittee on Water* important and challenging. A review of the activities of the *ACC Subcommittee on Water* has recently been completed.

*The European Parliament should recommend the EU to co-ordinate its activities within the UN entities working with water issues in a development perspective.*

### 4.1.2. The European Commission

In 1997 the European Commission (Directorates-General for Development and for External Relations) contracted HR Wallingford (UK) and Office International de l'Eau (France) to prepare Guidelines for water resources development co-operation, "Towards Sustainable Water Resources Management: A Strategic Approach." The report was published by the Commission in September 1998. The overall objective for the study was that "Water Resources be developed and managed in an integrated and sustainable way for the benefit of all, based on a set of guiding principles." These principles included: institutional and management principles; social principles; economic and financial principles; environment principles; information, education and communications principles; and technological principles. The programmatic context for managing water resources equitably, efficiently and sustainably included: water resources assessment and planning; basic water supply and sanitation services; municipal water services; and agricultural water use and management. And the priority themes for action were: institutional development and capacity building; participatory structures and gender equity; natural resources management; expansion of the knowledge base; demand management and pricing; and awareness raising and communications. The study also focused on the preparation of programmes and the activities to be undertaken as aids to application of the Guidelines.

It was a very ambitious and well-prepared study and included many important aspects to water management. It has since then been disseminated widely and guides the EC work for water resources development co-operation.

A difference between that study and the current one is that the Guidelines are directed towards putting Integrated Water Resources Management into operation, where the integration mainly is sectoral integration and water resources planning. The objective for the current study is to concentrate on *Integrated Water Resources management for "water security"*. The current study is thus pushing integration between land and water, integration within the river basin between the upstream and downstream areas, integration between water quantity and water quality aspects, and integration between social and environmental aspects a step further.

*The European Parliament should recommend that this understanding of Integrated Water Resources Management applicable also to internationally shared waters should be guiding the EU work in shared waters' areas.*

### 4.1.3. The World Water Vision and the Framework for Action – The Hague-process

Two new entities within the freshwater arena were established in 1996, the *World Water Council, WWC,* and the *Global Water Partnership, GWP*. The WWC is an international water policy think tank with members including "professional associations, NGOs, UN agencies, bilateral development organisations and international development banks". The GWP is an international network open to "government institutions from developed as well as developing countries, UN agencies, multilateral development banks, professional associations, research institutes, NGOs and the private sector". The GWP is supporting Integrated Water Resources Management by collaborating with governments and existing networks, and by forging new collaborative arrangements. The GWP is working through its Associated Programmes to help match needs to available resources and will be working at all levels in society. To be able to do so the GWP has developed a system of regional Technical Advisory Committees.

At the *First World Water Forum* in March 1997, the WWC initiated the work on a *World Water Vision, "Vision for Water, Life and Environment*". This WWV, aiming at long-term analysis, solution-seeking and advocacy, and involving a large number of people and organisations all over the world, was presented at the *Second World Water Forum* in the Hague, March 2000, together with the *Framework for Action* to achieve the Vision for water. The *World Water Vision* was prepared under the guidance of the *World Commission for Water in the 21st Century*, created in 1998, and the *Framework for Action* by the *Global Water Partnership*.
The *World Water Vision* has initiated work on Regional Visions for many of the regions of interest for this study, for instance Southern Africa, Nile River basin, West Africa, Southeast Asia, South Asia, and the Aral Sea basin. Visions on Water for Food and Rural Development, Water for People, Water for Nature, Water in Rivers and Water and Tourism have also been developed. Intensive scenario work has taken place and that is forming the bases for the report's "Water Futures". The report presents the uses of the water today, threats to nature and to people such as pollution, rivers drying up, floods and droughts. In the part dealing with key water management issues, it describes the often very fragmented management systems of today. The discussion on water futures is including methodologies, for instance, for how to accelerate the productivity of rainfed agriculture or on valuing ecosystems functioning, but also some discussion on water management, particularly on the need for institutional reforms, pricing of water services and to make the managers responsive to users. It does also describe the different stages successful co-operation appears to evolve through: confidence building, co-operation,

international agreements, and international law and alternative dispute resolution. The key actions taken to achieve the future we want as presented in the report are: recognition of the crisis and the need for action; stakeholder representation in integrated water resources management; full-cost pricing of water services for all human uses; more public funding for research and innovation; and increased co-operation in international water basins. The report gives a very extensive presentation of today's water situation, future scenarios and the future we want, but it provides somewhat less on how to reach that future, which is according to the mandate for the WWV. The mandate is to mobilise the political will to act, which should be resulting from the process initiated.

The *Framework for Action* presents Themes for Action resulting from of an international process linked to the Vision process. The themes are: making water governance effective by putting integrated water resources management into practice, promoting transparency and participation, reform and development of institutional frameworks, and realigning economic and financial practices. Generating water wisdom includes raising awareness of water issues, investing in people, promoting research, development and demonstration, and improving information generation and sharing. The urgent water priorities that need to be tackled are, according to the report, protecting and restoring water resources and ecosystems, achieving water-food security, extending sanitation coverage and hygiene education, meeting the challenge of urbanisation, and improving the management of floods. For investing for a secure water future, there is a need for assessing investment needs, meeting the resource challenges and bridging the gap, and to develop measures to support financial flows.

The *Framework for Action* report clearly indicates that this is a first step in setting out future actions. The action needs to be taken at country and local levels with international and regional support and co-operation.

These very ambitious studies, both with stakeholder participation from the regions world wide, were presented and discussed at the World Water Forum by regional representatives, NGOs representatives for major groups, people at large but also by governments at the Inter-ministerial meeting. It is essential that actions be initiated as a result of the Forum. In that process the EU may play an important role in a co-operative effort among its member states, and as suggested below, promote linking of the suggested efforts to secure enough water for key human and environmental uses, to work towards overcoming vulnerability to droughts and floods and to depletion, and to overcome the threats to water and water use posed by pollution, economic driving forces, conflicting interests, etc. In working towards this kind of water security, the EU should also promote an integrated approach to water issues that implies sectoral integration, land-water integration, upstream-downstream integration, quality-quantity integration and social-environmental integration. Such approaches should also include integration of surface water, groundwater and the ecosystems through which they flow. It would be based on political commitments to, and wider societal awareness of, the need for water security and sustainable development of water resources.

*The European Parliament should recommend the EU to carefully review the outcome of the World Water Forum process in order to incorporate relevant parts of these strategies and policies in its own 'Water and Development" strategy.*

## 4.2. Principal strategies and policies for EU support to water and development issues

Investing in improved water management and stewardship is an investment in socio-economic development, environmental sustainability and conflict prevention. Water security is intimately linked to the current and wider interpretation of the security concept. It is vital for any country, and in particularly for those that have to cope with challenges in water short regions, to link overall water policy and management to the socio-economic and environmental objectives.

Strategies and policies for the European Union to apply in its work towards assisting developing countries and countries in transition in their struggle to achieve a sustainable water future need to alert countries to develop their own strategy. However, the EU in its work should influence the countries within the region where the EU is working, towards an increased *water security*; which could be translated as: to *secure water* for drinking and for food production, to *overcome vulnerability* to droughts and floods and to depletion and to *overcome threats* from pollution, salinisation, economic driving forces, globalisation and from conflicting interests that may be expressed by stakeholders/riparians - all in harmony with nature and the demand of vital ecosystems. In order to do so, there are some key areas where EU support would be strategic.

*By investing in key areas, the EU would be able to assist in tackling urgent water priorities such as to achieve water and food security, to extend sanitation coverage and* *hygiene education, to meet the challenge of urbanisation and to protect and restore water resources and ecosystems in order for the assisted countries to achieve sustainable development.*

Some of the urgent priorities identified should be tackled by application of relevant techniques and practices (see Appendix II); all need a mobilised will to act, manifested by policies and strategies. Although work to some extent has already been initiated, progress is too slow and the EU needs to exert its influence to accelerate changes so that water security can be achieved soonest.
In this work the EU should assist in developing National Water Policies. Key areas where the EU needs to establish clear policies and strategies for its support are: for raising awareness and developing capacity; for promoting effective and efficient water management at all levels; and for assisting in conflict prevention and towards co-operation over shared water resources.

### 4.2.1. Raising awareness, developing capacity and sharing of information for water security

The EU should support water awareness initiatives. People need to understand the threats to freshwater resources and the consequences of irresponsible and unsafe water behaviour to water users and custodians, and to socially adapt to a changing situation. A right to water does also imply responsibilities.

There is a need to target messages, to share information and to provide education and training, not only on single items but also on the framework in which they operate for the people concerned to fully understand the consequences of unsustainable water use. Practical ideas such as those described in Appendix II need to be conveyed to those concerned. The target audience would be farmers, industry, opinion leaders, youth, women, the people at large, etc.

*The European Parliament should recommend the EU to support awareness initiatives, and to assist in enhancing the sharing of information and data, among stakeholders, including between riparians of a river basin, and in a transparent process. In such a process it is important to include not only water specialists but also economists, planners, etc. EU's support might assist in building confidence and trust among the riparian states.*

Education and awareness on water and sanitation hygiene are important to assist the countries in meeting basic human needs. In order to secure adequate food supply, the EU might provide assistance for research and capacity building to generate and ensure the dissemination of smarter technologies and the exchange of knowledge of appropriate water management for food production strategies. In education, training and capacity building on land-use linked to food provision, it is important to establish that land-use also implies water-use. Awareness and knowledge of the relation between water and ecosystem functioning is another important area where support is needed. In this, increased water security would imply that key ecological systems are kept operational to secure the ecological goods and services that they deliver. Awareness building and education about increasing pollution of water systems as a consequence of unwise industrial processes, agriculture systems and domestic use need also to be conveyed.

*The European Parliament should recommend the EU to contribute to a better understanding of the processes linked to unwise industrial and agricultural systems and domestic use, and to training in techniques to combat such threats, including by application of changes in processes. The EU might also, by information sharing and education, help in establishing Early Warning Systems to develop increased preparedness towards hazards such as floods and droughts. In all types of awareness raising and capacity building, participation by target groups at relevant levels, including by women, needs to be ensured.*

#### 4.2.2. Management strategies and policies

Key to sustainable use of water is to apply a strategic approach for the equitable, efficient and sustainable management of water resources. In order to do so some basic principles should be alerted to, including the Dublin principles.

At the Rio conference in 1992, basis for action, objectives, activities and means for implementation of an "Integrated Water Resources Development and Management" were developed and agreed. The concept is now widely recognised, but it will require a suitable institutional framework, supported by appropriate laws and policies to be translated into actions. The EU might support countries in developing such National Water Policies and provide assistance in the establishment of proper institutional structures. Other aspects of management strategic work where the EU might provide assistance are for countries to develop Demand Management, agree on a "Best Possible Use of Water", and for countries within their water management to include both Water Quality and Water Quantity Management considerations, as both these aspects are of growing importance and are clearly interlinked.

*4.2.2.1 Integrated Water Resources Management*

Already in Agenda 21 the integrated approach was agreed. "Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilisation. To this end, water resources have to be protected, taking into account the functioning of aquatic ecosystems and the perennial of the resource, in order to satisfy and reconcile needs for water in human activities." The growing and incompatible claims for more water for irrigation, industry and household in municipalities or in or between regions of a country make it necessary to apply a management framework where all these aspects are integrated. In the integrated approach it is important to realise that water and land management must be integrated for all types of land- and water-use processes, including food production, forestry, etc. A land-use decision is also a water-use decision.

Integrated water resources management has to encompass both land use and crucial and welfare supporting ecological services in terrestrial as well as aquatic ecosystems and their linkages. Terrestrial ecosystems in the upstream watershed area have to be protected because of - besides valued biodiversity - their importance for groundwater recharge and dry season flow. Downstream aquatic ecosystems tend on the other hand to be victims of human land- and water-related activities upstream as reflected in altered river flow and seasonality and water quality deterioration. They therefore need to be protected because of their importance - besides valued biodiversity - as a base for local fishery and income generation.

To achieve water security, ecosystem values therefore need to be incorporated in decision-making and water resources management. An integrated approach has to be taken to land, water and associated ecosystems basin by basin. Moreover, catchments of expanding urban areas have to be managed as an asset for development that delivers a set of freshwater and ecological goods and services, on which urban long-term stability will critically depend.

An integrated approach to water management entails managing water supply and water demands for all sectors in the society, not compartmentalised but integrated. Such an approach includes provisions to manage increasing competition and the incompatible claims within and between societies, and between society and environment, and to reduce excessive demand on water while increase output per unit of water. Within the integrated approach to water management it is important not just to integrate the sectoral use of water but also to apply a spatial integration, such as between upstream and downstream parts of a river basin.

Integrated water resources management also implies a trade-off between competing interests, a trade-off where it may be difficult to always keep up both quantity and quality for all stakeholders but where negotiations might have to take place.
In order to apply a true integrated approach to water in all its competing demands, the multiple values of water, for health and survival, for ecosystem function, for food production, for industries and employment, etc., must be recognised. Without this it is not possible to ascertain equity considerations between different users, or an optimal development for the different regions and sectors. An integrated water resources management, finally, requires a regulatory framework and institutions for implementation.

*The European Parliament should recommend the EU to support the integrated management approach and facilitate provisions needed for its implementation. The EU should also support training of personnel to implement the Integrated Water Resources Management.*

*4.2.2.2 Demand management*

As is been described in the introductory chapter, countries and regions will, when the population to share the water resources is increasing and  complexity of different uses is growing, climb the "management ladder". At the most advanced stage where the resource per capita is rapidly decreasing towards water scarcity and the competing demands are growing and becoming more complex, a demand management needs to be applied. Demand management, an integrated management of the demands, pre-supposes that each unit of water is utilised so that the most desirable value is being accomplished at the least, acceptable cost. Within demand management technical and logistic challenges must be met to agreeable costs, inter-sectoral competition including water for the environment be recognised, and priorities be set in water allocation in order to achieve best possible use of water. Demand management is becoming increasingly necessary in areas with heavy exploitation of surface waters and overdraft of groundwater due to different circumstances or increased pollution of land and water due to different types of land and water use.

*The European Parliament should recommend the EU to support water scarce countries with increasing and increasingly complex water demands in their efforts towards demand management. In these areas increased water supply through intercontinental water transfer can only be a short-term solution, although other types of water transfer solutions might be needed.*

*4.2.2.3 "Best Possible Use of Water", BPUW*

"Best Possible Use of Water" is described in chapter 2. To reach the most efficient use of water should be seen as important in all water management, but the need to promote more efficient utilisation of water resources is most obvious in a water scarce situation, whether as result of natural circumstances, over-use or pollution. Water allocation purely based on water use efficiency might however conflict with social objectives including the meeting of basic human needs, etc. It is therefore necessary to consider equity aspects in water allocation. Human interventions in the landscape are necessary to satisfy various needs and wants, social and economic, but would to some extent be conflicting with the functioning of ecosystems. A BPUW is balancing these different aspects, a balance that might be different for different situations or regions. The BPUW is also implying a trade-off where a consensus situation is reached by negotiation.

*The European Parliament should recommend the EU to support the application of "Best Possible Use of Water" within all water management, within countries and regions and within national and international river basin or aquifer management.*

*4.2.2.4 Management of water quality, including implications of linkages between quality and quantity*

Water quality degradation is becoming an increasing problem in all parts of the world. Degrading water quality is found as a consequence of all use of water, to a varying degree. Water used for food production or for forestry may become contaminated or polluted by fertilisers or pesticides. Water may become salinised due to mis-management of irrigation schemes. Sewage water diluted from domestic sources or industry is another source to degraded water quality. Different techniques and practices to enhance water quality, to turn wastes into resources and to prevent spreading of pollutants are described in Appendix II.

From a management point of view it is important to note that there are also clear linkages between decreasing water quality and water quantity. A high degree of polluting effluents entering a water body is resulting in a decreasing amount of water of an acceptable quality. If an increasing amount of water is withdrawn from a water resource, a decreasing amount of good quality water will remain accessible. Linkages between water quantity and water quality are of importance from a human and an ecosystem health perspective, but also from an economic perspective. Loss of quality means loss of use options and/or higher costs of treatment. Managing water quantity and water quality together and integrated is therefore an imperative for sustained land and water productivity, ecosystem maintenance and sustained economic development. Historically and currently countries develop a water management by arranging for supply to users. Quality is, of course, an issue, but primarily the concern is to supply adequate amounts. Only gradually does concern include attention to what happens to water while used and, consequently what are the implications from disposal of waste water, i.e. the quality dimension.

*The European Parliament should recommend the EU to support the application of an integrated management of water quantity and quality for a sustained water security; the sooner in a development process, the cheaper and the more resource efficient.*

### 4.2.3. Policies for EU support for application of regulatory measures and institutions at international and national level

As described in chapter 2 and 3 it is essential to apply different types of regulatory measures to be able to achieve efficient, effective, equitable and sustainable allocation and use of water resources. Increasing water demands and competition for water makes such measures even more important, at sub-national, national as well as international levels. Application of different regulatory measures would increase conditions for governing the water wisely.

*4.2.3.1 Structural changes needed*

To achieve a better governance of water by applying regulatory measures, different mechanisms would need to be included such as

- *Legal and formal regulations and improved policies*. This would create an enabling framework for good governance;
- *Institutional development*, based on better inter-sectoral or inter-ministerial co-ordination, decentralisation and a greater involvement of local governments and the private sector, encouragement of both formal and informal institutions to tackle management rather than operational responsibilities. *River Basin Commissions or authorities* would entail an increased co-operation in management issues, and should ensure an Integrated Water Resources Management at national and international levels.

- *Economic incentives and sanctions*, which would be a result of market oriented and economic reforms and where involvement of governments in partnership with the private sector is essential.
- *Full participation* with involvement of all stakeholders such as local communities and the informal sector, with due respect to gender and youth aspects in key decisions on water resources management.

*The European Parliament should recommend the EU to support structural changes such as policy changes and legal changes, establishment and promotion of formal and informal institutions, with participation of all stakeholders that would contribute towards improved water management. EU should encourage and support this kind of improved governance structure at national and international/regional levels to ensure best possible co-operation in Integrated Water Resources Management of an aquifer or a river basin area. In such work different types of co-operative arrangements or "support groups" could be established supported by EU.*

*4.2.3.2 Different types of co-operative arrangements among riparians/stakeholders*

Within Europe exist comprehensive long-term experience of regional multinational co-operation over larger lake and river basins, under situations sometimes politically difficult. Even though climatic and geographical conditions differ considerably and therefore solutions of water-related problems can not necessarily be transferred, the way

to create legal and institutional frameworks for a regional co-operation, to start dialogues between countries and to involve different kinds of stakeholders, can be used as good examples in other areas. Of importance are also the experiences of the involvement of local authorities and NGOs in the regional co-operation and the creation of networks and twinning arrangements between authorities and organisations inside and outside the region.
One example that seems to be a promising approach is the transferring of experiences gained from the Baltic Sea co-operation to the Lake Victoria basin in East Africa. Within this Swedish initiative, the Lake Victoria Region Local Authorities Co-operation and the Union of the Baltic Cities have agreed to develop a co-operation and exchange experiences.

*The European Parliament should recommend the EU to offer its experiences in multilateral co-operation over larger lake and river basins to developing regions and encourage network building on all levels between national and local authorities as well as different kinds of organisations, governmental and non-governmental. Partners in such networks could also be private sector entities.*

*4.2.3.3 Regional "support groups" for legal and formal regulations and institutions*

For countries to establish and improve their legal and formal systems or develop relevant institutions or apply improved economic or social structures, there might be a need for assistance. Such assistance could be provided through regional "support groups" where relevant knowledge available within the region, both on land- and water-use, on management systems and on good governance, would exist. Such groups could serve as a platform where, upon request, exchange of experience of application of different regulatory and institutional systems, etc., could assist countries in their efforts towards an improved governance system.

*The European Parliament should recommend EU to assist in establishing or, where existing, developing such regional "support groups". These groups could also develop methodologies for successful information exchange to secure enhanced confidence building between the riparians.*

### 4.2.4. Policies for EU's support towards conflict prevention and mitigation in shared waters situations

Sharing of a water resource implies competition between existing demands. If the resource is the only one or the major one in a water scarce area where two or more states or competing groups exist within the river basin, the competition might result in conflict of interests. In many cases competition, however, could result in co-operation to maximise the benefits of water use in order to meet the growing demand. To ensure such co-operation, different types of institutional arrangements could be established. As described in chapter 3 co-operative arrangements among riparians cannot last if the riparians do not interact with and gain support from such institutions. Co-operation arrangements are needed for allocation of water resources among riparians, for salvation of threatened land/water resources, but also as an opportunity for the people with least water, and with the greatest and most direct dependence on it. In co-operation arrangements, the insurance of the participation of all stakeholders is absolutely vital.

It is, also within an international river basin, important to realise that attempts to increase accessible amount of water might have political implications for the whole region. Successful management of shared resources therefore needs to be within a shared vision of how to best share the benefits emanating from the joint river system. Successful application of demand management in an international river basin or an aquifer implies co-operation between the upstream and downstream countries in a spirit of true hydro-solidarity. This may entail improved legal and formal regulations and institutional development at international level. A development towards these kinds of structural reforms might be promoted by high-level political networks of relevant ministries.

*The European Parliament should recommend the EU to assist by supporting the establishment of such networks. The EU or its member state could also assist as a "third party" in peace talks over water within a shared waters area, for instance by establishing regional platforms for facilitation/mediation, where neutral EU-countries or representatives may be of assistance. Such platforms could be linked with the "support groups" as suggested in 4.2.3.3.*

*4.2.4.1 Support for high-level political networks of relevant ministries*

High-level political networks of relevant ministries might be an important step towards more sustainable co-operation in shared waters area where there is no legal agreement between riparian states, legal agreements between only some of the riparian states, or legal agreements covering only few of the issues that are of mutual importance for the riparian states. The EU member states have some useful experience in development of co-operation between riparian countries through such high-level political networks, in, for instance, the gradual development of the Rhine River Commission, including its extension linked to its increasing amount of subject areas. A promising example of high-level political network may be the Nile River Initiative, which is being developing. Another is the network operating in the SADC region.

*The European Parliament should recommend the EU to actively support establishment and development of high-level political networks for an improved water security.*

## 4.3. Policies and strategies to be applied at regional level

Policies and strategies to be applied by the EU within its work in the different regions would of course be based in the principal policies but be adapted to the specific circumstances for the different regions. A key principle, however, is of course that it is the primary interests of the countries in the region that needs to be the priority. The EU's work is to be geared to assist in meeting these interests.

Seven key challenges to provide water security were recognised by governments, participating experts and people at large at the Second World Water Forum in The Hague, March 2000. They are: meeting basic needs, securing the food supply, protecting ecosystems, sharing water resources, managing risks, valuing water and governing water wisely.

These challenges need to be met in order to achieve water security in the 21st century, to achieve safe water provision, to minimise threats and to overcome vulnerability, as defined in 4.2. The EU strategic work in the different regions, both those recognised in this study and in other regions where the EU is operating, need to take these challenges into consideration as they are of importance for the countries concerned.

### 4.3.1. Policies and strategies for increased food security and increased water security

Strategies for EU assistance to ensure access to food and safe water for people living in the regions where the EU is operating would need to be based in the principal policies, the region's prioritisation and the efforts to meet the above seven challenges. Increased food supply may include policy, investment and institutional reforms, to change incentive systems, improve markets and the situation for poor and marginal farmers. It could also imply generating and disseminating better technologies and exchange of knowledge of appropriate water management and food production strategies, both for rainfed agriculture and irrigated agriculture. Different techniques for ensuring implications of such strategies can be seen in Appendix II . The strategic work would also imply the EU supporting actions at the community level in order to provide local people, and especially the poor, with the means to guarantee their own food security and to improve water productivity for food production.

Minimising pollution to sustain secure and sustainable supplies of water of acceptable quality is a pre-requisite to ensuring public health and an acceptable quality of life. Linked to safe water is the need for access to acceptable sanitation. Safe drinking water does not only imply a sufficient quantity of water but also water of acceptable quality. Safe sanitation would imply sanitation that does not jeopardise the quality of the water that will be used by people or for the environment. Water quantity and quality need to be managed in an integrated manner. Different techniques and practices for improved water quality are presented in Appendix II.

Increased water security would also imply ensuring that key ecological systems are kept operational to secure the ecological goods and services that they deliver. Loss of species and habitat will reduce the biodiversity and result in a decline in fish production and further exacerbate demands for protein from livestock production and agriculture. It is essential for countries to find a proper balance between human needs and the intrinsic value of ecosystems.

*The European Parliament should recommend the EU to support countries in their efforts to recognise all aspects including ecosystem values within the integrated approach to land and water management.*

#### 4.3.2. Policies and strategies for EU assistance in meeting the challenges for the regions in the study within co-operative regional and national water policy

The EU should, in its assistance to the regions in the study, work in accordance with the principles as described above. An important target within EU assistance should be that the countries respond to their challenges, although maybe different in detail, within a co-operative framework for a sustainable and secure water future of the region.

*4.3.2.1 North Africa and Sahel*

*Challenges*: For Northern Africa as well as for the Sahelian region a key challenge is to define and implement an operational framework for sustainable water resources management that enables more efficient use of water and emphasises innovative and traditional small-scale solutions to water resources management. For the Sahelian region the possibility for people to survive from their small-scale rainfed agriculture is particularly crucial.

*Recommendation: The European Parliament should recommend the EU, in co-operation with the governments in the region, to support policies that would ensure key inputs also from poor and marginal groups in water managing, and make markets more accessible in order for the poor to get better livelihoods. In a longer time perspective the attention needs to be devoted towards land- and water-use in an overall integrated perspective.*

*4.3.2.2 Horn of Africa*

*Challenges*: As the Horn of Africa is the source area for the Nile River, the main challenges are political ones. Political stability and food and water security are, by the countries and by the people living in the countries, seen as the main challenges. To manage the competing demands between countries but also between sectors is a key challenge where the political will to co-operate is a pre-requisite. The Nile Basin Initiative has been initiated as co-operative arrangement to meet challenges both at political, technical and management level.

*Recommendation: The European Parliament should recommend the EU to support work within the framework of the Nile Basin Initiative, which would enhance the political will and commitment among the countries, technology transfer to and between the countries, and which might result in increased confidence and trust among riparians. Such work may also result in institutionalisation and harmonisation of legal aspects to set up monitoring systems for use of water resources and generate exchange of information and data between the countries. Co-operation between the countries of the Nile Basin could also optimise water use efficiency between the countries and improve potentials for integrated water management including water for crop production and farmer participation.*

*4.3.2.3 West and Central Africa*

*Challenges*: The main challenges at political level are to mobilise political will and create awareness about water issues including to enhance the quality of life for the people concerned; to create stable macro-economic environment; and to reform water resource organisations. At the management level there is a need for effective and efficient use of land and water resources for food provision, safe drinking water supply and ecosystem maintenance within an integrated framework. To provide for gender balanced water management is further seen as a challenge.

*Recommendations: The European Parliament should recommend the EU to directs its support towards actions at both national and transboundary level in order to promote co-operation between the countries. It might provide support to enhance good governance at all level in order for the countries to be able to develop integrated water resources management. The EU might also support improvement of land and water resources planning, allocation and regulation of water abstraction.*

*4.3.2.4 Southern Africa*

*Challenges*: At the political level agreements and co-operation over the shared water resources of the region are pre-requisites for development, and many of the existing instruments are weak. Implementation of the SADC protocol as well as of bilateral agreements is essential. Weak institutional structure in areas with high dependence on agriculture for livelihoods and increased water scarcity, degraded watersheds and with polluted water bodies are important challenges for improved integrated management.

*Recommendations: The European Parliament should recommend the EU to provide assistance for the efforts to implement the SADC protocol and bilateral agreements. It could also support efforts towards integrated water resources development and management within a framework of co-operation in the region. The EU could also* *support efforts towards shared management of international water basins to stimulate mutual regional economic development and for ensuring of adequate water for life-supporting ecosystems.*

*4.3.2.5 The Ganges and Brahmaputra River Basins*

*Challenges*: The challenge of the region at the political level is the sharing of the waters of the two rivers system. The agreement between India and Bangladesh on the sharing of Ganges' water still does not result in sufficient amount of resources in parts of Bangladesh during lean water periods, which caused infiltration of salinised ocean water into large parts of the delta area. The rapidly increasing population in a very densely populated region is a key driver to increased irrigated agriculture, which is a management challenge. Salinised and polluted water are decreasing the amount water of acceptable quality that is available for food production and for drinking water. To overcome these challenges is both a management and a technical problem.

*Recommendations: The European Parliament should recommend EU to gear its support to the area towards provision of adequate technologies for water saving irrigation, crop development water treatment and desalinisation, protection of the quality of surface and groundwater, etc. Any support should be provided within an integrated water management framework where equity is a major consideration in resource management and service provision.*

*4.3.2.6 The Mekong River Basin*

*Challenges*: At the political level, co-operation within the framework of the Mekong River Commission is the main challenge and an area where the EU might be supportive. At the management level, the challenges are the deterioration of surface and groundwater quality, sedimentation and deterioration of soil quality, degrading of ecosystems, wildlife and wetlands threatened by development activities and increased exploitation, degrading of public health from land and water borne diseases and competing interests from economic growth, environmental quality and environmentally sound cultural heritage.

*Recommendations: The European Parliament should recommend the EU to continue or intensify its support works within the framework of the Mekong River Commission. The parties to the Commission have agreed to co-operate in all fields of sustainable development, management, utilisation and conservation of the water and related resources of the Mekong River Basin, including irrigation, hydropower, navigation, flood control, fisheries, timber floating, recreation and tourism. This kind of support should promote international co-operation.*

*4.3.2.7 The Aral Sea Area*

*Challenges*: Today, the challenges at the political level would be to reach an increased co-operation between the riparian countries, including the upstream countries. The countries would need to agree on a formula for water allocation among and within the countries for hydropower and industry and for irrigated agriculture. As the Aral Sea area has been and to some degree still is dependent on irrigated cotton production, the economic structure and dependence on a single crop also will need political decisions. A framework for co-operation is established through IFAS. Not all the riparian countries are parties to that. At the management level the depleted river system and the Sea, the salinised areas, the water and land polluted by fertilisers and pesticides and the declining health of the population and the environment are the main challenges to overcome.

*Recommendations: The European Parliament should recommend the EU to increase its support for technical and scientific co-operation within the area. Increased support for <u>all</u> purposes is needed to avert the negative trend in the region and to provide acceptable living conditions for the people living in the area. A complex GEF-project is operating in the area. Increased EU co-operation within that framework would ensure improved health conditions trough food and drinking water and sanitation provision. It does also integrate environmental aspects where the EU might provide assistance.*

*4.3.2.8 The Euphrates-Tigris Area*

*Challenges*: In this area the key challenges are political. Co-operation among the riparians of the river basin of the Euphrates-Tigris rivers area is required, and the key challenge is equitable and efficient sharing of the resources and to be able to fully use the water resources for energy, irrigation, household requirements, etc. There is a Euphrates-Tigris Technical Committee, though very little is known outside on the ongoing work. Discussion on water issues within the region is part of the Middle East Peace process in which many organisations and countries are involved. With rapidly developed water resources in a water scarce part of the world, co-operation over the resources is the only possibility to reach a sustainable development. Water resources management and best possible use of water resources all have to be integrated in the challenge - co-operation.

*Recommendations: The European Parliament could recommend the EU to, from a pure technical point of view, provide technical assistance and co-operation to prevent the build up of and/or recuperate salinised areas and areas with high degree of water-logging. Any EU support to the area has to be evaluated from a political point of view. The EU might also play a role in facilitating provisions for a joint plan of action or a development framework for the whole river basin-area.*

*4.3.2.9 The Jordan River Area*

*Challenges*: The political challenges of the area are the sharing of the waters of the Jordan River and its tributary river, Yarmuk, and the sharing of the groundwater aquifers under the West Bank. The negotiations of peace agreements include discussions on sharing these waters. There is, not ratified, agreement between Israel and Jordan, and an interim agreement, still mired, between Israel and the Palestine on the sharing of water resources in the region. As in other contentious regions, co-operation over the increasingly over-utilised resources is a pre-requisite for any sustainable use of the resources. Co-operation between the riparians would, if succeeded, also provide for exchange of knowledge and techniques between them. At the management level a challenge is to apply the "best possible use of water" approach in a region where salinisation is one of the major problems, though of course the overall water scarcity is the key challenge.

*Recommendations: The European Parliament should recommend the EU to provide its support within the political framework. The EU may provide technical support, for instance, for the provision of efficient irrigated agriculture or safe drinking water supply and sanitation to the area or for different water management projects.*

## 4.4. Suggested EU interventions for increased water security

The following are the areas where EU assistance would contribute towards increased water security. Recommendations to that effect should therefore be made by the European Parliament.

**I. Work to support awareness raising, information sharing, capacity development, education, etc.**

- EU should contribute towards increased awareness and capacity, by education and training in land and water management and for different kinds of water use, and for implementation of integrated water resources management.
- EU should support measures towards increased confidence building between riparians, for instance, by establishing or strengthening "regional support groups" that could assist in data and information sharing, networking, exchange of experience linked to the application of different regulatory and institutional systems, etc.

**II. Work to support development of management strategies.**

- The EU should contribute towards establishing and strengthening management strategies and policies, through integration of relevant management strategies, such as demand management, strategies for "Best Possible Use of Water", and interlinked management of water quality and quantity.

**III. Work to support co-operative arrangements and conflict prevention.**

- EU should support the application of appropriate regulatory measures and institutions at international and national levels by different kinds of structural changes, co-operative arrangements between riparians/stakeholders for legal and formal regulations and institutions .

- EU should provide support aiming at conflict prevention and mitigation in shared waters areas by support high-level political networks of relevant ministries, providing management support, provide "third party" assistance, etc.
- EU should provide specific assistance to the selected regions in accordance with these principles and with the countries, regions or river basin's priorities as described.

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# APPENDIX I
# SELECTED REGIONS - WATER AVAILABILITY AND USE

Water scarcity is a major threat to development and food security in many parts of Africa, the Middle East and Asia. Every day tens of thousands of people die due to lack of safe drinking water and adequate sanitation. Already today about 460 million people, more than 8 percent of the world's population, live in areas of water scarcity, a number that is rapidly increasing. The main parts of those areas are situated in Southern Africa, Northern Africa, Middle East, and South Western Asia. Between 1900 and 1995, water withdrawals increased by a factor of over six, more than double the rate of population growth (UN/SEI, 97).

Water quality deterioration is causing health problems to human beings and to the environment. This is increasing problems in developed as well as in developing countries and can exacerbate water scarcity problems, which can be perceived in several of the selected regions.

Human activities in the landscape are imperative in order to satisfy societal needs. As there are clear linkages between land, water and ecosystems, a set of side effects tend to develop.

In the regional subsections, four types of environmental problems caused by such interventions and affecting the environment on which the human being is totally dependent, can be identified:

- problems referring to *land productivity deterioration*, mainly in terms of land surface crusting, impeding infiltration and plant production problems, exacerbating overland flow and erosion, and contributing to downstream floods and inundations;
- problems referring to *deterioration of wetland functioning* due to manipulations with their water determinants, for example intentional drainage of wetlands for agricultural purposes, altered groundwater tables, changes in river flow seasonality and therefore in water levels;
- *water flow changes in various ways*: deterioration by regime changes in response to land use changes, and depletion due to upstream consumptive use reducing the blue water flow by increasing the green water flow;
- *water quality deterioration by pollution*, thereby altering on the one hand water usability for various purposes, and on the other hand, aquatic ecosystems and biodiversity.

The key challenges of the different regions will be identified by distinguishing between challenges on the political level and challenges on the managerial level. The political level challenges are mainly referring to:

- *co-operation needs* generated by shared resources. Water scarcity can be the cause of disagreements and conflicts among nations. In several of the selected regions with shared water resources, co-operation over the scarce resource is of particular importance.

The second group includes challenges related to:

- *physical resources* referring to challenges related to land use/green water and challenges related to blue water;
- *ecological resources* referring to challenges related to aquatic ecosystems on the one hand, and terrestrial ecosystems on the other. Wetlands will also be discussed here, recalling that some types are of terrestrial origin (rainwater or groundwater dependent), while others are surface water dependent, e.g. riparian wetlands and floodplains);
- *livelihoods* referring to issues of water supply and sanitation, public health problems. Also cultural heritage is included in this group.

## 1. North Africa and Sahel

### 1.1. Water availability

The region covers the semi-arid, the arid savannah and the desert zones of Western and Northern Africa. Northern Africa includes Algeria, Egypt, Libya, Morocco and Tunisia; countries with no humid areas, where 93% of the land is estimated to be either desert (86%) or arid lands (7%) (FAO, 1987). Only some 7% of the land along the Mediterranean and Atlantic coasts is climatically suited for rainfed agriculture. The Sahel is here defined in its most strict sense (not to confound it with the Sahelo-Sudanian and Sudanian agro-climatic zones of the coastal regions of West Africa),

including the semi-arid parkland savannah and bush savannah in Senegal, Mauritania, the Gambia, Mali, Burkina Faso, Niger, Chad and Sudan.
A common hydrological feature of both regions is that annual rainfall is at least 3 times lower than the potential evapotranspiration. The effect of this huge climatic deficit of water is not only a severe experienced water scarcity for all management purposes but also a very limited (often negligible) recharge of groundwater resources.
Annual rainfall in the Sahel ranges from < 150 mm in the arid Saharan-Sahel to 600 mm in the Southern Sahel. Annual potential evapotranspiration ranges from 1800 - 2500 mm (Rockström and Tilander, 1998). For Northern Africa the annual rainfall ranges between approximately 20 - 300 mm (FAO, AQUASTAT). Of this already extremely low rainfall, some 90% returns to the atmosphere as green vapour flow (evaporation + transpiration) and only some 10% contributes to blue water flow. The consequence is that countries in Northern Africa are among the most water stressed on Earth, with annual per capita blue water availability way below 1,000 $m^3$.
Egypt is for reasons well known as a special case in the region, as 97.5% of its blue water resources originates from runoff generated in countries upstream in the Nile River basin. Due to the special management and policy implications that follows from this external dependency on water for development, Egypt is treated together with the countries of the Horn of Africa, being countries of the Nile River basin.
Ephemeral rivers carrying storm-flow of runoff dominate in the region. The Niger River, carrying the 2nd largest discharge among African rivers, passes through semi-arid and arid areas of Mali and Niger. In water resources assessments these two countries present

very low water withdrawals in relation to potential withdrawals (< 10%). This is explained by the Niger River, a blue water resource used to irrigate merely 65,000 - 80,000 ha/country (mainly for rice production). This indicates opportunities of irrigation expansion. However, it is dangerous to interpret such discharge data as a sign of water abundance in the countries, as most of the potentially cultivated area in Niger (~ 11 Mha) and in Mali (~ 26 Mha) is located geographically beyond the reach of economically viable irrigation supplies from the Niger River.

National averages of annual cumulative water flow parameters give only a rough indicator of water availability in these arid and semi-arid regions. To begin with rainfall is concentrated during a very short period of the year. In the Sahel, where rainfed agriculture is practised in regions with > 350 mm of annual rainfall (in < 350 mm areas we find pastoral communities like the Saharan pastoral Touareg community), the lengths of growing period (days when rainfall exceeds half the daily potential evapotranspiration) are only some 90 days (concentrated during May/June - Aug/Sept). Moreover, rainfall is highly erratic and falls generally as large, convective storms with high intensity. The result is an extremely high temporal variability of rainfall, resulting in frequent periods of dry spells during the rainy seasons (negatively affecting plant growth and strongly affecting risk perceptions/management among land users). The spatial variability of rainfall is also very large. The Sahel is characterised by a sharp North/South gradient of declining rainfall, where a 100-km move northwards roughly corresponds to a decline of 100 mm of annual rainfall. But the spatially most dramatic hydroclimatic characteristic is the effects of the convective nature of the rainfall. The result is that rainfall can vary enormously over very short (< 5 km) distances.

## 1.2. Water use

*1.2.1 Blue water use*

Agriculture is by far the largest water-withdrawing sector in all countries in the region. Countries in Northern Africa depend strongly on irrigated agriculture and account for around 50% of the irrigated area in Africa (FAO, 1987). It is worth noting that the Sahel and Northern Africa host the two countries on the continent with the largest irrigated land area, Egypt (with some 30% of the total irrigated land on the continent) and Sudan (with some 20% of the irrigated total). For the Sahelian countries (except Sudan) irrigation constitutes a relatively small part of the food producing sector (< 2% of the arable land area is under irrigation). In addition to the irrigation schemes in Mali and Niger, it is worth mentioning the expanding irrigation on the lower valley of the Delta of the Senegal River in Senegal (mainly for rice) (Belieres and Faye, 1992). Despite the relatively low blue water withdrawals, the relative proportion of blue water withdrawals by irrigation as compared to industry and households/municipalities is similar to the much more irrigation dependent countries in Northern Africa. Some 80 - 90% of the total blue water withdrawals are allocated to irrigation, 10 - 11% is used by industry and some 2 - 6% for domestic/municipal purposes. The reason why the blue water withdrawals, as a proportion of total withdrawals, are similar for both regions is explained by the fact that also industrial and domestic withdrawals are relatively higher in Northern Africa compared to the Sahelian countries. This is manifested by the difference in per capita withdrawals of blue water; countries in Northern Africa, which are suffering from chronic water stress, have at present an annual blue water withdrawal of some 550 $m^3$/p/year. For the Sahelian countries (on a country level having much larger blue water resources) the blue water withdrawals are merely some 260 $m^3$/p/year.

*1.2.2 Green water use*

There is no data available on actual green water use by different biomes, including crop land, grazing lands, parklands, wetlands and natural habitats (e.g., national parks). It is safe to say that green water flow constitutes by far the dominant flow (compared to blue water) affecting social and economic growth in the Sahel. Over 80% of the population make their living from agriculture, and as mentioned over 97.5% of the land is under rainfed farming. Basically no rural water uses, be it for economic production of biomass (food, cash crops, fuel, fodder, timber, fiber) or domestic use to cover drinking, hygiene, livestock, etc., are covered by the existing data on water withdrawals. The reason for this is that rural people live in landscapes upstream from the perennial river systems, and the water enabling their livelihoods is simply water flow that does not reach the gauging stations in the rivers (which form the basis for hydrological data).

The consequence of the above is that the most relevant water flow parameters for water development in the Sahel is the local water balance at a catchment or watershed scale (and not at the river basin scale). Here empirical research on agricultural water use shows that only a small fraction of the rainfall is used for productive purposes; less than 15% is used by crops to produce food, a figure that can be < 10% on degraded farmland with no fertilisation (Rockström, 1999). Direct evaporation from soil and interception constitutes by far the largest water flow in the water balance, accounting often for > 50% of the cumulative rainfall. Drainage can be surprisingly high (10 - 20% of rainfall in the Sahel) even in drylands due to high intensity rainfall events and weak root systems and low water holding capacities of soils. Surface runoff, caused by high intensity rains on crust prone soils, which are dominant in the Sahel, can amount to 10 - 25% of cumulative rainfall.

### 1.3. Water and environment

*Land degradation* (or desertification) is a serious threat to large portions of land in the region, which has cause and effect links to water. Water is a major cause behind land degradation through water erosion, caused by storm-floods carrying topsoil through gullies, via rivers to the sea. Land degraded by water is even more susceptible to water erosion than prior to degradation, due to aggravated soil crusting and reduced vegetation cover, leading to increased water erosion. Water erosion is also a major determinant behind experienced drought in the region. Agricultural droughts, caused by poor rainfall partitioning (only a small proportion of the rainfall infiltrates), is arguably the major cause (together with notorious soil fertility decline) behind the extremely low and in large parts of the Sahel actually declining crop yield levels. The high order implication is that *environmental degradation caused by water* (strongly related to land mismanagement/human intervention) is contributing to environmental degradation on a larger scale, namely through a decline in carbon sequestration in the soil that have negatively impacted emissions of greenhouse gases.

The growing pressure on water resources for both urban but especially for agricultural purposes (primarily for irrigation) is a threat to the ecology of natural habitats like wetlands, swamps and marshes in river deltas and lowlands. *Water quality deterioration* is a serious and growing concern in urban catchments throughout the region, and a serious concern in irrigated catchments in Northern Africa (e.g., salinisation problems in the Nile valley, salt intrusion in tidal sections of the Senegal River and the use of brackish groundwater for irrigation).

### 1.4. Regional challenges

Key challenges are the preservation and sustainable use of physical resources such as land and water (both green and blue), ecological resources, to maintain or enhance quality of life, and to co-operate over the increasingly scarce resources.

For Northern Africa this implies in particularly to define and implement an operational framework for sustainable water resources management that enables more efficient present use of water, and emphasises innovative and traditional small-scale solutions to water resources management (e.g., the *lac collinaire* (water harvesting system) in Tunisia for livestock and irrigation).

For the Sahelian region the key challenge would be to integrated watershed management at the lowest scale. The large majority of the population depends, and will depend for a foreseeable future on rain for their livelihoods. The challenge is more on integrated participatory land and water management.

In all these countries it is important to secure urban water quality, quantity and sanitation.

# 2. The Horn of Africa

## 2.1. Water availability

Countries belonging to the Horn of Africa are Eritrea, Ethiopia, Somalia, Kenya, Uganda and Sudan, mainly arid or semiarid countries. The only areas with an annual rainfall exceeding 1000 mm are the Ethiopian Highlands and an area covering the Kenyan side of Lake Victoria, Uganda and the southwestern parts of Sudan. Most of the rest of the area has a mean annual precipitation of <500 mm, northern Sudan and Egypt south of Giza <25 mm/year. Rainfall distribution in the Ethiopian highlands shows a distinct peak in the summer, while there are two rainy seasons in the Lake Victoria neighbourhoods. However, the evapotranspiration is high, particularly in Sudan and Egypt, and fairly even during the year. Only in the Ethiopian highlands and at the southwestern sources to Lake Victoria does precipitation exceed evapotranspiration. Access to green water is thus only possible in the upstream parts of the river system. In the downstream parts the blue water is mainly entering the country with the Nile River, as external water.

As all those countries except Somalia are parts of the Nile River drainage area, any data of water availability need to reflect that a large proportion of the available renewable water is actually shared water. So is 119 $km^3$/year of a total of 147 $km^3$/year of the renewable surface water of Sudan transboundary water. Kenya and Uganda are both Lake Victoria riparian states, Lake Victoria being part of the Nile River drainage system. Thus for Kenya, 17.2 of 27.2 $km^3$/year is internally renewable water and 10 $km^3$/year is incoming via bordering rivers, in this case to a large extent the Lake Victoria. For Uganda the corresponding figures are 35 $km^3$/year as internally renewable from a total of 62 $km^3$/year of renewable surface water, and 27 $km^3$/year entering via transboundary or bordering flow. Data for Ethiopia and Eritrea are not available. For Somalia a large part of the total renewable surface water of 13.2 $km^3$/ is entering the country from Ethiopia, 7.5 $km^3$/year is contributed by transboundary flow. Egypt being the downstream country in the Nile River system receives 65.5 $km^3$/year as transboundary flow of a total of 66 $km^3$/year renewable surface water. It is totally dependent on the Nile River. (All data are from Shiklomanov, 1997).

## 2.2. Water use

In the more water rich areas with small scale agriculture, green water use plays a role, but for the majority of the area the access to green water is very small as the main part of the evapotranspiration is actually evaporation and thus the vegetation would not benefit from it. In those areas even small-scale farming has to a large extent to rely on blue water. Egypt and Sudan are the African countries most dependent on irrigation.

The data on water use per sector should be seen as not quite comparable figures as they emanate from different years around 1990 depending on access to data. For Ethiopia with a total withdrawal of 2.21 km3/year, 11% is domestic use, 3% industrial and 86% agricultural use. Data for Eritrea do not exist. Kenya is withdrawing 11.09 $km^3$/year, of that 20% for domestic use, 4% for industrial use and 76% for agricultural use. Somalia has a withdrawal of 0.81 $km^3$/year and is using 3% domestically and 97% for agriculture. For Sudan the withdrawal is 18.6 $km^3$/year, domestic use is 4%, industrial use 1% and agricultural use 95%. Uganda, with a withdrawal of 0.2 $km^3$/year, has a domestic use of 32% industrial use of 8% and agriculture use of 60%. For the downstream country Egypt the withdrawal is 56.4 $km^3$/year, 6% for domestic use, 8% for industrial use and 86% for agricultural use. (FAO, 1995, World Resources, 1994-95).

As can be seen the figures for per capita withdrawal are not compatible; they do not reflect just the water use per capita but also the different hydro-climates, e.g. difference in evaporation.

## 2.3. Water and environment

Water is needed to sustain the environment and the surface water dependent ecosystems. An exceeding demand for water may have clear implications for land production as well as for the environment as a whole and in particularly in vulnerable areas. Such areas are the Awash Valley in Ethiopia, a valley system where the ecosystem and landscape is a consequence of the pastoral system, and the Jonglei area, an extensive wetland area in southern Sudan, within the White Nile system. Both these areas are subject to disputes over water. In both cases, the environmental values have been recognised though further investigations need to be done. Few of the larger river projects such as dams and water transmission projects have been subject to careful Environmental Impact Assessments. For the Awash Valley and the Jonglei areas, however, the EU has been one of the donors for the investigations.

## 2.4. Regional challenges

### *2.4.1 Political challenges*

As this region to such a large extent is dominated by the Nile River, including White and Blue Nile and thus the issue of shared water, any new water project needs to be seen in an overall framework. Conflicts over water in the area are at risk as there does not exist any other legal agreement on the Nile other than the 1959 one between Egypt and Sudan. However, within the Nile Basin Initiative, a Council of Ministers of Water Affairs of the Nile Basin Countries (Burundi, Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda) are seeking to co-ordinate their activities, aiming at establishing a Nile River Commission.

About 80% of the Nile water comes via the Blue Nile, from Ethiopia. Until 1970, demands for Nile water did not exceed the supplies available. Since then, Egypt, in particular, with its rapidly growing population, is using more than its available resources. The Horn of Africa countries, which are seen as the "water tower" of the Nile system, are poor in terms of natural resources, especially water resources, have not been able to create capital and thus have had a minimal human resource development, while the economy of Egypt has developed. Economic and political difficulties have so far hampered development of water resources in Ethiopia and Sudan, such as dams on the Blue Nile tributaries and in the Sudan. But the upstream countries are gradually developing an increased demand for water and want to develop and use the Nile tributaries. In 1997 bilateral discussions between Egypt and Ethiopia were initiated (Allan & Nicol, 1998).

According to Allan and Nicol (1998) what is needed to be done at political level is to:

- "nurture a new approach to sharing water and respond to sub-basin proposals within the Nile Basin;
- mobilise the necessary investment to stabilise and develop economies in the area; and
- put in place appropriate and sustainable agreements (where the EU may play a role)".

Other areas that are potential conflict areas are the Awash valley in Ethiopia and the Jonglei area in Sudan. Even though these areas are both situated within one country, they are subject to international disagreement. The Awash River system is an entirely Ethiopian internal system, which the Ethiopian government wants to exploit for agriculture, and that could constitute some 75% of all large-scale irrigated agriculture in Ethiopia. But in this area some 200,000 Afar pastoralists live. The Afar people are a large group, in Eritrea, Djibouti and Ethiopia, but the Awash valley is their main grazing area. The EU has funded a rehabilitation programme for Afar pastoralists in the Awash valley from 1993 to 1997 that, however, according to Allen and Nicol, had not addressed the underlying causes for the continuing conflict in the valley. This, of course, has to be seen in the overall water framework in the Horn of Africa.

In the Jonglei area a canal, one of the largest water structures ever to be initiated in Africa has been planned since the early 1900s. The region that is an important wetland region, the Sudd, is crossed by several arms in the White Nile River system. The canal would shorten the river course. It would maximise the supply for the downstream countries as this shortening would result in a lesser evapotranspiration. Part of the project was also to irrigate parts of the area. The intention was that the savings should be divided evenly between Egypt and Sudan. The construction of the canal started in 1976 in a peaceful period but was disrupted in 1983. This issue is still unsolved.

*2.4.2 At the management level*

Any political agreement or decision on water sharing or use in the area will have implications for development of land and water resources as well as for the environment. The quality of life for the people living in the area is thus heavily dependent on political will to co-operate. But implementation of the will to co-operate needs to be manifested by an integrated water policy where management would need to be based on equitable sharing, not just among the riparians but also between different demands.

# 3. West/Central Africa

## 3.1. Water Availability

West and Central Africa, here grouped to cover the countries with humid to sub-humid hydro-climate, include the following countries for West Africa: Benin, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Nigeria, Sierra Leone and Togo. Humid Central

Africa covers Cameroon, Central African Republic, Congo, Equatorial Guinea, Gabon, Sao Tome and the Democratic Republic of Congo.
These are all countries with large green and blue water resources, and with subsequent long periods of the year suitable - from a water perspective - to produce biomass (over 80% of the arable land has six months growing season in West Africa, a figure that attains almost 100% of the central African farmland). Annual rainfall ranges from 1,500 to more than 3,000 mm among the Central African countries, and from 1,100 to 2,700 mm in the West African countries. These are high rainfall depths, but it is worth reminding that spatial and temporal variability of rainfall is high (even though not as high as in the drier regions like the Sahel), which means that national averages only give an indication of water availability. For example the northern regions of some West African countries (like Nigeria) experience dry sub-humid conditions with relatively high occurrence of meteorological droughts.

A distinct feature characterising these humid and sub-humid countries is a relatively high blue/green water ratio. Green water flow constitutes "only" an average of 60 - 65% of the hydrological cycle, which implies high runoff rates and a relatively large proportion of perennial water ways. This is reflected in generally high to very high per capita blue water availability, ranging from 17,000 $m^3$/person to over 100,000 $m^3$/person in the Central African countries, and a range from 1,800 (Ghana) $m^3$/pers - 36,000 $m^3$/pers (Sierra Leone) for the West African countries.

The Democratic Republic of Congo (DRC) and Congo are hosting by far the largest river on the continent, the Congo River (see the SADC region). The Sanaga River basin catches its waters from a 131,500 $km^2$ basin area in Cameroon and sheds an estimated 65 $km^3$ of water annually into the South Atlantic Ocean. In the humid West African region, the rainfall rich highlands of Guinea is the source of water flow in the Niger River, which discharges an estimated 180 $km^3$/year into the South Atlantic ocean through the deltas in southern Nigeria.

## 3.2. Water use

*3.2.1 Blue Water Use*

For the Central African countries as a region, irrigation is underdeveloped, manifested in a low proportion of annual withdrawal of blue water being used for agriculture (26%). Industry accounts for 57% of the annual blue water withdrawals, while domestic uses account for 17%. This state of affairs is strongly affected by the limited exploitation of the Congo River, which captures its huge volumes of blue water flow (30% of all monitored blue water on the continent) from a basin hosting merely 10% of Africa's population (UNEP, 1999).

For the humid and sub-humid West African region, irrigated agriculture accounts for 60% of the annual blue water withdrawals. This is a higher figure than for Central

Africa, but still a low figure for African countries. Industry withdraws 31% and domestic uses 9% of the annual blue water extraction.

In general irrigation development for the two regions is far below the potential. For the Central African countries, irrigation covers merely some 0 - 0.5% of the total cultivated land (no data available for Equatorial Guinea and Sao Tome) (FAO, 1995, and AQUASTAT, 2000). The potential for irrigation expansion is very high, with irrigation being practised only on < 1% of the potentially irrigable land (in Gabon, Central African Republic, Sao Tome and Democratic Republic of Congo), and some 10% in Congo and Cameroon (FAO, 1995, and AQUASTAT, 2000). The situation for the West African countries is similar. Blue water withdrawal for irrigation covers only some 0.2 - 2.7% of the agricultural lands (no data available for Guinea-Bissau). Less than 5% of the irrigable land is under irrigation in Ghana, Guinea, Liberia, Sierra Leone, Togo and Benin), while some 13% of the potential is under irrigation in Côte d'Ivoire and 28% in Nigeria. Basically, for the Central African countries, the totality of the blue water withdrawals in agriculture are done through formal irrigation in larger irrigation schemes (generally > 100 ha). In humid and sub-humid West Africa the informal small-scale irrigation is much more predominant, especially in Nigeria, where the fadama irrigation systems, tapping shallow groundwater in lowlands/local freshwater wetlands, are common (covering some 30% of the traditional irrigation in Africa) (FAO, 1987, Scoones, 1991).

There is also an interesting potential for developing the extensive freshwater wetlands (flood plains) and coastal mangrove swamps found in, e.g., Nigeria and Ghana for aquaculture, and rice production (Akpata and Okali, 1986).

*3.2.2 Green water use*

From the above it is clear that there is a significantly higher proportion of blue water flow in the hydrological cycle in humid Central Africa and humid/sub-humid West Africa compared to all other regions of Africa. This is a result of higher runoff production related to the larger rainfall depths and higher rainfall intensities than drier areas, like the Horn of Africa (where blue water flow is low but important) and the Sahel (where less than 10% of the rainfall contributes to blue water flow).

Despite the large production of blue water, green water use still forms the backbone of livelihood security for a large majority of the population in West and Central Africa. Over 80% of the population depend on rainfall in rural areas for their food-subsistence and farm economy.

It is important to note that despite the seemingly water abundant state-of-affairs in the Central African and West African region, water resources - both rain and surface/groundwater resources - are very unevenly distributed. Also, rains, despite lower temporal variability than in drier semi-arid regions, are still highly erratic, with large variations between rainy seasons and within rainy seasons. The implications are that both agricultural and meteorological droughts affect biomass productivity (food, pastures, timber and fuel) in large areas of e.g., Northern Nigeria, Ghana and Côte d'Ivoire.

### 3.3. Water and environment

Water erosion, ranging from sheet erosion to deep gully erosion, is a serious water resource management issue in the humid and sub-human West African region. Water erosion is closely linked also to human landscape activities, with the most serious driving forces being deforestation, overgrazing and poor management of farmland. This forms a formidable water challenge in West Africa, as water erosion not only manipulates the partitioning of rainfall (with less root zone soil moisture and reduced groundwater recharge) but also results in large volumes of top soil being flushed from upstream lands to downstream floodplains, finally discharging into the Atlantic Ocean. And it does, of course, result in increased land productivity deterioration.

Wetlands cover an extensive area in both regions. The freshwater swamps in DRC cover some 80,000 $km^2$ and are the largest in Equatorial Africa (followed by the Sudd in the Upper Nile and the wetlands of the Lake Victoria basin). The floodplains of the Niger delta and the Chad basin are also extensive wetland areas (Groombridge, 1992). These wetlands produce crucial ecosystem services such as flood control, water purification, shoreline stabilisation, habitat for numerous fish and other wildlife, and many local communities depend on them for their livelihoods. Drainage of wetlands for formal agricultural development (e.g., paddy rice schemes) and/or aquaculture, presents both a socio-economic potential and an ecological and socio-economic threat (to local communities). There has been a tendency that services from natural wetlands have been taken for granted, which has lead to low priority being given by governments to management and conservation of wetlands. With rapidly increasing population pressure in coastal zones, the pressure to exploit coastal wetlands increases, with a subsequent urgent need for policies on wetland management.

According to UNEP (1997), areas along the West African coast (from Senegal to Nigeria) suffer from chemical deterioration of soil and surface water resources as a result of salinisation (often as a result of poor irrigation management), nutrient and organic matter loss (due to poor land management), acidification and pollution (due to industrial activities). This has a direct impact on both blue and green water resource management, as the largest portion (generally > 75%) of all water resources sometimes pass through the soil before reaching either the atmosphere or groundwater/rivers.

### 3.4. Regional challenges

Main challenges of this region are at the management level. There is a need for effective and efficient use of land and water resources, green as well as blue, to secure adequate water resources for the environment, including for ecosystem functioning, for food provision and for safe drinking water supply, and to enhance the quality of life for people concerned. This could partly be ensured through application of different techniques (see chapter 3) but has to be done within an integrated management framework.

# 4. Southern African Development Community (SADC) Region

The Southern African Development Community (SADC) comprises currently 14 member States; Angola, Botswana, DRC, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe, and two island states in the Indian Ocean, Mauritius and Seychelles. The SADC has a total land area of 9.3 million $km^2$.

## 4.1. Water availability

Most of Angola, Botswana, Namibia, South Africa, Swaziland, Zambia and Zimbabwe lie on the predominant topographical feature of Southern Africa, which is called Southern African Plateau. Most of Mozambique lies on the coastal lowlands. Northern Angola and most of DRC are within in the Congo Basin, while Malawi and Tanzania are dominated by the Great Rift System. Topography is important when considering the surface runoff and blue water availability.
Rainfall in the SADC region – that is generally arid and semi-arid – is very variable and often unreliable both in time and space. Generally, precipitation is higher in Tanzania,

northern Mozambique, Zambia, Angola, DRC and the highland in Lesotho, but less in Namibia, Botswana, South Africa and major parts of Zimbabwe.

Long droughts that are interrupted by severe floods are increasingly becoming critical. In the SADC region, an average of about 65% of the precipitation evaporates soon after it has fallen, and a small proportion is available as green water. It varies for different sub-regions, and it can for instance be as high as 83% in Namibia, the region's driest country. Below is the relation between precipitation/evaporation and the blue water availability, presented for the main international river basins of the SADC region.

***The Congo River Basin*** is the largest water system in the SADC region and also the most water rich with the highest proportion of both blue and green water. The average annual precipitation is estimated to be 1,500 mm. Within the Congo River basin is more than half of the water resources of the entire SADC region. The mean annual runoff at the river mouth, which gives an indication of the available resources of blue water, is 1,260 $km^3$/year.

***The Zambezi River Basin***, which is the second largest but maybe the most important river of SADC, is located in the middle of the region. Precipitation, distinctly seasonal, lasts for only five consecutive months and is unevenly distributed across the basin, which of course is influencing the availability of green water, with annual average of 990 mm. The northern part of the basin (Malawi, Tanzania, northern and north western

Zambia) have an average annual precipitation of about 1,200 mm, while southern and south western parts average around 700 mm. The mean annual evaporation is 870 mm for the entire basin, varying between 1,000 mm to 500 mm. The mean annual runoff, the blue water, is 113 $km^3$/year.

***The Orange River Basin***, which is the most developed of all rivers in the region, has very different climate in the upstream and the downstream areas. At the source in Lesotho, the average annual precipitation exceeds 1,800 mm, with an annual evaporation of 1,100 mm, compared to the downstream area, where the annual precipitation is less than 50 mm and the annual potential evaporation over 3,000 mm. The mean annual precipitation for the entire basin is 330 mm. Runoff at the mouth is 12 $km^3$/year. The availability of green water is thus much more predominant in the upstream than the downstream parts of the river basin. The downstream parts have to rely on "imported" blue water, transported by the river.

***The Okavango River Basin***, which is the most ecological vulnerable river, has a unique outlet of inland delta. At the Angolan part of the basin, the mean annual precipitation is 800 mm, while only 58 mm appears as precipitation at Rundu (Cubango sub-basin) and 74 mm at Dirico (Cuito sub-basin), thus leaving less amount of blue water for the delta area. At the head of the delta, at Mohembo, the annual precipitation is only 44 mm. Potential evaporation in the lower parts of the basin is in the order of 2,000 mm/year. However, the mean annual runoff at the delta is estimated to 11 $km^3$/year.

***The Limpopo River Basin*** has an average annual precipitation of 520 mm, while the potential evaporation is mostly in the order of 2,000 mm. Areas with most rainfall are in the South African territories, where annual precipitation is between 800 and 1,000 mm in the mountainous areas. It decreases both to the north in Botswana and to the east in Mozambique. Along the main stream of the Limpopo, it is about 450 mm. Some of the areas in the central part of the basin have an annual rainfall of more than 1,000 mm. Run-off is 7.3 $km^3$/year. As water availability is dependent on seasonal rainfall it may, however, vary considerably, which could be seen during the floods of early 2000.

## 4.2. Water use

Available data for water use is mainly representing blue water use. The major water-using sector in the region is agriculture (to a large extent irrigated agriculture), which uses more than 60% of the water withdrawn. Zimbabwe uses more than 80% of its water for agricultural purposes. Domestic and industrial sectors are the most increasing water use sectors. In 1996, water use for urban and domestic purposes was 11% of the total water use in South Africa. In Botswana it did represent 30% of the total water use in 1990. Although environment as the natural ecosystem is increasingly becoming a legitimate water user, it had not been included in the annually reported list and national water demand planning in southern Africa until recently. In South Africa in 1996, as an example, the estimated water demand for nature was 3.9 $km^3$, which was about 20% of the total demand in South Africa. This does include green water for small-scale rainfed agriculture.

**Table 4.1 Estimated water use for different countries in SADC region, 1995 (Mm$^3$/year).**

| **Country** | **Domestic & Industry** | **Stock** | **Mining & Energy** | **Irrigation** | **Nature** | **Total** |
|---|---|---|---|---|---|---|
| Angola | 1 720 | 272 | 15 | 750 | - | 2,757 |
| Botswana | 175 | 44 | 65 | 47 | - | 331 |
| DRC | - | - | - | - | - | - |
| Lesotho | 84 | 19 | 5 | 160 | - | 268 |
| Malawi | 730 | 23 | 5 | 1,820 | - | 2,578 |
| Mauritius | - | - | - | - | - | - |
| Mozambique | 135 | 65 | 10 | 3,000 | - | 3,210 |
| Namibia | 200 | 70 | 15 | 248 | 5 | 538 |
| South Africa | 10,397 | 368 | 1,937 | 12,764 | 4,702 | 30,168 |
| Swaziland | 25 | 13 | 2 | 331 | 140 | 511 |
| Tanzania | 1,690 | 70 | 10 | 10,450 | - | 12,220 |
| Zambia | 532 | 60 | 20 | 1,580 | - | 2,192 |
| Zimbabwe | 697 | 30 | 30 | 4,980 | - | 5,737 |
| **TOTAL** | **16,385** | **1,034** | **2,113** | **36,130** | **4,853** | **60,515** |

Source: Chenje & Johnson, 1996.

**Table 4.2 Population in SADC States**

| **Country** | **Population in thousands in 1999** | **Estimated population growth % 2000-05** |
|---|---|---|
| Angola | 12 600 | 3.1 |
| Botswana | 1 600 | 2.7 |
| DRC | 49 000 | 3.0 |
| Lesotho | 2 100 | 2.6 |
| Malawi | 11 000 | 2.0 |
| Mauritius | 1 160 | 1.1 |
| Mozambique | 16 500 | 2.8 |
| Namibia | 1 700 | 2.5 |
| South Africa | 42 100 | 2.1 |
| Swaziland | 970 | 2.8 |
| Tanzania | 32 000 | 2.6 |
| Zambia | 10 100 | 2.4 |
| Zimbabwe | 11 900 | 2.0 |
| **TOTAL** | **192 730** | |

Source: SADC, 1998, World Resources 1996-97.

## 4.3. Water and Environment

The competing water demands, in particular water for food but also for domestic use and for industry, is resulting in less water left for the environment, to maintain land productivity and wetlands, and other ecosystem functioning. There needs not only to be a certain quantity but also water of acceptable quality for support of the ecosystems. Some of them are more vulnerable and have thus more detailed needs.

Wetlands retain a large volume of water for ecosystem maintenance. The largest wetland in the region is the Okavango Delta in Botswana. About 10 $km^3$ of water flows into the delta annually. Of this, 95% evapotranspirates as green water. The delta area is estimated at 84,000 $km^2$. Kafue in Zambia is another inland delta/wetland. These wetland areas in the region support local communities in many aspects; deterioration of their functioning would have an adverse impact not just on the ecosystems but also on the increasing population.

The SADC region has numerous floodplains, which support the life of ecosystems and of many local communities. Zambia's famous Barotse floodplain, which controls the flow of the Zambezi River is an example. Mana Pools, which is on the Zambezi between Kariba and Mpata gorges, is Zimbabwe's largest floodplain. In Tanzania, important floodplain areas exist along the Rufiji River, and in South Africa along Pongolo River.
Estuaries are coastal areas where freshwater and seawater interact at the in river mouth.

They trap sand, silt and organic matter from both land and the sea. Estuaries in the southern African are important grounds for a variety of marine species and large number of both resident and migratory birds, but many of the estuaries are degraded and polluted.

## 4.4. Regional challenges

*4.4.1 At the political level*

In the SADC region, there are fifteen international river basins (see table on next page) with great potential for the socio-economic development of the countries that share them. These shared river basins contain most of the available surface water resources in the region. Although there are increased efforts at international regulation of these immense resources, most of the existing instruments for co-operations are very weak and not functioning well. As a part of the efforts to regulate the shared water resources in the SADC region, there is a SADC Protocol on Shared Watercourse System, a multilateral agreement, which was signed in 1995 in Pretoria.

Established agreements and co-operation over the resources are therefore a prerequisite for a sustainable development in the region. Implementation of the SADC protocol, as well as of bilateral agreements, is essential and an area where the EU can be of assistance.

*4.4.2 At the management level*

The main challenge is how to preserve physical resources as land and water, both quantitative and qualitative, while maintaining the ecological resources, the ecosystems and the biodiversity in a region with a rapidly increasing population pressure. Health of people as well as ecosystems needs to be secured in an area that today is developing an increasing number of water transfer schemes. A demand and integrated management needs to be applied, within a framework of co-operation.

**Table 4.3 Shared Water Resources in International River Basins in Southern African Region of SADC.**

| Shared River Basin | Basin Area ($Km^2$) | River Length (Km) | Mean Annual Runoff ($Mm^3$) | Basin States | Existing (Ex) or Proposed (Pr) River Basin Organisations |
|---|---|---|---|---|---|
| Buzi | 31 000 | 250 | 2 500 | Mozambique & Zimbabwe. | No Co-operation. |
| Congo | 3 800 000 | 4 700 | 1 260 000 | Angola, Burundi, Cameroon, Central Africa, Congo, DRC, Rwanda, Tanzania, Zambia | No Co-operation . |
| Cunene | 106 500 | 1 050 | 5 500 | Angola & Namibia. | - Permanent Joint Technical Commission between Angola and Namibia (Ex) |
| Cuvelai | 100 000 | 430 | Ephemeral | Angola, Namibia. | ---- |
| Inco-mati | 50 000 | 480 | 5 000 | South Africa, Swaziland & Mozambique. | - JPTC, tripartite committee between SA, Mozambique, Swaziland on their common waters, including Limpopo and Maputo River Basins (Ex)<br>- Komati Basin Water authority |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | between SA and Swaziland (Ex) |
| Lim-popo | 415 000 | 1 750 | 7 300 | Botswana, Mozambique, South Africa & Zimbabwe. | - Joint Permanent Techn. Committee between SA and Botswana (Ex).<br>- Limpopo Basin Permanent Technical Committee (Ex)<br>- Limpopo River Commission (Pr) |
| Maputo | 32 000 | 380 | 2 500 | South Africa, Swaziland & Mozambique. | - Joint Permanent Technical Water Commission, JPTWC, between Mozambique and Swaziland (Ex)<br>- JPTC, tripartite committee between SA, Mozambique, Swaziland on their common waters (Ex) |
| Oka-vango | 570 000 | 1 100 | 11 000 | Angola, Botswana, & Namibia. | - Permanent Okavango River Basin Water Commission (OKACOM) (Ex) |
| Orange | 850 000 | 2 300 | 12 000 | Botswana, Lesotho, Namibia & South Africa. | - LHWC between SA and Lesotho (Ex)<br>- Permanent Water Commission between SA and Namibia (Ex)<br>- Perm. Senqu/Orange River Basin Water Commission between all (Pr) |
| Pungue | 32 500 | 300 | 3 000 | Mozambique & Zimbabwe. | - River Basin Water Commission for Save and Pungwe Rivers (Pr) |

| | | | | | |
|---|---|---|---|---|---|
| Rovuma | 155 500 | 800 | 15 000 | Mozambique & Tanzania. | ---- |
| Save | 92 500 | 740 | 7 000 | Mozambique & Zimbabwe. | - River Basin Water Commission for Save and Pungwe Rivers (Pr) |
| Umbeluzi | 5 500 | 200 | 600 | Mozambique & Swaziland. | ---- |
| Zambezi | 1 400 000 | 2 650 | 113 000 | Angola, Botswana, Malawi, Mozambique, Namibia Tanzania, Zambia & Zimbabwe. | - Zambezi River Authority, ZRA, between Zambia and Zimbabwe (Ex)<br>- Zambezi River Action Plan (Ex)<br>- ZAMCOM between all Zambezi States (Pr) |

Nile River Basin, which is mostly out of the region, has now two SADC States as its riparian, namely Tanzania and DRC. Source: various sources including Ohlsson 1995, Pallet 1997.

## 5. Ganges-Brahmaputra-Meghna River Basins

The Ganges-Brahmaputra-Meghna is one of the largest river basins of the world. This 174-million hectare basin spreads over Bangladesh, Bhutan, India, Nepal and China (Tibet). The Ganges River originates on the southern slope of the Himalayan range, and on its way receives supplies from seven major tributaries. Three of them – the Gandak, Karnali (Ghagara) and Kosi – pass through Nepal, and they supply major portions of the Ganges flow. After leaving the Himalayas, the river flows in the south-easterly direction through India to enter into Bangladesh. It forms the boundary between India and Bangladesh for about 112 kilometres and then turns south-east to join the Brahmaputra River in the middle of Bangladesh.

The Brahmaputra rises from near Lake Mansarovar and, after running in China (Tibet) in an easterly direction, comes to the north-eastern part of India and then to Bangladesh to join the Ganges River.

The smallest among the three, Meghna, originates in the north-eastern part of India and then enters Bangladesh to join the combined flow of the Ganges and Brahmaputra. Of the total basin area of this massive river system, 62.93% is in India, 7.39% in Bangladesh, 2.58% in Bhutan, 8.02% in Nepal and 19.08% in China (Tibet).

**Table 5.1. Ganges-Brahmaputra-Meghna Basin**

| | Ganges | Brahmaputra | Meghna | Total |
|---|---|---|---|---|
| Area (1000 $km^2$) | 1 078 | 577 | 91 | 1 746 |
| Arable (1000 $km^2$) | 667 | 86 | 45 | 798 |
| Av. run-off ($km^3$/yr) | 522.80 | 537.32 | 59.80 | 1 276.1 |
| Energy Potential (MW @ 60% LF) | 944 000 | 54 000 | 2 000 | 150 000 |
| Pop. 1990-91 (M) | 416 | 80 | 39 | 535 |
| Water use per capita | 1.01 | 8.24 | 4.43 | 2.42 |

| | | | | |
|---|---|---|---|---|
| ($m^3$/ year) | | | | |
| Water use/unit cultivable land ($m^3$) | 0.57 | 7.27 | 4.33 | 1.50 |

Source: B. G. Verghese & Ramaswamy R. Iyer, Harnessing the Himalayan Rivers: Regional Co-operation in South Asia (New Delhi: Konark Publ. Pvt Ltd, 1993), p. 44.

### 5.1. Water availability

Water availability is very uneven, both temporal and spatial. Both the Brahmaputra and Meghna rivers are supplied mainly by monsoon rains; 80-85% of the total precipitation falls between May and September. At the slopes of the Himalayas, in the Brahmaputra source area, the annual precipitation is between 5,000 and 10,000 mm, while the mean annual evapotranspiration, although of course decreasing with increasing height, is 1,200-1,300 mm.

The Ganges river is also supplied by monsoon rains and snow, though less intensive. The annual precipitation is 500-1,000 mm, with areas around 2,000 mm. The rainy season is June through September. Evapotranspiration is 1,400-1,800 mm/year; less in the mountains (ESCAP 1995). This, together with intensive use of the water resource, results in the Ganges delta area experiencing several severe dry seasons.

### 5.2. Water use

The river system, which carries such a huge significance in the lives of millions of people in two countries, suffers from high seasonal fluctuations in its flow. Nearly 80% of the Ganges' annual flow takes place in the four months of July to October. This monsoon flow is not only sufficient, but it also regularly creates floods in India and Bangladesh. But, the dry-season runoff is not adequate to meet the requirements of these regions. For the last 50 years, India and Pakistan (later Bangladesh) have been in dispute over sharing the dry-season waters of Ganges.

From Table 1, it is clear that the waters of the Ganges River are extensively used and largely exploited compared to the other two rivers of the system. The Ganges River is the lifeline for the two most populous states of India: Uttar Pradesh and Bihar. The water of this river is used for irrigation, drinking water and industrial purposes. The river is also uses as an important navigation route. The Brahmaputra and Meghna rivers are largely unexploited in the Indian side as they flow through the hill areas in its north-eastern part. However, the Ganges-Brahmaputra-Meghna river basin bears significant importance not only for India but also for Bangladesh. The silt from the river system has built a large part of Bangladesh itself. Most of Bangladesh is directly dependent on the Ganges-Brahmaputra-Meghna basin and on the water that is "imported" by the rivers from the upstream countries, in particularly India. About 20% of the Bangladesh water supply is from groundwater.

The rivers provide irrigation, navigation, fishing habitats, water for domestic and industrial use. Also, their flows prevent salinity intrusion in Bangladesh. The water maintains the environment and ecology of the southern region of Bangladesh. This river system also constitutes the major source of future development of this underdeveloped region.

The main water use sectors are agriculture, which is using 85%; industry, ca 2%; and domestic use, ca 3%. The rest is unspecified. Due to extensive variations in water supply, there is a distinct predominance for irrigated agriculture through blue water utilisation. In Bangladesh the irrigated area has increased from 1,058,000 ha in 1970 to 2,933,000 ha in 1990. As the population of Bangladesh was estimated to increase by 25% between 1987 and 2000, there is certainly a distinct need for land and water for food production. (ESCAP, 1995).

### 5.3. Water and environment

A major environmental problem is deteriorated water quality due to extensive use of human discharge from intensive agriculture use of fertilisers and insecticides, industrial effluents and domestic sewage. The increased wastes tends to deteriorate land productivity and the ecosystem functioning. The deteriorating water quality is also decreasing the amount of water of acceptable quality, particularly during lean seasons.

## 5.4. Regional challenges

*5.4.1 At the political level - dispute and co-operation over water*

The dispute over the water of this river dates back to 1951, when Bangladesh was the eastern province of Pakistan. It originated when India planned to construct a barrage at Farakka, 18 kilometres upstream from the East Pakistan border. The plan included a 38-kilometre canal of 40,000 cubic feet/sec capacity, to take off from the barrage to supplement the waters of the Bhagirathi-Hooghly at the lower point. The official reason was that the diversion would make the current of water strong enough to flush off the silt and clear Calcutta port, which is situated on the Hooghly river. Beside that, the demands of a growing Calcutta city and the agricultural needs of the state of West Bengal induced the Indian government to go ahead with the project. With the independence of Bangladesh in 1971, it was expected that this dispute would be resolved to mutual advantage of both neighbours in view of the help rendered by India during Bangladesh's liberation struggle. Yet, the political realities in both countries blocked the path of a negotiated settlement of the dispute. The construction of the Farakka Barrage and the feeder canal were completed at the beginning of 1975. In the same year they were commissioned on a trial basis, following a short-term agreement signed by India and Bangladesh for 40 days of the dry-season period.

The years 1977, 1982 and 1996 are three important landmarks in the Ganges water dispute at Farakka. In 1977, the first five-year agreement for water sharing was signed.

When it expired in 1982, the agreement was not renewed but instead was followed by a couple of short-term measures. In 1996, the most recent agreement was concluded. In concluding the agreement in 1996, one major factor was the change of governments in both India and Bangladesh. Each was able to start afresh in a favourable political climate. The most important reason for the agreement seemed to be the fact that a higher flow was assumed to be available at Farakka than the data indicated. In the very first season after the treaty was signed, however, it became evident that the flow stipulated in the 1996 treaty was not available in the river, and that the flow at Farakka was lower compared to previous years. The result was a situation of embarrassment for the Bangladeshi government, which began to regard river flow data as a national secret. The political nature of the 1996 agreement on Ganges water did not encompass the notion of hydrological variations.

The massive population growth and intensified use of water in the agricultural sector has been multiplying the scarcity tendency of the water in the Ganges-Brahmaputra-Meghna basin. A Joint River Commission has been established by the two riparian countries since 1974, but it enjoys advisory power only. India argues that the augmentation of the Ganges water should be accomplished by diverting largely unexploited Brahmaputra waters to the Ganges. The proposal is to connect Brahmaputra with the Ganges through construction of a 320-kilometre long canal link, 120 kilometres of which would run through Bangladesh. This proposal is bitterly opposed by Bangladesh. Bangladesh argues, on the other hand, for building dams and storage facilities in the upstream of the

Ganges in Nepal and within its own territory to address the water scarcity issue in the basin.

*5.4.2 At the management level*

In the basin, the demand for water is rapidly increasing. Much of the basin is even now critically water short seasonally, while in particularly the Brahmaputra sources during the summer monsoon are water abundant. To meet the growing demand, there is a need for basin-based water management. Management of physical and ecological resources need to be properly integrated to successfully enhance quality of life for the people.

## 6. The Mekong River Basin

Six sovereign states – China, Burma, Thailand, Laos, Cambodia and Vietnam – share the resources of the Mekong River, the tenth largest river in the world, and together cover an area of 2.3 million square kilometres. The Mekong river drainage area is 0.79 million $km^2$. The part of the river system upstream the Golden Triangle, where Thailand, Burma and Laos meet, comprises to a large extent mountain ranges and highlands. About 70% of Laos consist of mountains, including parts at the border to Thailand where the river runs. The upstream 120 km of the river in Cambodia shows continuous rapids. The more even parts of the river are the ones where the river runs through the Korat Plateau in Thailand and Laos, and of course the delta area in Vietnam.

Close to Phnom Penh the tributary Tonle Sap River joins the Mekong River. The Tonle Sap runs between the Tonle Sap Lake and Mekong, sometimes in a reversed run.

The Upper Mekong basin is fairly unexploited but is becoming important as a generator of hydropower. In north-eastern Thailand, the Mekong system is essential for agriculture and fisheries. But it is of much greater importance for Laos, where most of the wet-rice cultivation is taking part in the vicinity of the Mekong that is the most populated part of the country. For Cambodia, the river is also a lifeline. The capital is well integrated with the river, and the river system provides water for water supply, irrigation, fisheries and navigation. For Vietnam the river is the main water supplier for rice cultivation. For the Lower Mekong basin, the river, thus, is essential for the bases of economic development of the countries.

### 6.1. Water availability

The Mekong region has a monsoon climate with a rainy season from May to September. Annual precipitation in the most upstream areas is 600 - 2,700 mm. The driest area, the Korat plateau, is receiving 1,000 – 1,600 mm/year, while the precipitation for the delta area varies between 1,100 – 2,400 mm/year. The temperature is fairly constant, 20-30$^{o}$C, with few exceptions during the year, and results in a high rate of evapotranspiration and abundance of green water (Ojendal-Torell, 1997).

According to Shiklomanov (1997) the population of 75 million (1994) in the river basin area would share an average of 505 $km^3$/year transported by the Mekong river. The following data (from the World Resources, 1994-95, but representing 1987) illustrate water availability in the countries of the Lower Mekong basin: The internal renewable water resources of Cambodia are 88.1 $km^3$/year; an additional 410 $km^3$/year entered the country from other countries. For Laos the internal renewable resources were 270 $km^3$/year; data for external contribution not available. Thailand's internal renewable resources were 110 $km^3$/year, and the external flow into the country was 69 $km^3$/year. Vietnam had internal renewable resources amounting to 376 $km^3$/year; data for external renewable resources were not available. The Burman and Chinese parts of the river basin are so small, compared to the country itself, that data representing the countries would not be representative for the part belonging to the river basin.

Arable land in percent of total land area (in thousand ha) is for Thailand 40% of a total of 51,089; for Laos 3% of a total of 23,080; for Cambodia 13% of a total of 17,652; for Vietnam 20% of a total of 32,549; and for China 7% of a total of 39,500 (FAO yearbook 1994). Data for Burma is not available.

## 6.2. Water use

Total annual withdrawal (blue water) for Cambodia was 0.52 $km^3$/year, of that 5% for domestic use, 1% for industry and 94% for agriculture. The total annual withdrawal for

Laos was 0.99 $km^3$/year, where 8% was for domestic use, 10% for industry and 82% for agriculture. For Thailand the total annual withdrawal was 31.9 $km^3$/year, 4% for domestic use, 6% for industry and 90% for agriculture. Vietnam had a total annual withdrawal of 28.9 $km^3$/year, 13% for domestic use, 9% for industry and 78% for agriculture. These data have changed since 1987 due to industrialisation mainly in Thailand and Vietnam, but new, compatible data are not available.

Data for green water use is not available, but the following land use figures, in percent of total land area, will give an indication (Arable land harvested/permanent pasture/forest and wood land): Thailand 17/2/26, Laos 2/3/53, Cambodia 10/11/24, Vietnam 20/1/50. Data for China and Burma are not available. The remaining part is not harvested arable land, wetlands, urban areas, etc (FAO, 1994).

**The Mekong River Basin Agreement**

The Agreement on Co-operation for Sustainable Development of the Mekong River Basin was signed in April 1995 by Cambodia, Lao PDR, Thailand and Vietnam. The Agreement covers the Lower Mekong basin with 78% of the area and 82% of the water discharge of the entire basin. The implementation of the Agreement is intended to protect and promote the interests of people living within the Mekong River basin through a co-operative regional approach to the development of water and basin related resources. The Agreement established the Mekong River Commission, MRC, to replace the former Mekong Committee/Interim Mekong Committee. The Upper Mekong countries, China and Burma, invited to join the MRC, currently participate as observers.

### 6.3. Water and environment

Competing demands for water resources is one of the key problems in the Mekong River basin. Conflicts over water use have become frequent. Increased water demand for irrigation and rice production may effect other water uses, such as inflows to hydropower reservoirs, salinity flushing, and urban and industrial consumption. Water shortage frequency seems to be increasing and quality decreasing. Freshwater fisheries are threatened, which can be a very serious problem as fish play a key role in local diets. Improved transportation on the rivers may adversely affect the hydrological regime, since improved transportation will require advanced improvement works. Competing demands also have resulted in that wetlands have been reduced both in area and quality throughout the region.

Unsustainable agricultural and forestry practices have resulted in that forests have been reduced alarmingly in all countries; protected areas are poorly managed; and land uses and agricultural practices may limit agricultural output. Soil quality and physical properties have deteriorated in some areas. Contamination by agro-chemicals and fertilisers has become a serious problem.

Urban environmental issues, due to rapid urbanisation, are similar, serious and growing throughout the region. Urban infrastructure development has lagged far behind economic growth. Many cities in Cambodia, Lao PDR and Vietnam still use the roads, sewers, drains and water distribution systems that were built half a century to a century ago. Conditions are often unhygienic, unsafe and undignified. Solid waste management is inadequate. Surface and groundwater in and around urban centres has become seriously polluted and sanitation facilities are lacking. Urban air quality is deteriorating in the large and many medium-sized centres due to vehicles, industries and coal-fired power plants.

Rapid industrialisation also contributes significantly to pollution of land and water resources even though it so far is concentrated around a few development centres. Hazardous waste from industry cause increasing problems. Air pollution and atmospheric acidification is a problem in Thailand and Vietnam due largely to the use of high sulphur oil and poor combustion technologies in industrial processes. Health for the people has not been given priority in the industrial development.

The coastal environment has been severely degraded along the region's long coastline through conversion into shrimp ponds, industrial and urban development and tourist resort development. Negative impacts include coastal erosion, vulnerability to typhoons and seawaves, mangrove forest destruction and loss of aquatic and marine habitats.

Rapid increase in energy demand/supply has resulted in serious effects on natural resources and the environment, both through the use of hydropower and coal combustion.

## 6.4. Regional challenges

Key Mekong River Basin Environmental Challenges identified for the Mekong River basin thus include the following:

- for *physical resources:* deterioration of surface and groundwater quality, changes in hydrological regimes due to development projects, intensifying and critical sedimentation, and deteriorating soil quality,
- for *ecological resources:* degrading of terrestrial and aquatic ecosystems mainly by development activities, fish are adversely impacted by development activities, wildlife and wetlands are threatened by development activities and increased exploitation, and biodiversity is declining,
- for *quality-of-life values:* degrading of public health resulting from land and water related diseases, subsistence economies threaten sustained environmental quality, and environmentally sound cultural heritage contributing to the socio-ecological systems is being lost.

The necessity for co-operation among the riparian countries is obvious. The co-operation needs to be undertaken within the framework of the Mekong River Commission.

External support is important, both via Asian Development Bank, UNDP, bilateral donors and EU.

# 7. The Aral Sea Area

## 7.1. Water availability

The Aral Sea was the fourth largest inland water body on the earth and had an original volume of about 1,066 $km^3$ and a maximal depth of 69 meters, most of it less than 30 meters deep. The precipitation in the plain area is 90 - 120 mm/year; in the upstream piedmont areas, 400-500 mm/year; and in the high mountain source areas, >2000 mm/year. The evaporation in the downstream areas is some 900 mm/year. Before 1960 this was balanced by the discharge by the rivers Amu Darya and Syr Darya – two thirds by Amu Darya and one third by Syr Darya. These were the only rivers reaching the Aral Sea. Groundwater discharge to the sea is 0.07-5 $km^3$/year. Most of the near-surface groundwater, though, is too high in salt content for it to be able to use without desalination.

The total drainage basin of the Aral Sea is 1.9 million $km^2$, of which 28% is in South-Kazakstan, 24% in Turkmenistan, 23% in Uzbekistan (including Karakalpakstan), 12% in Afghanistan, 7% in Tajikistan and 6% in Kyrgyzstan. The water reaching the Aral Sea before 1960 originated with 4% from South-Kazakstan, 1% from Turkmenistan, 9% from Uzbekistan, 6% from North-Afghanistan, 55% from Tajikistan and 25% from

Kyrgyzstan (FAO, 1997). This shows that the rivers are receiving most of their water in the upstream parts, and that the downstream countries are mainly confined to transboundary inflow of water. The downstream countries thus are getting a low but important proportion of blue water. The green water availability in the plain area is very low due to the low precipitation.

## 7.2. Water use

### *7.2.1 Consumptive water use during Soviet and post-Soviet time*

In 1919 Lenin decreed that the Soviet Union should become independent from cotton import. It became later the second largest cotton producer of the world, with over 90% of the production coming from the Aral Sea region. By the end of World War II, the production started to grow beyond a sustainable use of water and soil resources, which became evident by 1960. An increasing amount of irrigation canals and inter-basin diversion canals were created. Between 1965 and 1986 irrigation fields expanded from 5.6 to 7.6 million hectares. Of these, 4.3 million hectares were located in the Amu Darya basin and 3.3 in the Syr Darya basin, most of it in the most downstream areas where the evaporation is very high.

Water uses doubled during the same period. The main reason for this was the inefficient irrigation systems, where sometimes less than 30% of the water withdrawn for irrigation was actually used by the crops. Thousands of kilometres of irrigation canals, without

any linings(!), transported water over sandy soils. Many irrigation schemes were designed without adequate drainage. This resulted in a dramatic salinisation, and the mid-stream and downstream parts of the river now have a salinity of 0.9-1.1 g/l. Almost 30% of the irrigated land has a reduced crop yield by 20-50% due to salinisation. The sea lost two-thirds of its volume between 1960 and 1989.
The less productive conditions of the soils resulted in an overuse of fertilisers, herbicides and pesticides, sometimes 10 times the normal dose. This has resulted in heavily polluted water unfit for human consumption, both in the river systems and the shrinking Aral Sea, and in unproductive soils. Several serious diseases frequently occur, including hepatitis, typhoid, tuberculosis, throat cancer and birth defects, and are linked to the disastrous environmental condition. The mean lifetime expectance has decreased dramatically. Both the terrestrial and the aquatic ecosystems have lost most of their species.

### *7.2.2 Water use per sector today*

Today the main water use, which is more or less exclusive blue water use, in the Aral Sea countries is still for irrigation, and of that, a large quantity is still for cotton production. Of the area, 3% is used for cotton production in Kazakstan, 0% in Kyrgyzstan, which is too cold, 39% in Tajikistan, 32% in Turkmenistan and 40% in Uzbekistan. In 1996, the industrial water withdrawal was for the Aral Sea basin around

2%; in Kyrgyzstan and Tajikistan it was more than 2%, while the downstream areas withdraw less for industry (FAO AQUASTAT).

A very small amount of water is used for domestic use, in particular in the rural parts close to the sea. Data available through the FAO AQUASTAT (1997) show that 93% of the urban population is connected to a piped water supply in Kazakhstan, but only 26% of the rural population. For Kyrgyzstan the figures are 86% and 75%, for Tajikistan 90% and 20%, for Uzbekistan 89% and 66%, and for Turkmenistan (data from the national working group) 86% and 14%. It has, however, not been able to get figures on how many have a safe water supply more than 300 days a year. But the lack of safe water and acceptable sanitation is having an adverse impact on the health situation. For instance the child (under five) mortality rate is > 7% in the Aral Sea countries.

### 7.3. Water and environment

Water demand for the environment is, of course, not met, which is resulting in deteriorating land productivity and ecosystems, both terrestrial and aquatic. Wetlands in the delta area are growing dry and dead. The water regimes of the sea and the river systems are being drastically reduced and are heavily polluted by an over-exceeded use of fertilisers and pesticides. The entire area is an ecological disaster.

### 7.4. Regional challenges

*7.4.1 At the political level*

The disastrous situation, for the environment and for the people living in the area, is still the key challenge. This work is now co-ordinated by the International Fund for the Aral Sea, IFAS, to which all the riparians except for Afghanistan are members. A large, ramificated GEF project is a key element of the ongoing work. The EU is one of the partners, the EU/TACIS. However, the adverse trend of the depleting sea and its polluted environment has so far not been turned.

After the collapse of the Soviet Union, when all the republics declared sovereignty, the different political interests in the area have become tangible. Kyrgyzstan is facing economic problems, mainly due to a shortage of energy supplies from Russia and the neighbouring countries. It has therefore an interest in using the Toktogul reservoir in the upstream parts of Syr Darya for hydropower production. Uzbekistan, being a downstream country to Kyrgyzstan as well as an upstream/downstream country to Tajikistan, has possibilities for cheaper energy production through its own fossil fuel, but needs water for irrigation. Uzbekistan is thus heavily dependent on Kyrgyzstan to release enough water during summer time from the Toktogul reservoir and also on Tajikistan to do it, but Kyrgyzstan needs the water for winter energy production.

Tajikistan, being the upstream country in the Amu Darya drainage basin, is in charge of hydrotechnical installations put in place during the Soviet era and wants to exploit them.

Had it not been for its internal problems, the situation between Tajikistan and the downstream countries might have been even more contentious. Afghanistan is also a riparian to the Amu Darya and will presumable be a more important water user once stability within the country increases; it would need to be part of interstate co-operation.
The political challenges in this area of shared waters are important, and the countries of the region will not be able to reach any kind of sustainable development unless all parties co-operate in the efforts towards such a goal.

*7.4.2 At the management level*

Within the political framework water management at all levels needs to be clearly improved. There is a need to revert the negative trend, to be able to "cure" and preserve land and water as well as the ecosystems and the biodiversity in order to restore public health and quality of life for the people living in the area.

# 8. The Euphrates-Tigris Rivers Basins

## 8.1. Available water resources

The Euphrates-Tigris river basin lies primarily in Turkey, Syria and Iraq. The catchment area is 423,800 $km^2$, of which 233,000 $km^2$ is that of the Euphrates, 171,800 of the Tigris, and 19,000 $km^2$ of the Shatt al-Arab, which is the part of the basin downstream of the confluence of the two rivers (Murakami, 1995).

The main sources of the Euphrates are within Turkish mountains, where a sub-tropical climate prevails with abundant but seasonal rainfall and a comparatively lower rate of evaporation as compared to the rest of the drainage basin. In southern Syria, the Khabour River is a major tributary and represents, at the same time, the most downstream contribution to the Euphrates. A little bit further downstream of this confluence, close to the Syrian/Iraq border, the Euphrates has its maximum runoff. The reason is a very high rate of evapotranspiration, together with a lack of rainfall or tributaries from the area below this point, decreasing the amount of water.

Before the commencement of the construction of the large dams in Turkey, which will be commented on below, the mean annual runoff at the Turkish/Syrian border was, on average, about 30 $km^3$/year. The Khabour River in Syria added ca 1.8 $km^3$/year. Iraq used to receive on average 33 $km^3$/year at Hit, which is 200 km downstream from the Syrian border. This has been reduced considerably since the development of water regulation and storage schemes during the 1970s and 1980s. In 1989, when the Atatürk dam, the largest Turkish dam, across the Euphrates fairly close to the Syrian border, was completed, some 80% of the natural runoff had been regulated. (Murakami, 1995).

The Tigris River has a number of tributary rivers in Turkey, but unlike the Euphrates, it also receives water from four tributaries south of the Turkish/Iraq border, and some of the contributions originate in Iran. So far, the construction works of large dams have not come as far as the ones on the Euphrates River. The runoff depends on snow and rain in the highland areas and varies considerably over time. 53% of the mean annual flow is from March through May. Heavy flooding occurs some years. The minimum flow conditions are from August through October when, in all, only about 7% of the total annual discharge is recorded. The mean annual runoff at its confluence with the Euphrates is 48.7 $km^3$/year. (Murakami, 1995).

## 8.2. Water use

Historically, water in the region has been used mainly for food production. Still, the data available show a strong dominance for water use for agriculture. In 1996, the following situation was reported: for Iraq water use for agriculture was 92%, for industry 5% and for domestic use 3%; for Syria, 83% was used for agriculture, 10% for industry and 7% for domestic use. Since these two countries to a large extent rely on the Euphrates-Tigris, thus on blue water, the figures may be seen as a rough expression for the dependence of the main sectors of the economies on the basin resources. In the case of Turkey the situation is more complex, and the reliance on Euphrates-Tigris, although quite important, is not dominating as it is in the downstream riparian countries. For

Turkey as a whole, about 57% of the water resources were used for agriculture, 19% for industry and 24% for domestic use (World Resources, 1996).

*8.2.1 Water abstractions for blue water use*

A significant characteristic of the basin is, on the one hand, a low level of socio-economic development, rapid population growth, weak integration in the national economic and social system and, on the other, a considerable potential for agricultural development and hydropower generation. Most of this potential is within Turkish territory. To develop this potential, it is necessary to harness the water resources of the Euphrates and Tigris. It is important to note that the variation in the seasonal and inter-annual flows of the rivers is quite substantial. For the Euphrates, for instance, the flow at Birecik near the Syrian border ranged from 15.3 $km^3$ in 1961 to 42,7 $km^3$ in 1963. At Hit, which is located in Iraq, a peak flow of 7,390 $m^3$/sec (1969) can be contrasted with a recorded low flow of 850 $m^3$/sec (1930). All these figures are referring to the situation before the construction of the big dams, at natural flows. Today the flow has changed considerably. The tremendous variation in seasonal flow is, moreover, not correlated with the variation in the need for water in society, i.e. for agriculture.

Ideas and plans to harness the water resources of this “fertile crescent” and “cradle of civilisation” have a long history in the region. Water diversion works for irrigation in the Euphrates-Tigris system started already 4000 BC, at that time in Mesopotamia, the land of the present Iraq. At that time, water logging and salinisation was a major problem, a problem amplified by the irrigation methods of that time.

More sophisticated water diversions, through barrages and canalling of water, were introduced in the alluvial areas along the Euphrates at the beginning of the 20th century. But it was not until after World War II - for the benefit of 21$^{st}$ century society - that regulations of fluctuations of discharge started in the upstream parts of Iraq (Murakami, 1995).

Leaving aside the historical achievements, and the associated hazards of the so-called hydraulic civilisations, the contemporary efforts are mainly the result of ambitious programmes, developed and gradually implemented over the last few decades. The most grand scheme in the area is the GAP regional development project in south-eastern Anatolia in Turkey. From its initiation in 1977, a regional development package has been elaborated and partly implemented. Its main components include 21 dams, 19 hydropower plants and plans for irrigation facilities to 1.7 million hectares. It is, thus, quite a huge project with an official budget of. US$ 32 billion (figures are a few years old).

During the1970s Turkey initiated construction of a series of dams in the Euphrates River at Keban, Karakaya and Karababa/Atatürk. In Syria, the Tabqa dam is a major structure from 1974. The Atatürk, which is the largest dam in the region, was ready for operation in 1989 (Kolars, 1994, Unver, 1997, Altinbilek-Akcakoca, 1997). The dams were initially intended mainly for hydropower generation but are now important sources also for irrigation. It is important to note that multi-purpose projects entail trade-offs. To reap the full potential of water resources for irrigation, it is not possible to generate as much electricity as would otherwise have been possible, and *vice versa*.

Water abstractions from the Tigris River are, so far, primarily within Iraq. The earliest ones are the most downstream ones, initiated just before the World War II. Barrages are used for diverting flood control water or for irrigation. The Mosul Dam in the most upstream Iraqi area is a much later construction and used for hydropower, irrigation and flood control. Several of the upstream constructions were initiated as late as at the end of 1980s, though not all of them have been completed.

*8.2.2 Water use and its implications*

The river development works and the associated facilities for diversions to extensive agricultural fields, where irrigated agriculture is to be practised, have, of course, significant consequences. Urgent development needs and considerable potential in terms of natural resources - in certain parts of the river basin – is the raison d'être for the projects. But it is inevitable that these kind of river and regional development projects will result in a reduced water availability in other parts of the basin. In addition, the implications on water quality might be considerable. In this connection it is, however, important to consider the benefits for upstream as well as downstream areas from a regulation of the riverine flow.

The hydrological consequences from the GAP regional development project depend to a large degree on the size and orientation of the irrigation system. In the official Master Plan for GAP, it is estimated that the consumptive use of water in the Euphrates portion of the basin amounts to 10,429 billion $m^3$ annually, or about 1/3 of the average annual discharge (before dam constructions) across the border to Syria. The actual reduction will, however, depend on many circumstances. The time frame for the development of the irrigation area is, for instance, quite uncertain and will probably be extended as compared to initial plans.

Because of the high rate of evaporation in the area, particularly in the southern segments of the basin and an erratic rainfall pattern which is poorly correlated with the agricultural seasons, the dependence on river water resources is significant. Ambitious plans for development of the river system have, however, given rise to tensions between the riparian countries. Construction and utilisation of the Atatürk dam has decreased possibilities for people in downstream areas to utilise river resources to the same extent or in the same manner as before. On the other hand, it has increased the possibilities for towns like Istanbul and Ankara to meet some of their energy demands from this source. Possibilities for the increasing population of Iraq to use Euphrates water are heavily dependent on the upstream countries. In the case of the Tigris, the contributions to river flow within Turkey are comparatively modest, which places Iraq in a relatively more favourable position (Kolars, 1994).

### 8.3. Water and environment

Increasing development of and dependence on the river resources is resulting in land productivity deterioration, salinisation and water logging. It is also decreasing the amount of available water in the downstream areas. Such impacts need to be included in an overall management framework.

## 8.4. Regional challenges

### *8.4.1 At the political level*

To be able to fully utilise the water resources for energy, irrigation, household requirements, etc., co-operation between the riparian states is required. Such co-operation would need to include not just water issues but also issues related to interethnic relations, etc. Needless to say, the interrelationship is very complex (Kolars, 1986, Schulz, 1995).

There are no existing legal agreement involving all the riparians. Apart from interests to benefit from the river resources in the three riparian countries, the relative abundance of water in the upstream parts of the Euphrates-Tigris area is of significant interest also for other countries in the Middle East, who are much less fortunate in this regard. Water resources of the Euphrates-Tigris are frequently alluded to in connection with attempts to stimulate of the Middle East peace process, in which many countries and organisations are involved. From the Turkish side, it is emphasised that water may be subject to commercial deals and technical co-operation, while the reluctance to consider the water resources of the Euphrates-Tigris as a direct component in the peace process is noticeable. There is a Euphrates-Tigris Technical Committee where all three countries are members. However, very little is known outside the committee on the ongoing work of that committee. It is difficult to obtain any reliable data on water abstractions and water flow of the rivers at different localities along the rivers.

*8.4.2 At the management level*

At the basin level, the main challenge is to find a formula for co-operation across national borders and jurisdictions. This, in turn, must be based on “best possible use” of water in the various segments of the river, and in the basin as a whole. It is, however, a difficult task to handle since “best possible use” in one segment may not be conducive the interests in other parts of the basin. The EU might play a role as facilitator to develop a joint plan for the basin where the interests and concerns of the various riparian parties are being negotiated and taken into due consideration. Support to a process that gradually may result in a more effective co-operation over water between the riparian states, and in a wider context is, of course, most worthwhile.

From a purely technical point of view, the EU might provide technical assistance and co-operation to prevent the build up of and/or recuperate salinised areas and areas with a high degree of water-logging. As evapotranspiration of the region is quite high and the soil contains salts easy to dilute, a major threat in, and from, the irrigated areas is water logging and salinisation.

# 9. The Jordan River Basin

## 9.1. Available water resources

The Jordan River has a drainage basin of 18,300 $km^2$ situated in five political entities: Lebanon, Syria, Israel, Jordan and the West Bank. The sources of the river originate in Lebanon, the Golan Heights and Israel, and are discharging into the Sea of Galilee. Ten kilometres south of the Sea of Galilee, the Yarmuk River, the largest tributary of the Jordan River, is entering it. The Yarmuk River has sources in both Syria and Jordan and forms the border between the countries before the confluence. When entering the Dead Sea, the Jordan River would have a natural annual flow of 1,470 $km^3$/year (Wolf, 1995).

The climate in the area is, except for in Lebanon subtropical areas, arid and has scarce, erratic rainfall and a very high evaporation. 80% of the area is arid or hyperarid. The mean annual precipitation for the area is 300 mm, and the actual evapotranspiration is 90-95% of the precipitation; the potential evaporation is of course much higher (Salem, 1994) The whole system is running below sea level, and the salinity is very high, except for in the Yarmuk River. The Dead Sea has a salinity that is seven times that of the ocean.

There are three principal groundwater aquifer systems west of the Jordan River. These aquifers recharge in the hills of the West Bank. The main one is discharging towards the Israeli Mediterranean areas and Gaza, a smaller one towards the northern Israeli areas, but the eastern aquifer, with an average discharge of 0.125 $km^3$/year, towards the Jordan River (Al-Khatib and Assaf, 1994, Shuval 1992). As this is highly depending on the erratic rainfall, the variations can be substantial. Thus available water resources are scarce, both blue and green water.

## 9.2. Water use

Water for use in the region is almost entirely through blue water, by water abstractions or by treated or desalinated water. Water use efficiency is a key to development of land and water resources in the region.

### *9.2.1 Water abstractions from the river system*

The main manmade abstractions from the Jordan River are the National Water Carrier, carrying water from the river upstream the Sea of Galilee towards the southwest parallel with the coastline towards the Gaza strip, and the East Ghor Canal, carrying water from the Yarmuk River east of the Jordan River to the Dead Sea. The amount of water leaving the system for the National Water Carrier is 0.5 $km^3$/year, or about 60% of the total amount of water entering into the Sea of Galilee. With the high rate of evaporation, the amount leaving the Sea is only 10% of what is entering. The abstraction from Yarmuk to the East Ghor Canal is ca 0.15 $km^3$/year, or about 1/3 of its total flow. About 0.1

km$^3$/year is diverted to the Sea of Galilee. The return flow from the East Ghor Canal to the Dead Sea is approximately 1/5 of the abstraction amount (Kolars, 1992, Wolf 1995).

Several other water diversion schemes have been planned and are included in the water negotiations of the region. Examples are the West Ghor Canal, which would divert water from the East Ghor Canal to support parts of the West Bank; diversion from the Litani River in Lebanon to Hasbani, one of the Jordan River sources upstream the Sea of Galilee; and other minor diversions (Wolf, 1995).

Lebanon and Syria are minor users of the water from the Jordan River. Very little of the water used is green water. Even in Lebanon, irrigated agriculture is dominating. The major source for Lebanon is the Litani River, and for Syria, the Euphrates river, but of course diversion of water from Litani River to Hasbani would influence Lebanon's water budget. Plans of an Arab Diversion of water from the headlands of the Sea of Galilee trough the Golan Heights to the Yarmuk River would have an influence on water access both for Israel and for Syria, since Syria is using a proportion of the water of the Yarmuk River for irrigation (Wolf, 1995).
As these diversions would have an impact on access to water for the different countries in the region, an impact that would vary from country to country, this of course needs to be carefully negotiated and mutually agreed. Co-operation over water is the basis for survival in the area.

*9.2.2 The use of water*

The main users of the water of the Jordan River are Israel, Jordan and the Palestinian and Israeli settlements on the West Bank and the Gaza strip, with the minor users Lebanon using water from the tributary Hasbani and Syria water from the Yarmuk.
Israel has a renewable natural annual water supply of 1.6 $km^3$/year, where 60% is groundwater, mainly from the West Bank aquifers, and 40% surface water almost entirely from the Jordan River. The Israeli water use is estimated to 1.8 $km^3$/year, where the excess is from wastewater reuse, desalination and was up to 1991 an overdraft of groundwater. Israel is using 73% for agriculture, 22% for domestic use and 5% for industry (Naff and Matson, 1984, Wolf 1995). Israel irrigates 66% of its irrigated cropland and is thus almost entirely using blue water for agriculture.

The West Bank settlements are using about 0.115 $km^3$/year, of which 90% is groundwater. The green water use is nil and 78%, entirely blue water is used for irrigation and 22% for domestic use. The Gaza strip population is overdrafting its accessible 0.06 $km^3$/year of renewable groundwater by another 0.035, of which 85% for irrigation and 15% for domestic use (Kahan, 1987). This is leading to serious problems of saltwater intrusion.

Jordan has a renewable annual water supply of  0.7 $km^3$/year, of which 50% is groundwater and 50% surface water, mainly from the Yarmuk River. It is overdrafting its groundwater resources by 0.17 $km^3$/year. 85%, mainly blue water, is used for agriculture, 10% for domestic use and 5% for industrial use (Garber and Salameh, 1992).

The total population in the Jordan area (Gaza, Israel, Jordan, Lebanon, Syria, and West Bank) in 1997 was 32 million and is estimated to become 57 million in 2025, an increase of 78% (Postel, 1999). As this would imply an increased overdraft of non-renewable water resources and an escalating water scarcity, both Israel and Jordan have given up hopes of food self-sufficiency and rely on international market for their increasing need of food supply.

## 9.3. Water and environment

As the water demand by different sectors in the area is high and increasing, the pressure on existing resources is important, and various water use efficiency techniques are being applied. This, of course, is also reducing the water use for the environment, which may result in a deterioration of land productivity, of water usability or of ecosystem functioning. According to Safriel (1999) 0.9-2.1% of regional annual renewable water is allocated for the environment, mainly in nature reserves and national parks.

## 9.4. Regional challenges

### *9.4.1 At the political level - water conflict and co-operation*

Historically, and in particularly during the last century and after World War II, disputes over water have taken place in this area. In 1953-55 the Johnston negotiations took place, resulting in the so-called Johnston accord aiming at agreement on water sharing between the riparians of the Jordan River. Even if not ratified, this agreement formed a foundation of technical discussions on day-to-day operations between Israel and Jordan, which has proven useful for the continuous process. (Wolf, 1995) Since then Water Wars, conflicts and disagreements mainly bilateral have been ongoing.

The peace process, resulting in the peace treaty between Israel and Jordan that was signed in October 1994, included an Israeli commitment to provide additional water to Jordan. In September 1995 an interim agreement between Israel and the Palestinians was concluded, where Israel for the first time recognised that the Palestinians have legitimate rights to West Bank water (Postel 1999). With the peace process still mired down it remains to be seen if this progress will continue.

### *9.4.2 At the management level*

As the countries sharing the Jordan River water resources, including the groundwater resources, are already overusing the existing resources and the rapidly increasing population is also resulting in an escalation of the competing demands for water, the challenges are enormous. The challenges are for an equitable water sharing between the riparian countries/entities, and for a possibility to adjust demands to supply. This would also be a process to preserve physical and ecological resources and secure the quality of life for the people living in the region. But there is a need for co-operation over the resources. The EU and its member states may have an important role as mediators and as suppliers of expertise. Such expertise could also be provided for instance for drinking water and sanitation or different water management projects.

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# APPENDIX II
# TECHNIQUES AND PRACTICES

## 1. Introduction

Before any water and development project is launched, investigations should be made to assess and evaluate *existing* techniques and practices for water extraction, storage, distribution, use, and recycling. To the extent possible, productive and non-productive water-related practices and techniques should be distinguished. Also, competitive water demands and avoidable and unavoidable tradeoffs should be identified. New, complementary or alternative techniques and practices should be identified with consideration to recommended management principles. While unproductive water losses should be kept at a minimum, efforts should also be made to maximise productive water uses, wastewater recycling, and non-harmful material return flows.

Water-saving and non-polluting practices within all sectors of society, particularly in agriculture, can be improved through information campaigns, professional training programs, community meetings, and school educational programs. To inform and educate private individuals and key individuals within the industrial sector of the ways, in which wastewater volumes can be minimised and wastewater recycled, is a crucial component for enhancing the availability and accessibility of usable water.

This chapter has been divided into two main parts: (i) measures to enhance water availability and accessibility, and (ii) measures to enhance water quality. The techniques and practices in each subchapter are not presented in priority-ranking order.

## 2. Measures to enhance water availability and accessibility

There are various techniques and practices by which the availability of water in the soil, aquifers or pipes can be enhanced, and by which available water resources can be made more accessible to water users. Yet, their suitability and desirability for various purposes depend on social, cultural, institutional and political arrangements, the technological, economic, and financial capacities, the prevalent geomorphologic and hydro-climatic conditions, as well as the objectives of the development project.

### 2.1. Water extraction and use

Freshwater can be collected or withdrawn from various sources in the landscape, namely from lakes, rivers, groundwater aquifers and even directly as precipitation or dew from the atmosphere. Irrespective of the type of source, water should be wisely extracted and used, with respect to its finite availability and vulnerability to quality degradation, and to the high and continuously increasing water demands in all sectors of developing societies. All water sources should be exploited at the lowest rates possible. The collected water should be allocated effectively and equitably among the various uses and users with respect to individual quality demands.

### *2.1.1 Wise use and management of groundwater resources*

In both developed and developing countries, the importance of renewable and non-renewable groundwater for societal development is increasing dramatically. Some 50% of all urban water uses world-wide rely on groundwater. Many of the most important cities in the world, including Mexico City, Lima, Dhaka and Jakarta, are heavily dependent on larger groundwater aquifers for urban water supply. In contrast, rural communities often depend on low-yielding boreholes in shallow aquifers (producing perhaps only 0.5 – 5.0 litres per second). In arid areas, where rainfall is low or virtually non-existent, groundwater (often non-renewable) may be the only source of water for the human population. While groundwater supplies are of obvious importance to cities in arid areas, they are also extensively used in humid areas – largely because they provide naturally purified water that requires little or no treatment (even for potable uses).

However, groundwater is a sensitive water resource; it may take considerable time to be replenished and the water moves very slowly within the aquifers. Therefore, once a groundwater aquifer has become contaminated, it may take very long time before the aquifer has become pure enough to be put into use again (if at all) and technical purification of a contaminated aquifer is a difficult and sometimes impossible task. Fossil or non-renewable groundwater is not, or to a very small extent, replenished and can thus be of considerable age.

Presently, groundwater is being exploited at an increasing rate in rural as well as urban areas, particularly in semi-arid and arid countries. High irrigation rates (relying upon groundwater sources) coupled with high evaporation losses in soils with low infiltration capacity (bringing little recharge to aquifers) result in fast depletion of groundwater aquifers. In cities with central water and sewage systems, often the extension of water infrastructure and wastewater handling capacity may not keep pace with the increasing service demands of the growing urban population. This could lead to uncontrolled disposal of untreated domestic and industrial effluents and wastes into water bodies and landfills, bringing contamination of groundwater aquifers as a result. Groundwater is not only affected by point-source pollution on the ground (i.e. solid or liquid waste disposals or accidental spills) but also by diffuse pollution caused by infiltration of water contaminated by substances in atmospheric dry deposition, contaminated rainfall, and polluted urban and agricultural runoff.

Sensible uses of especially fossil groundwater should therefore always be promoted. Groundwater use for large-scale irrigation and particularly for crops that are highly water consumptive (e.g. cotton and wheat) should be avoided to the greatest extent possible. In areas where no other alternative water source is available, groundwater should be pumped at the minimum rate possible and supplied primarily to low-water consumptive crops. At best, groundwater should be used at small scales only, and for activities or processes that require water of highest quality, e.g. drinking, cooking, hospital/health care, and some special industrial processes.

Improved management of groundwater aquifers utilised for urban water provision is urgently needed to mitigate actual and potential degradation caused by excessive exploitation and inadequate pollution control. Proactive and flexible management should be adopted involving continuos monitoring and evaluation and long-term planning. Emphasis should be placed on prevention rather than remediation. Groundwater aquifers vary in susceptibility to uncontrolled exploitation and in vulnerability to anthropogenic pollution. The vulnerability of aquifers needs to be assessed to improve protection of groundwater resources. The aim should therefore be to protect both quantity and quality of groundwater. An integrated approach to municipal, private and industrial groundwater utilisation and wastewater disposal is needed (it has never been achieved in the past). The aim for both urban and rural groundwater management is: (1) to conserve groundwater for potable and sensitive uses; (2) to maintain good yields of groundwater;

(3) to safeguard water quality; and (4) to handle solid waste and liquid effluents effectively.

*2.1.2 Rainwater harvesting to supplement irrigation*

Rainwater harvesting technologies combined with supplemental irrigation has proven to be a favourable approach for dry tropical regions to make better use of the erratic large intensive rainfalls. Instead of letting the rainwater wash away from the crop fields and feed into poorly used rivers or create damaging floods, it can be captured – to some extent – as runoff by simple technologies during intensive rainfalls, and hereafter used for supplemental irrigation during dry spells. After a heavy rainstorm, the surplus runoff can amount to 25-50% of the rainfall (in e.g. farm ponds, earth dams, and sub-surface tanks), but less than 1000 $m^3$ of water per hectare of farmland would be sufficient to supplement the primarily rainfed farmland during the critical water stress period (of 2-3 weeks) to avoid reduced harvests. To become cost-effective, natural gravity on sloping land should be taken advantage of for water conveyance.

*2.1.3 Rainwater harvesting for small-scale use of rainwater*

Rainwater harvesting for home-garden cultivation of vegetables, fruits, and nursery plants (primarily for cash-income generation) is also a cost- and water-effective strategy for coping with low and erratic rainfall and high evaporative demands in dry developing regions. Water is collected in simple buckets elevated 2 meters above the ground and dispersed over the plants by means of a filter, some tape, and perforated emitters. Small-scale farmers in India, Southeast Asia and Sub-Saharan Africa have successfully adopted such low-cost systems.

*2.1.4 Drip irrigation to reduce unproductive water losses*

Drip irrigation is another central technology that is recommendable for dry tropical regions where the evaporation losses from the fields generally are high. By dripping water directly to the cultivated plants from perforated surface or sub-surface pipes (at a low flow rate of 1-20 litres/hour), the crop is supplied with only the necessary amounts of water within a small soil volume near the roots and at the right time. Hereby, water consumption by weeds (weed evapotranspiration) and soil evaporation is dramatically reduced, and drainage losses and runoff are reduced to near zero. Instead, water uptake efficiency by the crop plant is greatly improved as well as the overall crop production output. Drip irrigation technologies are available for both large-scale commercial enterprises as well as for low cost small-scale farming systems.

*2.1.5 Desalination – an alternative for energy-rich countries*

At present, desalination of salty water (i.e. mainly sea and brackish, but also brine, waste, or river water) to produce freshwater is now only a realistic option for energy-rich countries in the semiarid and arid regions. The desalinated water is mainly intended for domestic and limited industrial uses, as it would be too expensive to use it for irrigation (with current energy requirements for desalination). For Middle Eastern oil-rich countries, desalination provides an important part of the water supply for households. More than 25 per cent of the world's desalination capacity is found in Saudi Arabia, followed by 12 per cent in the United States, 10.5 per cent in Kuwait and 10 per cent in the United Arab Emirates. However, even the best desalination plants currently in operation require nearly 30 times more energy that would be theoretically possible (which is 2.8 kJ for removing the salt from one litre of seawater). Through improvements in technology, the present energy requirement could be reduced to 10 times the theoretical minimum, at least.

The different desalination techniques are classified according to the energy required: thermal, mechanical, electrical, or chemical. The different techniques used are distillation, freezing, reverse osmosis (of sea or brackish water), and electrodialysis (of sea or brackish water). Essentially, each desalination method also differs in the amount of energy required. Some modern desalination facilities are now being run with electricity produced by wind turbines (e.g. in Egypt and Libya) or other solar electric technologies, such as photovoltaics (e.g. in Libya, Qatar, and Indonesia). Yet, most commercial desalination methods still take advantage of inexpensive fossil fuels. Thus, the key determinant of a nation's capacity to adopt desalination technologies is the availability of cheap energy sources and financial assets. At present, the greatest barrier to widespread desalination is the economic cost of available energy resources.

Alternative energy uses must thus always be taken into consideration – in addition to alternative water sources – when considering the option of desalination.

### *2.1.6 Mitigation of soil salinisation by drainage and effective irrigation*

Measures to mitigate and reduce soil salinisation is critical for the maintenance of soil productivity of farmlands in semiarid and arid (sub) tropical regions of the world. Soil salinisation, i.e. the accumulation of salts in the soil, is caused by either or a combination of three mechanisms. Firstly, the salts can originate from seawater that has infiltrated an over-exploited groundwater aquifer or has flooded the land. In for example the Ganges River delta, particularly in the densely populated area of Bangladesh, river depletion has caused the intrusion of seawater into the groundwater aquifers and into freshwater canals, threatening the area's food production capacity. Secondly, it can arise when the groundwater table is at a shallow depth and moisture is drawn to the surface by capillary force, bringing with it dissolved salts that are left behind when the moisture evaporates. This has been the case in the Murray-Darling in Australia, where deep-rooted trees were replaced by shallow-rooted grasses whose soil water uptake was much lower, causing rising of the groundwater table and salt accumulation. Thirdly, the salts may originate from excessive irrigation water (which always contains some percentage of salts) that has not properly drained off the field (so called waterlogging) and has left behind salts to accumulate in the soil. In regions with high potential evaporation rates, drainage to divert excessive irrigation water and salts has become a prerequisite for

maintaining the soil in an arable condition. Otherwise, a situation like the one in many arid parts of the Middle East, where salinisation has left large areas of previously cultivable land unfit for cultivation, may arise. The Aral Sea area is an example of a combination of the two last processes.
Technical measures to mitigate soil salinisation are of different types: leaching methods, methods to maintain high soil water content, drainage methods, different irrigating method, use of salinity tolerant crops, etc. Some are field technical methods and some are computer model methods. They have advantages and disadvantages, which very often are site-specific. Most importantly, mitigation of salinised soils should be approach from an *integrated* land-water management perspective. Salinisation of soils is practically unavoidable in the semi-arid and arid regions, and all measures available to mitigate this soil productivity-reducing process should be encouraged. Valuable irrigation water should be carefully applied and allowed to sufficiently drain off the land.

*2.1.7 Reparation of cisterns and pipes to reduce leakage*

Reparation of existent water storage and distribution systems should always be a high priority in developing countries, where leakage from broken pipes and cisterns have caused high unproductive water losses annually. Existing sewer lines should however not be extended, as they demand large water volumes that only increase the volume of wastewater and thus the cost of wastewater treatment.

## 2.2. Waste and wastewater practices

The conventional "end-of-pipe approach" to the handling of wastes is not a recommendable approach for a sustainable development of poor arid regions. Rather, efforts should be made to encourage *on-site* separation, local treatment and recycling. The central component is the physical separation of different wastes already at the source, in order to avoid the accumulation of wastes and wastewater that need later handling and treatment. In practice, this approach may build upon different stages of separation, i.e. separation of: (1) urine and faeces; (2) toilet water and greywater; (3) greywater and urine; and (4) greywater and industrial and municipal wastewater. Hereby, different types of wastewater can be reused for suitable purposes, with respect to their respective quality.

### *2.2.1 Handling of human wastes according to Ecological Sanitation*

Ecological Sanitation (Eco-San) is the alternative sanitary approach to the handling, purification, and recycling of human excreta. It has proven to effectively reduce health- and pollution-related problems in the developing world. The Eco-San approach has many advantages, not least for households where fertilisers are expensive and financial assets are limited. It is affordable, simple, ecologically sustainable, and as effective as any other modern sanitary method.

Ecological Sanitation can be practised with a variety of different techniques. Yet, all Eco-San systems involve the following two steps: (1) sanitation, when the faecal pathogens in human excreta are destroyed; and (2) recycling, when the sanitised excreta are reused as fertilisers. The system can be based on *urine diversion* or *no urine diversion*, i.e. the urine may be diverted from the faeces with "urine separating toilets", or permitted to mix with the faeces in a "mulching container". The sanitation process proceeds either in a *dehydrating toilet* or a *composting toilet*, depending on how the pathogens are to be destroyed. *Dehydration* requires less than 20% humidity and high pH to dry the faeces and destroy the pathogens, whereas *decomposition* requires more than 60% humidity for killing the pathogens. (20-60% humidity should not be permitted as it provides perfect conditions for reproducing harmful organisms). Dehydration with urine diversion is the most effective means to kill pathogens. (Table 1.)

Table 1 **Examples of ecological sanitation systems**

| **Examples** | **Urine diversion** | **No urine diversion** |
|---|---|---|
| **Dehydration**<br>(< 20% humidity) | Long-drop method (Yemen)<br>WM-ekologen (Sweden)<br>Twin chamber (Vietnam)<br>Twin chamber (Mexico)<br>Solar heated (El Salvador) | Earth toilet, Ladakh (India) |
| **Composting** | No-cost toilet (China) | 'Clivus Multrum' (Sweden) |

| | | |
|---|---|---|
| (> 60% humidity) | Solar heated (Mexico)<br>Multi-unit (Sweden) | Solar heated (Ecuador)<br>CCD (South Pacific) |

*Source*: Winblad in Drangert *et al*. (1997)

If correctly adopted, Eco-San practices could help to substantially improve present capacities of the developing countries to secure the demands of basic provision of sanitation, food, and water. Ecological alternatives in sanitation have been given increased prominence on the development agenda, not least by the Swedish International Development Cooperation Agency (Sida).

*2.2.2 Promotion of dual pipe systems*

A primary effort to reduce problems related to wastewater is the reparation of leaking sewage pipes and septic tanks. In fact, in poor regions with scarce water resources, central sewage systems should at best be avoided. However, such a stance could be counteracted by national policies promoting the privatisation of wastewater treatment plants.

Where pipe systems are preferred and/or existent, dual pipe systems should be promoted if affordable. These make it possible to distribute water according to the water quality requirements of different water uses. A dual pipe-system can be constructed in different constellations. Either, it could consist of two parallel pipe-systems transporting potable and non-potable water, respectively, to the user. Or, it could consist of two parallel pipe-systems leading water of non-usable and reusable quality, respectively, from the user.

The latter system is useful for areas where water-borne sewage systems are in use. The reusable water can be used for example to irrigate parks, sport fields and cemeteries. The main advantage of a dual pipe solution is that it saves a lot of water, by making it possible to substitute virgin water for reusable water, and also to use non-potable water for non-potable uses (thus saving the water of highest quality for potable uses only). Even though installation costs are high, the long-term benefits are important.

*2.2.3 Low-cost treatment of industrial and municipal wastewater*

Treatment of industrial and municipal outlets is centrally important, as they are responsible at present for severe pollution of lakes, rivers, groundwater aquifers, soils, and coastal waters in many parts of the world. Often in developing cities, only a smaller portion of the total wastewater volume undergoes treatment. Also, a large share of the residential settlements is not connected to any treatment plants, particularly in peri-urban and rural areas. Efforts to cope with such residential wastes and wastewater are also needed.
Treatment of contaminated water does not require advanced technological equipment and large financial resources to be effective. Low technology solutions are available for treatment of wastewater so that the quality of the effluent is not harmful to human or

ecosystem health. Although high-technology facilities would treat the wastewater effluent to a higher quality, their adoption by a developing region may be much likely to cause future problems when equipment deteriorates and breaks down.
The Orangi project in Pakistan and the Codominal project in Brazil are good examples of successful local initiatives at community level for treatment of wastewater.

*2.2.4 Irrigation with urine and grey water*

Agriculture is the main water consumer in practically every part of the world, especially in developing countries. By avoiding mixing grey water and urine with faeces, grey water and urine can be used for irrigation. Unlike urine (which is generally sterile), grey water may require some treatment, e.g. filtration in a smaller pond, before use. By reusing urine and grey water for irrigation, the need to extract ground- and surface water for irrigation purposes can to some extent be reduced.

*2.2.5 Reclamation of potable water*

Reclamation of potable water is successfully practised in Namibia. In Windhoek, for example, domestic water is directly reclaimed since more than 30 yeas for potable reuse without any negative health effects.

*2.2.6 Local water and sewage systems to reduce wastewater volumes*

Flushing-toilets consume large amounts of water for flushing, transportation, and dilution (about 40% of the total residential water demand). Support should instead be given to the installation of urine-diversion toilets, which do not waste any water for flushing and disposal. Also, these toilets make it possible to separate urine from faeces already at the source. Support should therefore be given to such local domestic sanitary practices. Conventional solutions with flushing toilets, entailing mixing, dilution, and end-point treatment of human excreta, should not be encouraged at best.

### *2.2.7 Artificial groundwater recharge*

Artificial recharge of groundwater can by advantage be practised in semi-arid and arid regions if the discharge point is situated at a distance from the recharge area and the aquifer is a soil aquifer. Such practice has two advantages: on the one hand, it generates naturally purified water at low costs; on the other, it is a natural form of water storage and does not entail any evaporation losses. Technically, water is allowed to infiltrate and replenish the aquifer during short periods with excess of surface water. Artificial groundwater recharge can be used to naturally purify wastewater and turn into potable groundwater. Treated wastewater can be allowed to recharge the groundwater aquifer by first letting it pass through purifying material, e.g. sandbanks. Drinking water quality is thus obtained without using any or very little chemicals. Reuse of wastewater after local or central treatment, constitutes an important strategy for urban areas. Methods for recharging aquifers include in-stream recharge (river infiltration) and recharge through a series of ponds (bank infiltration).

## 2.3. Adaptation of land use to climate and soil preconditions

### *2.3.1 Agricultural practices and techniques*

In order to minimise unproductive soil water losses, agricultural practices and techniques need to be adapted to the climatic and soil-related conditions at hand. First of all, in climatic regions with high evaporative demand and where water is demanded by other competitive uses, large-scale irrigation - particularly with non-renewable (fossil) groundwater - should be avoided to the greatest extent possible. Instead, irrigation should be limited and supplied by *recycled water* of adequate quality (such as grey water, e.g.). Secondly, irrigation practices should be combined with *effective drainage* practices in order to reduce soil evaporation, runoff, and waterlogging. Irrigation should be carried out in ways that minimise the need for additional water application to mitigate salinisation. Thirdly, *crop selection* may be an important measure to lower the evapotranspiration from crops, as water is consumed at different rates by different crop varieties. Fourthly, *soil conservation* measures could help to minimise evaporation losses from the soil and transpiration from weed, and could enhance water infiltration, the availability of water in the root zone, and/or the recharge rate of groundwater into aquifers.

*2.3.2 Tree plantation and cutting*

With regards to the various water demands of society, trees can be used for various purposes. With the appropriate measures, trees can help to minimise unproductive water losses and soil degradation processes and to enhance the availability of valuable water. Firstly, on flat land with high evaporative demands and slow water infiltration rates, *forest plantation* may increase the rate of evapotranspiration losses – soil water that could have been permitted to recharge the groundwater aquifer and extracted for possibly more essential purposes by society. Forest plantation should here be initiated only with consideration to such possible groundwater recharge reductions. Secondly, on sloping land with low organic contents and high susceptibility to erosion, forests are needed to maintain high infiltration rates and groundwater recharge. Thus, *clearing and cutting of forests* under such conditions could diminish groundwater recharge and the availability of groundwater for societal purposes. Such recharge losses should be weighed against the benefits of forest clearing and cutting. Thirdly, in areas with shallow groundwater tables (e.g. in parts of Australia), *deforestation* is causing groundwater to rise and accumulate in the soils, resulting in waterlogging and salinisation. (The trees function as important preventive mechanisms against waterlogging by consuming the water in the soil). Forests should thus not be extensively cut in areas with shallow groundwater tables. Fourthly, mixing woody perennials and crops on the same farmland, so called *agroforestry*, is a rather simple soil-water saving practice that provides multiple benefits to society. The woody perennials (e.g. trees, shrubs, palms, and bamboo) shelter the soil and plants from the desiccating sun and thereby reduce unproductive evapotranspiration losses from the soil and the crop plants. Additionally, the woody perennial helps to stabilise the soil against erosion, provides mulch, and can (depending on its kind) supply fodder and fuel wood. Fifthly, in river basins susceptible to erosion (e.g. in the Yellow River basin), *deforestation* often leads to erosion, river siltation, and to the sedimentation of reservoirs. In erosion prone river basins, deforestation should therefore be restricted.

*2.3.3 Livestock management practices*

Like human beings, livestock is fundamentally dependent on an adequate and regular supply of water for unimpaired health and growth. Water is needed not only directly for drinking, but also indirectly, in the surroundings, for securing a steady supply of feed. Livestock indoors may be dependent on water for the maintenance of good hygiene (sanitary conditions) secured by human labour. Livestock that are kept outdoors all year long do not need this kind of water-dependent human service, but can keep their hygiene within appropriate levels if a suitable size of grazing area is provided.

Thus, the overall challenge is to secure adequate and regular water supply for the livestock – without jeopardising the needs of human beings. In many poor rural areas, the livestock has multiple significant functions for society. In fact, it may be regarded as an economic asset and livelihood security, by functioning as a ‘secure’ bank that pays off when the animal is sold on the market, eaten, milked or in other ways benefited from. Also, livestock may be part of the local culture and in some places even regarded as holy (as the cow in India). Nevertheless, the livestock should not be allowed to become a threat to and a competitor of the limited valuable water resources in the area. If management of livestock is to be sustained, available water sources need to be utilised in such a fashion that an adequate quality and supply of water are guaranteed for both humans and the livestock. A particular task is here to manage and make use of the excreta and urine from livestock so that the latter can function exclusively as a *beneficial* contribution to the household, locally, and to society as a whole.

*2.3.4 Other measures to reduce unproductive water losses*

It is important that a certain percentage of the land surface is kept permeable for the infiltration of surface water, so that recharge of groundwater aquifers and downstream streams and rivers is enabled. Thus, pavement of roads and parking lots, which seal infiltration of precipitation and runoff, should not be carried out unrestrictedly. Likewise, in areas where irrigated agriculture depends on water diversion from large reservoirs, the latter should be designed so as to minimise surface evaporation losses. High evapotranspiration losses from reservoir surfaces (including aquatic plants in the reservoir) are responsible for significant reductions of river flows downstream.

## 3. Measures to enhance water quality

Solid and liquid wastes can be treated and recycled in different ways. Wastewater can be reused for potable, non-potable and indirectly potable uses. Here, three lines of practices by which the handling, treatment and transportation of wastes can be improved are presented. The aim, again, is to secure adequate quality of surface, ground and soil waters, as well as of the water in the distribution system.

## 3. 1. Turn wastes into resources

*3.1.1 Recycling of nutrients in human and livestock excreta*

Human excreta, especially urine, contain large amounts of nutrients and so can be used as cheap effective fertilisers. Hereby, nutrients in the excreta are prevented from leaking into water bodies, and the amount of nitrogen and phosphorous discharged into water bodies may be reduced by up to 95%. Also, constructive use of the excreta from livestock should be a general management goal just as the domestic recycling of human excreta. About 50 percent of the nitrogen ingested by livestock are excreted in the urine and easily lost by evaporation and leaking. In many parts of the world, livestock residue (mainly faeces) functions as the primary fertiliser, yet, it should be properly handled. In some cultures, such a practice is more questionable, whereas in other places, it has become an invaluable part of the daily farm practices. By bringing the faeces and/or urine back to the soil, as manure for the crops, instead of allowing it to leak into groundwater aquifers or to mix with runoff and surface waters, a constructive process of nutrient recycling can be achieved.

*3.1.2 Recycling of industrial and municipal wastes*

The amount of wastewater and sludge created by urbanised societies can be drastically reduced with the adoption of local solutions for treatment and reuse of “waste”. By making the producer, such as the industry or company, responsible for treating its own waste, thereby applying the Polluters Pay Principle, the incitements to retrieve and reuse rest-products will increase markedly. Recycling makes it possible to increase the production output without increasing the amount of external inputs needed. Hereby, the total production costs for industries can be reduced. Lower rates of waste generation means lower rates of waste disposal, waste treatment, and pollution. Likewise, municipal wastewater can be reused after necessary treatment, for toilet flushing, irrigation of golf courses, cemeteries, parks, and fountains, recreational impoundment, as well as for the enhancement of wildlife habitats. Components in the sludge can also be reused, e.g. the energy by burning of residual organic matter, phosphorous, nitrogen, and aluminium or iron. Hereby, sludge can be turned into a societal resource.

### *3.1.3 Recycling of wastes with livestock and aquaculture*

Livestock can be combined with aquaculture, so-called livestock-aquaculture. This is an age-old common practice in Asia. In essence, the livestock excreta are used to supply nutrients to fish farms. The practice has many advantages; while providing increased fish production, jobs, water resources protection, and biodiversity, it offers an easy-to-handle, low-cost, nutrient-using, and water-saving alternative to conventional treatment.

## 3.2. Prevent spreading of pollutants

The idea is that nutrients, water, minerals and other substances that are limited in availability should be reused instead of being discharged into water bodies or dumped into landfills and trash pits. Important decisions to be taken are where and when to collect the "wastes", what to do with the "wastes", and how to transport the "wastes".

### *3.2.1 Handling of wastes with on-site separation*

Wastes should be handled at the source. In most places at present, societies have adopted the end-of-pipe approach whereby the waste problem is pushed out of the way till the end of the pipe, where it has been taken care of in a centralised treatment plant. Yet, this approach is not sustainable and should be replaced by "on-site treatment" for industries, municipal enterprises, as well as households.

Moreover, sanitation should involve the separation of faeces from urine. Faeces are the main source of pathogens. With the use of urine separating toilets in combination with an effective method for pathogen degradation (decomposition and/or dehydration), the faeces will be sanitised at the source rather than at the endpoint, if at all. In fact, by excluding faeces from municipal effluents, the treatment process will become more effective and smaller amounts of pathogens will be discharged into water bodies. This is sometimes called the "Don't mix-approach" or Ecological Sanitation. Moreover, wetlands can be constructed and used for the removal of nutrients from livestock wastewater, as an ecologically sound and cheap way of waste handling.

*3.2.2 Recycling of wastes*

Discharges of wastewater and dumping of solid wastes by landfilling should be reduced and recycling should be increased to the maximum extent possible. This can be achieved by seven basic measures. Firstly, application of sludge on agricultural land should be avoided. Disposal of sludge by spreading it as a fertiliser in agriculture must not be done, as it contains pathogens, toxic organics and heavy metals that can be taken up by the crop and accumulate in human bodies after digestion. Secondly, the extent to which wastes are dumped into landfills and trash pits must be reduced. Thirdly, in water scarce areas where fertilisers are highly demanded but expensive, pit-latrines and flush-toilets should be avoided where possible, and substituted by composting toilets. Fourthly, the use of wetlands to purify livestock excreta should be promoted where these could become a natural integrated part of everyday life. Fifthly, support should be given to the installation and use of local on-site treatment solutions. Hereby, pollution can be more effectively prevented. Sixthly, support should be given to the upgrading of existent central treatment plants. Lastly, household sanitation practices can be improved by awareness raising through information campaigns, training programs, and school educational programs.

### *3.2.3 Improvement of wastewater transportation*

As stated earlier, reparation of leaking sewer pipes and septic tanks is an important step to improve the transportation of waste. Also, an effective drainage of storm-water contributes to reduce the risk for the spreading of pathogens and contamination of potable water sources. Flood mitigation measures should also be supported. After a heavy rainfall, storm-water may infiltrate the soil and mix with sewage water, causing flooding. Also, contaminated floodwater may reach the groundwater table and the piped water systems. Such risks can be reduced by: (1) protection and extension of existing retention ponds; (2) bank protection; (3) plantation of forest-bush strips; (4) restoration and protection of existing floodplains; and (5) by the enhancement of natural uptake and drainage of floodwater, e.g. by water-consumptive plants, and soils with high infiltration capacity. Persistent Organic Pollutants and some resistant pathogens will, however, not be possible to reduce by such methods.

## 3.3. Minimise the use of non-degradable harmful chemicals

To reduce and prevent present high utilisation levels of non-degradable (persistent), eco-toxic, bio-accumulating chemicals in the developing world are one of the key efforts to be made for the safeguarding of present and future water resources. It is also an indispensable strategy for enhancing the quality of human and ecosystem health. Much of the present pollution in the developing world is a result of uncontrolled use and discharge of dangerous chemicals into passing streams, rivers, lakes, and drainage systems without any source- or end-point treatment facility. Non-degradable chemicals are particularly dangerous, as they, per definition, cannot be degraded in nature by biochemical processes. Instead, they accumulate in the tissues of living organisms or accumulate in sediments of rivers, lakes and coastal zones, or in the soils and groundwater aquifers. Sooner or later, they will impose direct or indirect threats to human health. Non-degradable chemicals are utilised both in agriculture, industries, and households.

### *3.3.1 Agricultural and domestic practices*

Pesticides are chemical or natural substances that control pest populations, mainly by killing the pest organisms, be they insects, diseases, weeds or animals. Pesticide use is increasingly quickly, particularly in developing countries. Even on small holdings in poor rural areas, pesticide use is becoming increasingly common. However, the use of artificial pesticides should be avoided where and whenever possible.

Artificial pesticides can have various destinies after field application, yet, regardless of the pathway, sooner or later they may show up in forms undesirable and threatening to human health. The applied substances are often only partially taken up by or adsorbed to crops. The rest washes or drains off the soil, infiltrates and accumulates in the soil, or percolates into the groundwater. Pesticides do not only harm people but also the useful organisms such as natural enemies of pests. Over time, pests build up resistance to pesticides, whereby new pesticides need to be found. The Aral Sea area is heavily hit by such effects.

Locally based traditional alternative to pesticide use is preferable. The best approach to dealing with pests is to adopt integrated pest management. This builds on a combination of biological, chemical, mechanical, and genetic methods and techniques and would so far be quite expensive. Generally, they aim to interfere in the life cycle of the pest organism, so that its reproduction is impeded or reduced. Often, native traditional crops do not require pesticides to the same extent as genetically manipulated high yielding crop varieties. Generally, low-external-input systems should be favoured, involving the use of locally developed solutions to pesticide use. Although natural pesticides are less effective than chemical ones, ecological pest management options should always be investigated. Generally, both preventive and control measures should be used.

Artificial fertilisers should also be avoided and replaced, where possible, by other low-input methods of enhancing soil fertility. The efficiency of artificial fertilisers has often proved to be lower than expected. Also, they may disturb the soil life and soil balance and lead to depletion of micro-nutrients in the soil. Alternative sources of nitrogen are crop wastes, animal and green manure, legumes in rotation, tree crops (e.g. Accacia), blue-green algae, and nitrogen fixing bacteria in rice paddies.

Within the household, chemicals should be used that do not impose any threat to the life and human usability of groundwater aquifers, streams, rivers and lakes. Private individuals should be encouraged through information and education to use non-harmful alternative substances, e.g. for washing, cooking, etc.

### *3.3.2 Industrial practices*

Implementation of favourable effective industrial practices and technologies is a central and indispensable part of pollution prevention programs. Successfully adopted, these can help to: (a) reduce the extraction of valuable raw material, (b) reduce the generation of hazardous wastes, (c) increase recycling of valuable rest products, (d) reduce wastewater volumes, and (e) reduce the volume of fluid and solid wastes. Hereby, the pressures on ecosystems and water resources, from resources extraction and pollution, can be significantly reduced. Before selection or assessment of a particular technology is made, the entire lifecycle of the product should be investigated, i.e. the extraction of raw materials; the production of primary products; product manufacturing; utilisation; discharge landfill, or shredding; production of recycled product; and back to a new phase of product manufacturing (etc).

Non-degradable harmful substances, require specific handling techniques, as they cannot rely upon biological methods for degradation. Here, the challenge is to separate the harmful substances from the reusable material and water (and products). Separation should be accomplished as early as possible in the production cycle (near the source). By maximising the separation efficiency, the volume of hazardous rest-products can be minimised, while the recycling rate of water and processing agents is maximised.

‘Cleaner technologies’ and ‘eco-technologies’ are new types of technological methods for industries, which are increasingly advocated and applied internationally. Whereas ‘cleaner technologies’ reduce the *production* and *release* of harmful contaminated waste, ‘eco-technologies help to reduce the *use* of raw materials in the production phase. Also, cleaner technologies mainly help to minimise point-source pollution, while eco-technologies reduce non-point source pollution.

A ‘cleaner technology’ can be adopted for two main reasons. Some clean technologies help to eliminate or significantly reduce the generation of hazardous waste. Others are applied to increase the recycling capacity of chemicals within the industry. An effective recycling procedure requires separation techniques that effectively separate the reusable from the non-reusable rest products, so that the latter can be reused in the production process. Pollution prevention should prioritise waste reduction over recycling, but if waste reduction technologies are not available, recycling is a good approach to reducing waste generation. The cleaner technology must reduce the quantity and/or toxicity of the waste produced. Examples of industries in which cleaner technologies are promoted are the textile industries. According to a case study, the adoption of a clean technology (spec. reactive dyeing of cotton) could save up to 60% of total water consumption and

20% of total chemical consumption in the dyeing and rinsing processes. The mining industry, metal industries, and oil-refinement industries are other heavy polluters of nearby watercourses for which clean technologies exist and would beneficially be invested.

Generally, economic benefits to the industry may be realised by reducing disposal costs and lowering the liabilities associated with hazardous waste disposal. For small-scale industries in developing countries, however, implementation of cleaner production technologies may be constrained by attitudinal, organisational, and technical barriers, aside from financial shortages. Small-scale industries therefore need both technical and financial support and incentives from policy organisations and non-governmental organisations. Information and educational campaigns for the industrial owners and workers should also be part of the external support program. Additionally, the availability of local management options should always be investigated.

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