BALANCING WATER USES:

WATER FOR FOOD AND WATER FOR NATURE

Thematic Background Paper

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1 CURRENT SITUATION

1.1 Pressure

“On the one hand, the fundamental fear of food shortages encourages ever greater use of water resources for agriculture. On the other, there is a need to divert water from irrigated food production to other users and to protect the resource and the ecosystem. Many believe this conflict is one of the most critical problems to be tackled in the early 21st century”. This was a key conclusion of the Framework for Action exercise of the Global Water Partnership (GWP, FFA, 2000, p58).

The Green Revolution—based on modern, high yielding plant varieties, requiring high inputs of fertilizer and water—has led to increases in world food production at a pace that outstripped population growth. Food prices have declined markedly. Increased water use in irrigated agriculture has benefited farmers and the poor. But increased water and chemical use that fueled the Green Revolution has contributed to environmental degradation, and threatened the resource base upon which we depend for food and livelihoods.

In spite of increases in agricultural production and lower food prices, the task of providing food security to all is incomplete. Malnutrition persists, mostly in South Asia and Sub-Saharan Africa. Much malnutrition exists in regions dubbed “economically water scarce”, meaning that while there is water available in nature, sometimes abundantly, it has not been developed for human use. Small farmers and the poor are particularly disadvantaged and can face acute water scarcity. They do not have access to water to satisfy their needs for either food security or sustainable livelihoods.

The agricultural community sees continued growth of irrigation as an imperative to achieve the goals adopted by the international community to reduce hunger and poverty. Under a base scenario that included optimistic assumptions on productivity growth and efficiency, IWMI estimated that 29% more irrigated land will be required by the year 2025, and because of gains in productivity and more efficient water use, the increase in diversions to agriculture would be 17%. FAO (2000) and Shiklomanov (1999) had comparable results.

2 A review by the World Bank of 585 irrigation projects found an average economic internal rate of return (IRR) of 15%, substantially above the assumed opportunity costs of capital (World Bank, 1994). Many irrigation projects, particularly in Africa, under-performed however, or had major social and environmental external costs. This has led to strongly held differences of opinion concerning the benefits and costs of irrigated agriculture.

3 There is no consensus on the poverty alleviation impacts of irrigation. Recent research led by IRRI, for instance, concluded for 6 villages in Madhya Pradesh, India, that incidence, depth and severity of poverty were substantially lower in the villages where there was irrigation – compared to rainfed villages (Janaiah et al., 2000). Similar research in Myanmar concluded that recent expansion of irrigation infrastructure in the 1990s has not increased household income, due to farmers’ inability to cope with the economic and technical demands of the new rice-based technologies (Garcia et al., 2000). The acrimonious debate on dam development has convinced many that water resources development threatens livelihoods. A recent article on the Mekong in Newsweek, for instance, was titled “Strangling the Mekong: A spate of dam building has stopped up Southeast Asia’s mighty river and may threaten the livelihood of millions who lie along its banks (Newsweek, March 19, 2001).


5 FAO (2000) estimated a 34% increase in irrigated area, and a 12% increase in irrigation diversions, and similarly Shiklomanov (1998) projected a 27% increase in irrigated diversions.
Citing similar international commitments to maintain and improve environmental quality and biodiversity, many in the environmental community see it as imperative that water withdrawn for agriculture is reduced, not increased. Irrigation development has impaired the ability of many ecosystems to provide valuable goods and services, including flood protection, water purification, and provision of food and fiber. It is argued that not enough attention is given to alternative, but more sustainable means of production. Taken from the perspective of sustainable use, Alcamo et al. (2000) projected an 8% decrease in the amount of water that should be diverted to irrigation. The difference between the 17% increase and 8% decrease is on the order of 625 km$^3$ of water—close to the 800 km$^3$ of water that is presently used globally for urban and industrial use.$^6$

In an effort to bridge these divergent views of the world, and provide water security for all, access to food and water for the poor in society, as well as sustain natural resources for future generations, the World Water Vision was developed (Cosgrove et al. 2000). The Vision ended with a target of reducing additional withdrawals for agriculture to 6% in the next 25 years. Yet, this is accepted by neither the agriculture nor the environmental communities, who feel that it is too little and too much, respectively. Balancing the need for water in agriculture and nature, and achieving the twin goals of food and environmental security, will be a major challenge.

1.2 State

To produce one kilogram of grain requires about one thousand liters$^7$ of crop evapotranspiration. However, one kilogram of meat requires much more water to produce—depending on how much feed is given. In California for example, about 13,500 liters of water is used to produce one kilogram of beef. Renault and Wallender (2000) estimate that a typical diet of a person from USA requires about 5,400 liters water in the form of evapotranspiration. On the other hand a vegetarian diet with approximately the same nutritional value is responsible for the consumption of 2,600 liters of water per day. Compared to the 2 to 5 liters of water we need to drink daily, and 20 to 50 liters needed for bathing and other personal needs, the 2000 to 5000 liters of water to produce food dominates the water for human needs equation.

At present, 31 percent of the world’s total cereal area is irrigated, and contributes 42 percent of the total cereal production (IWMI, 2000). Irrigation dominates cereal production in South Asia and Near East, contributing 50 and 75 percent respectively to the total cereal production in those regions. In East Asia, 58 percent of the total area is irrigated and contributes 65 percent of the total cereal production.

Rain-fed agriculture dominates in other regions. Rain-fed agriculture in Sub Saharan Africa, Central Asia, Eastern Europe and Australia is about 95 percent of the total cereal area and contributes about 90 percent of the total cereal production. Rain-fed area in Europe and in North America is about 80 and 70 percent of the total area respectively contributing about 80 and 60 percent of the total cereal production in the two regions.

Under-nourishment remains a major problem, even though globally the number of malnourished people has been reduced by 160 million from the 1990 levels. In 1997, 790 million people in developing countries were classified as food insecure, 60 percent of whom live in South Asia.

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$^6$ To get an idea of the magnitude, Egypt’s High Aswan Dam releases annually about 55 km$^3$, so the difference is equivalent to more than 10 High Aswan Dams annual supply of water. Put in other terms, this is more than the 500km$^3$ projected to be used for domestic water supply worldwide in 2025.

$^7$ There is a wide range in the estimated amount of kg/m$^3$ of evapotranspiration, from about 0.5 to 1.5 – this reflects differences in the definition of crop per drop in agriculture.
and Sub-Saharan Africa. In Sub-Saharan Africa, the number of food insecure people has increased from 125 to 186 million people between 1997 and 2000 (FAO, 1999).

Expansion and intensification of irrigated area has contributed significantly to increases in food production. The total crop and cereal area stabilized during the mid-eighties, but irrigated area has continued to increase at a steady pace due to the expansion of irrigation on previously rain-fed lands (see Table 1). More than half the net irrigated area in developing countries is found in China and India. The combined net irrigated area of China and India has increased by 68 percent in the three decades before 1990 and 15 percent in the decade after 1990. Crop intensification due to technological advancements and better management has been the main factor offsetting the decline in crop and cereal area due to land degradation and urbanization.

Dams, important to large-scale irrigated agriculture, have come under increased scrutiny. The World Commission on Dams (2000) recognized that “dams have made an important and significant contribution to human development, and the benefits derived from them have been considerable,” but in too many cases “an unprecedented and often unnecessary price has been paid to secure those benefits, especially in social and environmental terms, by people displaced, by communities downstream, by taxpayers, and by the natural environment.” The report outlined a way forward with an innovative rights and risks approach. In spite of the efforts to incorporate all points of view, many countries and communities do not embrace the report, as they would like to maintain the option for construction of dams for economic development, and see the report as presenting too many barriers. Nevertheless, it can be expected that public investments in large dams and irrigation projects will be increasingly difficult to justify.

Private investments, mainly in the groundwater sector have contributed most to the growth in net irrigated area in India and China. In India, about 29 percent of the 24 million hectares net irrigated area in 1960 was irrigated from groundwater (Fertilizer Statistics of India, 1962, 1993, 1999). This has increased to 55 percent of the 53 M ha net irrigated area 1995/1996. IWMI estimates that more than two-thirds of the total cereal production in India is from irrigation (IWMI, 2000) and about two-thirds of that is from tube-well irrigation (Seckler, 2000). In China, the tube-well irrigated area has increased from 11 million hectares in 1985 to 13 million hectares, about 26 percent of the actual irrigated area in 1995 (FAO, 1999). Estimates show that two-thirds of the total cereal production in China is from irrigation and a substantial proportion of this is from well irrigation.

**Table 1. Net irrigated area growth**

<table>
<thead>
<tr>
<th>Year</th>
<th>1961</th>
<th>1990</th>
<th>1997</th>
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<tr>
<td></td>
<td>World</td>
<td>Developed countries</td>
<td>Developing countries</td>
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<td>Total</td>
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<td>1961</td>
<td>140</td>
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<td>38</td>
</tr>
<tr>
<td>1990</td>
<td>242</td>
<td>73</td>
<td>65</td>
</tr>
<tr>
<td>1997</td>
<td>266</td>
<td>10</td>
<td>66</td>
</tr>
</tbody>
</table>

Environmental degradation threatens food production. Increasing salinity and water logging in irrigated areas and declining groundwater tables in groundwater irrigated areas are major

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8 It is recognized that in many instances, surface water and groundwater are intricately linked, and the provision of surface water for irrigation, also makes water available for groundwater use.
concerns for future food production. For example, a substantial proportion (60 to 70 percent) of the total cereal production in India is in states which are operating at above or at the full potential level for tubewell irrigation (Seckler, 2000). Much of the area in the North China Plain's breadbasket is threatened by groundwater depletion. These are indications that future food security in India will primarily depend on how their surface and groundwater irrigation is managed. Similar pictures are emerging in China and Pakistan.

1.2.1 Rainfed agriculture

Rain-fed agriculture, often a neglected component of the water, food, and environmental security puzzle contributes 58 percent of cereal production on 69 percent of the cereal area. Globally, about 14 percent of the land surface is covered by agricultural lands and is dependent primarily on rainfed agriculture. IWMI estimates that in a median rainfall year, rainfed crop evapotranspiration is on the order of 20 percent of all rainfall on the earth's landmass, compared to the three percent area covered by irrigated lands and 6 percent of total evapotranspiration by irrigated lands. From this perspective, rainfed agriculture is a significant consumer of water—water that would have otherwise contributed to other ecosystems, or contributed to river runoff. Rainfed agriculture, because of its magnitude of resource use, is clearly a competitor for scarce land and water resources.

Rainfed agriculture has important global water and food security relevance for the following reasons. First, many of the food insecure people in rural areas are dependent on rainfed agriculture. Second, if more could be produced on the existing rainfed lands, there would be less need for irrigated area expansion. Third, rainfed agriculture consumes a significant amount of water resources. An important conceptual advance has been the introduction of thinking on “blue water”—river runoff that is available for exploitation, and “green water”—water that would have evaporated from land surfaces before contributing to runoff (Falkenmark, 2000). The argument is that too much focus has been given to blue water and there is an important need to consider green water as an important water resource.

1.2.2 Equitable access

Food security requires either access to the means of production, or enough income to purchase food. Sustainable food security can be achieved if sufficient stable food supplies are readily accessible to vulnerable sections of the population. Access to water can be a constraint on poor people in producing food in many situations. Social exclusion issues such as denial of access to water and food on the basis of gender or ethnicity, coupled with conflicts and violence further deteriorate the level of food security. Geographically isolated tribal people, who are cut off from knowledge of more advanced technologies often pay much higher prices for basic food needs and are vulnerable to food insecurity despite relatively easy access to water resources. Likewise, households in arid and rugged terrain are more food insecure. The reasons behind lack of access to water are many, but can be grouped into three situations that relate to water availability.

The first is due to physical water scarcity—when an area has little or no additional water supplies to meet additional uses. In this case it is difficult for poor people to tap into existing, already allocated supplies. The poor are often the most vulnerable group when water is reallocated to

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FOA, the Global Water Partnership (GWP), the International Commission on Irrigation and Drainage (ICID), International Federation for Agricultural Producers (IFAP), the International Union for the Conservation of Nature (IUCN), the International Water Management Institute (IWMI), UNEP, WHO, the World Water Council (WWC) and the World Wide Fund for Nature (WWF).
higher valued uses as they are likely to lose access. Much of the arid areas stretching from North Africa to the North China plains fall into this category. But also, many river basins in the world including those in the Indian and Pakistani Punjab, and the Yellow River have reached the physical limit of usable resources.

The second case is one where development efforts have led to exploitation of water resources, but these are not equitably managed. Pockets of water scarcity exist because of inadequate rights, infrastructure, or management efforts to deliver water services to all people. This is a chronic problem in many irrigation systems, particularly in Asia.

The third problem is when there is a lack of financial or human resources to tap available resources, a situation that exists in much of sub-Saharan Africa. Compared to other parts of the world, there is a lack of access because of lack of water infrastructure. For example, the irrigated area in Africa (South of Sahara) increased from 2.7 million hectares in 1961 to 5.2 million hectares in 1998, while the irrigated area in Asia increased from 102 million hectares to 205 million hectares during the same period.

1.2.3 Water quality and land degradation

Rapid deterioration of water quality in many areas poses a serious threat to the sustainability and the safety of food production systems. Pollutant loads have increased enormously due to increased industrial, urban and agricultural uses. Poor drainage and irrigation practices have led to waterlogging and salinization of roughly 20% percent of the world's irrigated lands reducing productivity (Wood et al, 2000). Concentrations in natural and man-made drainage systems reach high levels as the amount of drainage flows decrease. Security and stability in food supplies in the next century will be closely linked to success in water quantity and quality control.

Degradation of dry lands is an urgent global problem, placing some 1 billion people in 110 countries at risk, mainly in developing regions. In highly industrialized regions, ameliorating soil contamination and combating acidification are priorities. This trend has also been observed recently in some developing countries where higher fertilizer and herbicide applications are used to increase the productivity with inadequate measures to control their overflow into natural systems.

1.2.4 Impacts on ecosystems

For the environmental community, at least for the cross-section represented in the development of the Vision for Water and Nature (IUCN, 2000), the current situation is already one characterized by dried-up and polluted rivers, lakes and groundwater. More than 50% of wetlands have been lost during the last century (IUCN, 2000, p9). Business as usual, represents inevitable degradation or complete destruction of the terrestrial freshwater and coastal ecosystems that are vital to life itself (IUCN, 2000). Important fisheries, dependent on healthy aquatic ecosystems, are endangered. Fish provide 21% of animal protein in Africa, and 28% in Asia (WCD, 2000). In order to avoid further degradation, fundamental changes are required to establish an ecosystem-based catchment management approach (IUCN, 2000, p28.).

Freshwater biological diversity is high relative to the limited portion of the earth’s surface covered by freshwater. Freshwater fish, for example, make up 40% of all fish, and freshwater molluscs make up 25% of all molluscs. Freshwater biodiversity tends to be greatest in tropical regions, with a large number of species in northern South America, central Africa, and Southeast Asia. Worldwide the number of freshwater species is estimated to be between 9,000 and 25,000 (McAllister et al, 1997 reported in Cosgrove and Rijsberman, 2000).
The loss of freshwater biodiversity is poorly monitored except for some larger, commercial species. Available data suggests that 20–35% of freshwater fish are vulnerable or endangered, mostly because of habitat alteration. Other factors include pollution, invasive species, and overharvesting. A recent comprehensive review of the impacts of irrigated agriculture on wetlands and wildlife conservation (Lemly et al., 2000) concludes that the conflict between irrigated agriculture and wildlife conservation has reached a critical point on a global scale.

1.3 **Response**

The World Water Vision and Framework for Action process (Cosgrove and Rijsberman, 2000; GWP, 2000), culminating in the second World Water Forum (HRH the Prince of Orange and F.R. Rijsberman, 2000) in March 2000, attempted to develop a widely shared vision on sustainable water resources development and management. This process raised the issue of water on the international agenda. Thousands participated and contributed to the production of many regional and sectoral Water Visions. The process suffered from a major shortfall: it failed to bring the sectoral interests together.

1.3.1 **Improved dialogue**

In fact, the two sectoral Visions on Water for Food and Rural Development (Hofwegen and Svendsen, 2000) and on Water and Nature (IUCN, 2000) reflect the sharply diverging world views of the two rather separate communities involved in preparing them. To build bridges between the two sectors a new initiative is being developed by a consortium of key international actors in the water sector, called the Dialogue on Water, Food and Environment (IWMI et al, 2001). The Dialogue strives to develop a shared view on desirable water resources development and management strategies. The initiative focuses on (1) stimulating cross-sectoral dialogues at national and river basin level, (2) improving the knowledge base on integrated water management solutions to achieving water and environmental security, and (3) learning from local action initiatives.

Dialogue leading to increased understanding across the agriculture and environmental communities is definitely a necessary, although not sufficient, condition for achieving both food and environmental security.

1.3.2 **Productivity versus efficiency**

Many of the solutions to water-related food and environmental security problems come from within agriculture. How we develop and manage water supplies impact food security, ecosystems, and the services they provide. This requires a different perspective that focuses on the value obtained from the use of water.

A common perception is that increasing efficiency in agriculture is the solution to the water crisis. Technically defined, efficiency tells us how much diverted water reaches the crops, and how much is wasted “down the drain”. Unfortunately, this perspective is misleading. The real “wastage” comes from not being as productive as possible with the water that is currently consumed (not wasted down the drain) in agriculture. The Chishtian Irrigated area, located in Pakistan’s Punjab, is a landscape heavily dominated by agriculture. To get an idea of how efficiently water was used, IWMI performed a water accounting exercise.\(^{11}\) During the 1993/94

\(^{11}\) Based on Molden et al. (2001)
agricultural year, 740 million cubic meters (MCM) of water entered the area\textsuperscript{12} from irrigation deliveries, rain and groundwater sources. Human uses, dominated by crop agriculture, consumed 90\% of the supply—evidently quite efficient.

From a larger, basin perspective, farmers are very effective in converting water into crop production. But, groundwater was mined during the year and in this area very little water was available for environmental purposes such as flushing salts or for ecosystem sustenance. Farmers in the Chistian area are, if anything, too efficient! Certainly increasing the efficiency, and leaving even less for other uses, is not recommended.

While efficiency is very high, productivity is very low. Wheat yields are on the order of only 2 tons per hectare, while rice yields are on the order of 1.4 tons per hectare. In terms of kilograms and dollars per cubic meter, water productivity is low when compared to other systems worldwide.\textsuperscript{13} For wheat, water productivity is on the order of 0.6 kg/m\textsuperscript{3} compared to a range of about 0.5 to 1.5 kg/m\textsuperscript{3}. Productivity increases will require a package of technological and policy interventions, that is not necessarily easy to implement.

A focus on increasing productivity of water in agriculture is required. Why is getting more crop per drop so important? The answer is simple—growing more food with less water alleviates scarcity, contributes to achieving food security, and puts less strain on nature.

\subsection*{1.3.3 Integrated natural resources management}

But we even need to go beyond increasing the amount of grain produced per unit of water, to consideration of the value derived from the consumption of water. This view recognizes that water use in agriculture, and especially irrigation water serves the needs of many uses—including fisheries, livestock, bathing, small-scale industry and enhanced ecosystem services (Bakker et al, 1999). Understanding these multiple uses and their interaction requires new ways to view water and natural resource management.

The variability and quantity of rainfall in large areas of Africa and South Asia are not conducive to stable agriculture. It is in these areas where there are many food insecure people, often smallholder or landless. They neither have the income to purchase food, nor can they be assured an adequate crop yield from year to year. The development of drought resistant crop varieties, alternate tillage practices to conserve water, and low-cost technologies such as treadle pumps (Shah 2000) or water harvesting structures that provide access of water to the poor are potential solutions with a high poverty alleviation impact. But the impact and potential of these technologies and management approaches is not well known—further work in these areas should have a high priority. The approach of the Green Revolution—to focus on the areas with a high agriculture potential and improve technology and infrastructure—needs to be replaced by an integrated natural resources management (INRM) approach. An INRM approach involves users and stakeholders in a participatory manner and integrates management of land, water and soil fertility in a systems approach. Such an approach need not be “low-tech”. It may well be that

\textsuperscript{12} 504 MCM from irrigation diversions, 143 MCM as rain, and 73 MCM as net groundwater abstraction. Crop evapotranspiration was 595 MCM, while evaporation from cities was about 50 MCM.

\textsuperscript{13} For wheat this converts to 0.6 kg/m\textsuperscript{3} of water. A range of water productivity of wheat from 0.6 to about 1.5 kg/m\textsuperscript{3} was found worldwide. The gross value of production for the rice-wheat cropping system per cubic meter of evapotranspiration is on the order of US$0.07, at the low end of the spectrum (Sakthivadivel et al, 1999). For 40 systems, IWMI calculated a range of water productivity calculated in this way from 0.05 to about 0.80 $\text{US} per cubic meter.
recent advances in molecular biology\textsuperscript{14} will have great benefits on the development of, for instance, drought resistant plant varieties\textsuperscript{15} and that this forms an important part of the integrated approach.

2 **SUCCESS STORIES AND LESSONS LEARNED**

The good news is that we are developing more integrated approach to solving the problems of the water crisis. There are considerable advances made, for instance in the valuation of water in different uses. Renwick (2001), for instance, shows that the fisheries in irrigation reservoirs at Kirindi Oya, in Sri Lanka, Kirindi Oya, contributed additional income equal to 18\% of the rice production in the system. Renault et al. (2001) show that the perennial vegetation\textsuperscript{16} in the same irrigation system use a rather large amount of water in the irrigation system “beneficially”, increasing the percentage irrigation water that is beneficially used (compared to paddy rice alone) from 22 to 65\%. The Millennium Ecosystem Assessment, one of the largest undertakings to assess the health of the world’s ecosystems and the goods and services they provide will explicitly look at agroecosystems—and has done so in a pilot analysis (Wood et al., 2000). All these are signs of increased understanding of the needs of agriculture and the environment. Eventually this ought to lead to improved co-management of water and land resources for agriculture and nature (see Annex).

Legally protected environmental flows, flows that can be considered as the “water rights of ecosystems”, are being experimented with, particularly in South Africa and Australia. The Lesotho Highlands Water Project (see Annex) is one of the first in which the design of environmental flows was in integral part of the project design. In other areas, wetlands that have seen major impacts from water development for agriculture are being rehabilitated, such as in the Waza Logone floodplain in Cameroon (see Annex).

We often underestimate the adaptive capacity of societies. Where water is really becoming scarce, users do respond. This was demonstrated by the development of highly productive drip irrigation systems that dominate agriculture in Israel, and also in Zanghe Irrigation district in China. In the latter system, as water moved out of agriculture to domestic and industrial use, farmers managed to increase water productivity more than three-fold over a period of thirty years. In Gujarat, India, a grass-root mass movement to recharge declining groundwater sources is underway (Shah, 2001) to protect groundwater resources on which so many people depend for drinking and food.

\textsuperscript{14} Advances in genomics have led to the mapping of the human genome, but of the rice plant genome as well.

\textsuperscript{15} A recent review of the status of breeding for tolerance of abiotic stresses by John Bennet of IRRI (Bennet, 2001) is quite optimistic. The recent advances in genomics, the development of advanced analytical tools at molecular level by the public sector, provide a basis for understanding the mechanisms of stress tolerance. It concludes that investments by the CGIAR in the new tools for gene discovery will produce breakthroughs in our understanding of abiotic stress tolerance. While drought is the most important, it is also the most intractable of abiotic stresses. Bennet concludes that there is considerable scope for improvements, however. Developing plants that are high-yielding even when grown under recurrent mild water deficit would benefit both irrigated and rainfed crops.

\textsuperscript{16} Mostly trees in home gardens such as coconut palm trees and fruit trees.
3 ISSUES AND POLICY IMPLICATIONS

3.1 Basin Perspective

With increasing water scarcity, it is essential to view water allocation and distribution among users from a basin perspective. Traditionally in the water sector, much of the focus has been aimed at individual systems or communities. This focus has to change to cope with wider issues of competition for water, and particularly competition for good quality water.

Looking at water from a basin perspective means that we have to look not only at water supply and demand for all users, but also institutional issues involved with the provision of services. The issue may best be exemplified by the issue of “scaling-up,” whereby each separate water use may by itself not have a noticeable impact, but as the number of such water uses intensifies, the overall impact on water resources and other water uses is significant.

In light of these issues, safeguarding and developing sustainable water resources management requires a combination of inputs or interventions in three major dimensions:

- The upstream-downstream dimension that recognizes that each water use or water user potentially impacts on all the other uses and users;
- The institutional dimension that needs to consider how planning, policies, rights, regulations, allocation procedures, monitoring, water user organizations, etc., need to be designed and implemented to enhance the effective functioning of organizations at basin and system levels as well as at the level of individual uses or users;
- The provision of services to different water uses and water users so that water is delivered with a highly reliable level of service to encourage productive water use, but that this is also made consistent with other service inputs such as credit, technology, marketing.

The basin perspective allows us to look with more clarity at the importance of upstream-downstream issues. The most obvious element is that there is some form of equitable allocation policy maintained throughout the basin that recognizes existing uses, yet has the ability to reallocate water amongst uses and users to meet emerging needs.

The institutional dimension means that both suppliers and users of water need to be involved at basin level for effective planning, implementation, regulation, and other water management functions. Previous moves towards more localized participatory involvement in these tasks also need to scale up to the basin level to have groups dealing with basin-scale issues. A clear definition of property rights and mechanisms of enforcement of defined rights becomes more important with increasing scarcity. Single-purpose line agencies need to have greater interaction or there need to be more comprehensive management organizations at basin level that can address the complexity of interaction between different uses and users.

Provision of services for water users needs to be viewed from a different perspective. Traditionally, service provision has been geared for a single or specific water use, dealing with such aspects as the reliability of irrigation deliveries, power, technology, credit, marketing, infrastructure, etc. While much needs still to be done to make such services more effective, they also need to be addressed from the basin perspective to ensure that improvement of services at one location or for one set of users does not impinge on the potential of other users and uses.
3.2 Financing

Investment in large irrigation projects increased during the 1970s but then fell by more than 50% during the 80s (Rosegrant and Ringler, 1999). It is argued that the massive investment in irrigation during the 70s expanded both cropped area and cropping intensity and enabled realization of potential of the green revolution technologies. The resulting increase in food production led to the lowering of food prices, thus reducing the apparent financial benefits. (even though others benefited from reduced food costs). Development costs for new irrigation lands have increased markedly in recent years. Costs have increased by more than 50% in the Philippines, 40% in Thailand and have nearly tripled in Sri Lanka. In the face of declining cereal prices it is increasingly difficult to justify new irrigation developments on financial costs and benefits alone (Rosegrant, 1997). In Africa, institutional and technical constraints make irrigation development much more costly than in Asia, varying about US$ 8000 per /hectare for Africa (Rosegrant 1997, FAO 1992) compared to $1400 per hectare in Asia. Thus, although food security is a major problem, large-scale irrigation development is an unlikely solution.

Most of the water-related infrastructure projects in the past 40 to 50 years were financed by the government sector. Recently, private sector financing of large water sector infrastructure is increasing. About 15 % of the infrastructure financing in developing countries is now being done by private finance, a growing trend (Briscoe, 1999). Full cost recovery and institutional changes in the sector will further enhance this trend.

Today the annual cost of water services for developing countries is about US $70-80 billion per year, but to achieve water security may require about US$ 100 billion additional investment per year (GWP, 2000).

3.3 Capacity building

Increased scarcity leads to more complex water problems, yet we are ill-equipped to handle these. Integrated Water Resources Management at river basin level requires substantial human capability development. In Asia, there is strong experience in managing water for food security on which to build, but in much of Africa, there is little experience in developing and managing irrigation. There is a need to strengthen the capacity of water managers at all levels—from farmers to irrigation managers—to deal with emerging problems of competition, use of low quality water, managing for multiple uses of water, water savings, and sustainability. However there is an apparent decline in the number of universities and training centers offering courses on agricultural water management.

3.4 Co-Managing Water for Agriculture and for Nature

One of the challenges of water management is to shift from managing water to meeting one need—water for cities, or water for agriculture—to integrated water resource management - managing water resources to meet a variety of needs. Water managers have mastered the art of managing water for hydropower, domestic use, flood control, and irrigation. We should also be able to learn how to co-manage water for nature. But this would require some knowledge and experience that is not widely available. A first step is to identify environmental requirements. In water accounting studies in developing countries, we rarely find that environmental needs are recognized and not assessed by water resource managers (Molden et al. 2001). The recognition that there are environmental requirements is a big first step for water resources management.
The second step is to match the temporal quality, quantity and demand patterns of various sectors. It is insufficient and unwise to allocate an annual quantity of water to the environment. Natural systems have demands for water that vary enormously in time and space. In fact, floods and droughts may be more beneficial than “average” flows, which are highly prized in agriculture. Recognizing these temporal requirements, it should be possible to allocate water to nature, and distribute it in a manner when its value for nature is highest, while at the same time meeting the demands of agriculture.

3.5 Increasing the Productivity of Water

Moving away from a single focus on measuring agricultural productivity per unit of land, in tons per hectare, as if that were the only scarce resource, will require a considerable paradigm shift. In agriculture, productivity of water can be defined as the physical output per unit of water depleted\(^\text{17}\) by agriculture, and expressed in terms of kilograms per cubic meter of water.

Considering the productivity of water in more than 40 irrigation systems worldwide, Sakthivadivel et al. (1999) demonstrated a 10-fold difference in the gross value of output per unit of water consumed by evapotranspiration (figure 1). Some of this difference is due to the price of grain versus high valued crops, and certainly not all agriculture can be devoted to high valued crops. But even among grain producing areas, the differences are large, demonstrating a potential for improved water productivity. In areas where water has become scarce, such as in China, IWMI and partners have indeed monitored significant increases in water productivity.

Can water productivity be increased to such an extent that food security can be achieved without increasing (on a global scale) the withdrawal of water for agriculture — thereby contributing significantly to achieving environmental security as well? An analysis of such a global challenge, using the IWMI’s Podium Model\(^\text{18}\), yields the following results. In this scenario\(^\text{19}\), there is a moderate expansion of 3% of the harvested area, and 10% of irrigated area. But the withdrawals by irrigation are constrained to decrease by about 10%. The only way that enough food can be grown is then by increases in water productivity on rainfed and irrigated land. For the period of 2000 to 2025, we have estimated that an annual growth rate of about 1.8% or roughly a 60% percent increase for the period, on irrigated land, and 1.0%, or a 30% increase on rainfed land in water productivity would be required\(^\text{20}\). This significant increase in water productivity is roughly double the increase expected in business as usual scenarios. If food and environmental security are to be achieved simultaneously, then this is the challenge.

\(^{17}\) Water is depleted when it is rendered unavailable for further use downstream. Water is depleted either by evaporation, directing flows to sinks where there is no environmental use, or incorporating water into a product (Molden, 1997).

\(^{18}\) IWMI et al. 2000, and http://www.iwmi.org

\(^{19}\) Population grows as per the UN Medium population growth forecast to 7.8 million, and the calorie level is assumed to increase from a present per capita value of 2700 to 3000.

\(^{20}\) For irrigation, water productivity was calculated as kg per cubic meter of water withdrawn. On irrigated land, we calculated the growth in terms of kg per unit of evapotranspiration.
In other words, can agriculture evolve to provide food security, poverty alleviation and environmental security without an increase in water use? Can it be done in a way that increases access to land and water resources for resource poor farmers and increase the opportunities to realize benefits from other uses – be it fish, forestry or ecosystem services. Perhaps we can compare the current “world water crisis” to the energy crisis of the 70s. Some people use the low energy prices of the 90s as proof that the energy crisis of the 70s was just scare mongering by doomsday prophets. But then again, the major focus on energy in the 70s led to a massive focus on energy research that has brought us major increases in energy efficiency, recycling and renewables. Perhaps that is what we really should expect of the focus on the “water crisis” of today too – a renewed focus on using water more efficiently, effectively and, of course, equitably.

Divine (1999) argues that by implementing conservation programs we are not saving water, but rather we are “freeing up” water from one use so that it can be used by another use.
4 Acknowledgements

This paper is based in part on: (1) several unpublished presentations made by the authors (Molden et al., 2000, Molden and Rijsberman, 2001, Rijsberman, 2001) and (2) two background papers prepared by a group of IWMI researchers for the Rural Development Strategy of the World Bank (IWMI, 2001a) and the forthcoming United Nations World Water Development Report - Chapter 3 on Water and Food (IWMI, 2001b).

5 REFERENCES


IWMI; FAO; GWP; ICID.CIID; IUCN; UNEP; WHO. 2001. Dialogue on Water, Food and Environment.


ANNEX

A) Real Water Savings in China: Growing more rice with less water

Water conservation is an appealing option compared to developing new storage and diversion facilities, as these often carry high financial, social, and ecological costs (World Commission on Dams, 2000). “Real water savings” (Keller et al., 1996) imply that we reduce wastage of water in one area to free it up for transfer to a beneficial use elsewhere. In essence, through real water savings, water is redistributed from a use of little or even negative benefit, to one that has higher benefit. For example, reducing irrigation drainage water that has a negative downstream environmental impact, and providing this water to a beneficial purpose, say a drinking water supply, would constitute real water savings at a basin scale.

In many places, real water savings is an important mechanism to increase the productivity of water. One important example comes from China. The Zhang He reservoir, situated in the Yangtze river basin, was constructed primarily for irrigated agriculture. Over time reservoir water also met increasing demands from higher valued urban and industrial water uses. Water managers—farmers, irrigation service providers, and water resource managers - were able to shift water out of agriculture to meet these other needs (figure A1). Production levels remained stable over the time period in spite of this massive shift of water out of agriculture (table A1). Growing more rice with less water—improving the productivity of water—was made possible through policy, management, and technological changes (IWMI 1999 Annual Report).

Figure A1. Annual deliveries to irrigation and other uses at Zhang He Irrigation District, China.

B) Co-management agriculture-nature: Bundala National Park, Sri Lanka

We believe that there are ample opportunities to improve the productivity and value of water through co-management. The Ramsar Bundala site in southern Sri Lanka offers an example (Matsuno et al, 1998). At Bundala, the health of the natural lagoons is dependent on changes in salinity levels driven by floods, dry spells, and connection of the lagoons with the ocean. The Kirindi Oya Irrigation and Settlement project added a reservoir and extended irrigated area upstream of the lagoon system. The project also brought additional water into the small catchments of the lagoon. Drainage water from irrigation has added additional freshwater supplies and has apparently diluted salinity levels, changing the ecosystem and damaging the lagoon based shrimp fishery.

Drainage discharge from the Kirindi Oya project dominates the inflow into the lagoon and is a cause for lowering salinity levels and increased lake levels. It is often stated that Kirindi Oya is a water-short irrigation system, meaning that farmers do not get enough water to grow their crops. Yet these drainage flows could be reduced and through better management this additional water could be used to enhance crop production. This could be done through a combination of reservoir operations, changes in water distribution, improved on-farm practices, and recycling of drainage flows. The downstream lagoons would benefit by reduced drainage flows that are closer to the natural situation. This seems to be a win-win situation. But, more knowledge is required about ecosystem water requirements, and bridges need to be built between the various interests operating in the area.

C) Restoring the Waza Logone Floodplain

In Cameroon, a floodplain has been brought back to life through the Waza Logone Rehabilitation Scheme (IUCN, 2000, p.37). A dam constructed in 1978 for rice irrigation greatly restricted the downstream flooding of the downstream floodplain along the Logone River, causing severe ecosystem degradation and the disruption of traditional livelihoods. In 1988, IUCN—the World Conservation Union—initiated a project to rehabilitate the floodplain, including the 171,000 ha Waza Park. Pilot water releases through newly constructed openings in the main river levee have enabled restoration of approximately 60% of the affected floodplain. The renewed flooding dramatically improved the living conditions for the people and their environment, without affecting the rice scheme. This ongoing project has shown that ecosystem rehabilitation and

<table>
<thead>
<tr>
<th>Period</th>
<th>Annual irrigated area (10^3 ha)</th>
<th>Rice crop production (10^3 tons)</th>
<th>Rice yield (T/ha)</th>
<th>Rice water productivity (kg/m^3 water supply)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966-78</td>
<td>139</td>
<td>561</td>
<td>4.04</td>
<td>0.65</td>
</tr>
<tr>
<td>1979-88</td>
<td>135</td>
<td>905</td>
<td>6.72</td>
<td>1.17</td>
</tr>
<tr>
<td>1989-98</td>
<td>118</td>
<td>920</td>
<td>7.80</td>
<td>2.24</td>
</tr>
</tbody>
</table>
water allocation for irrigated rice do not have to compete, but can exist side by side for the benefit of local people and ecosystems (Braund, 2000).

D) **Environmental Flows for the Lesotho Highlands Water Project**

The Lesotho Highlands water Project is a large interbasin transfer project that will bring water from the Sequ/Organge River in Lesotho to the industrial heartland of South Africa. As part of the project an Environmental Flow Assessment is carried out, financed by the World Bank (IUCN, 2000, p42.). The study focuses on understanding the complete river-ecosystem and developing a series of flow scenarios. Each scenario describes a possible future flow regime in the river system (resulting from dam releases and the catchment runoff) and the resulting conditions of the river. Preliminary findings have already influenced the design of the Mohale dam in the form of a multiple-outlet structure, including a higher capacity lower-level outlet. These structures would allow releases of varying quantity and quality, including occasional flood flows, to meet the requirements of downstream ecosystems. The project exemplifies how a methodology can be adopted that integrates biophysical, social and economic considerations in water resources development (World Bank, 1999).