between dykes, the aquatic bonds with their floodplains and their groundwater are severed. The sponge-like qualities of river valleys are lost, and so is the precious rainwater delivered to the land by oceanic rainclouds.

CLOSING THE CYCLE

More strikingly than any other aspect of contemporary life, modern cities reflect society's disquieting ambivalence towards water, the life-giver. Cities are hot, dry and dusty places. Not necessarily because of the absence of rain, but because every drop hitting roofs, streets and parking-lots is meticulously collected, sewered and discharged downstream. No chance to refresh the air, to fill up the groundwater, to nourish a tree. Rain is regarded by city planners as a problem, as a nuisance requiring expensive infrastructure to eliminate.

The obvious idea to make use of rainwater, be it for washing, watering gardens and parks or even toilet flushing, is not *en rogue* with mainstream water engineers. Tokyo for instance, with as much as 2,500 cubic meters of rainfall per year — a very wet city indeed — uses virtually none of this free gift from above. Instead, 2,000 million cubic meters of drinking water every year are imported through mighty and expensive pipelines from distant reservoirs up to 300 kilometres away. The rain, needless to say, is swiftly conducted back to the sea.

The lack of respect for rain is resulting in ever increasing water abstractions from nature, and has cost many of the world's aquatic ecosystems dearly. Today, once mighty rivers like the Colorado in North America or the Indus in South Asia hardly make it to the sea. Every single drop has been appropriated, abstracted and used. Likewise, underground water reservoirs are being exploited at disquieting rates. All along the Mediterranean coast and on many islands, seawater is now penetrating the substrata from which the groundwater has been pumped. Once groundwater becomes salty, it is irretrievably lost as a drinking water resource.

Freshwater is a finite resource. Recognising the limits requires making better use of every litre of rain, every litre pumped from rivers and wells. Agriculture in particular holds a huge potential for greater water efficiency. Irrigation alone currently accounts for 80 per cent of all water uses world-wide. Yet still, spray irrigation is widely applied although in a hot climate less than one fifth of the water reaches the plant roots. More sophisticated technology such as drip irrigation could easily cut water consumption in half. Growing drought-resistant crops such as millet, lentils, groundnuts and figs, instead of maize and cotton, could reduce water demand even further.

Reusing water is another way to deal with scarce resources. However, most water users leave their foul footprints: detergents from households, agricultural pesticides, and industrial chemicals all end up in water. Hence, used water is usually regarded as waste, collected in sewers, treated and returned to nature in a doubtful state.

In view of the scarcity of freshwater available on earth, humanity can no longer afford water pollution. We will have to learn that wastewater is actually a valuable resource that can be recycled for irrigation, industrial purposes and many other applications. However, in order to be able to purify and reuse wastewater, we must keep it free of toxic and persistent pollutants. Already, some industrial companies in Scandinavia and Canada are showing the way by introducing wastewater-free technologies which internally recycle process water.

Closing the cycles could drastically reduce water consumption. At the same time, it would rectify one of the main causes of marine pollution. Rivers world-wide carry millions of tons of unwanted chemicals from mining, industry, agriculture and households into coastal waters. It is a disgrace for our century of technical progress that we have not stopped spoiling and injuring the cradle of all waters, the ocean.

THE PRESENCE OF THE DEW

Many cultures and religions believe that every morning is a repetition of earth's creation, a tangible expression of the eternal renewal of life. Dawn is adorned with morning dew, a cloak of pearls seen shining in the first light, then vanishing. Dew is regarded as the silent messenger of higher powers, joining the black of night and the bright light of day, bringing together sky and earth, ocean and land. For centuries, it used to be highly revered and protected as the agent representing birth and beginning. Humanity must realise that in the 21st century as well, the presence of the morning dew is much more than a religious symbol of life. It is the very essence of survival.

AVOIDING WATER WARS AND ENSURING FOOD FOR ALL

BY PROF M. S. SWAMINATHAN

1. INTRODUCTION

A recent study carried out by the U N Commission on Nutrition, of which I am a Member, reveals the following facts.

Childhood malnutrition, especially stunting, is closely related to potentially permanent brain damage. About 1 billion children will suffer physical and mental impairment by 2020.

About 1 billion adults in developing countries are underweight. Such adult malnutrition impairs work capacity, lowers resistance to infections and markedly amplifies the risk to future generations.

There is a fundamental link between maternal and childhood malnutrition and the subsequent susceptibility of the child in adult life to dietary diseases, such as diabetes, high blood pressure, heart disease and some cancers.

New analyses reveal that 30 to 50% of adults in South Asia are underweight; there are about a billion malnourished adults worldwide.

Such serious problems facing us as we approach a new millennium can be solved only by a new social contract between governments, civil society organisations, mass media and donor agencies which will ensure water, food and sanitation to every

child, woman and man. Water occupies the first position among the inputs needed for sustainable food and livelihood security. As water becomes scarce, there will be an expansion in the number of water lords, water markets and water conflicts.

Most of the water conflicts are local or regional. For over a thousand years, water conflicts have occured at the local level. Local level courts like the one operating at Valencia in Spain have helped to resolve such conflicts. As we approach the new millennium water conflicts at the local, national and regional level are likely to increase. There will also be intersectoral conflicts on the use of water. Hence, it will be prudent to study the problem in detail and develop an integrated strategy for the sustainable harvesting, use and allocation of water.

II. EVOLUTION OF THE CONCEPT OF FOOD SECURITY

The concept of food security has been undergoing refinement during the last 50 years. Immediately after World War II, food security meant building emergency grain reserves and ensuring the *physical* availability of food in the market. After the onset of the green revolution in the late sixties, it became obvious that *economic* access to food is equally important for ensuring food security at the household level. During the eighties, it became evident that the gender dimension of food security should receive attention, in view of the growing feminisation of poverty and agriculture. This was highlighted at the World Conference on Women held at Beijing in 1995. The principle of *social access*, with reference to women and marginalised communities was hence added to the concept of food security. Finally, after the UN Conference on Environment and Development held at Rio de Janeiro in 1992, there has been an increasing understanding of the role of environmental factors in food security. The ecological foundations essential for sustained agricultural progress are increasingly under stress due to human activities. Agenda 21 of UNCED addresses these concerns. Without safe drinking water and environmental hygiene, the biological absorption and retention of food will be poor. Thus, *environmental access* to food becomes important.

Based on the above considerations, the Science Academies Summit held in July 1996 at the M S Swaminathan Research Foundation, Madras, India, in preparation for the World Food Summit convened by FAO in Rome in November 1996, proposed the following comprehensive definition of food security.

Policies and technologies for Sustainable Food Security should ensure: that every individual has the physical, economic, social and environmental access to a balanced diet that includes the necessary macro — and micro-nutrients, safe drinking water, sanitation, environmental hygiene, primary health care and education so as to lead a healthy and productive life, and that food originates from efficient and environmentally benign production technologies that conserve and enhance the natural resource base of crops, animal husbandry, forestry, inland and marine fisheries.

III. WATER AND FOOD SECURITY

A. Physical Access

Humanity now uses over one-half of the total accessible freshwater runoff. Projected growth rates in irrigated areas are significantly lower than in the recent past. For the world as a whole, the irrigated area is projected to grow at 0.6 percent per year, as compared to 1.5% during 1982-93. Current global water use is around 4500 cubic kilometers. However, freshwater is distributed unevenly across the globe. Countries with freshwater resources in the range of 1000-1500 cubic meters per capita per year face water stress, particularly in drought years. Agriculture is by far the biggest user of water, accounting for more than 70 per cent of water withdrawals worldwide and more than 90 per cent water withdrawals in several low income developing countries. Population rich and land hungry countries like India and China, have no option except to produce more food and other farm commodities from less per capita arable land and irrigation water availability in the coming millennium. The largest increases in irrigated areas during the coming decades are expected in India and China. However, even in India, the projected 1995 to 2020 rate of growth in irrigated areas of 1.2 per cent per year is well below the rate of 2.0 per cent per year achieved during 1982 to 1993. Much of the additional irrigation water comes from groundwater and this source is being increasingly exploited in an unsustainable manner. Major irrigation projects are running into serious environmental and social problems.

The adequate availability and equitable and efficient use of irrigation water are essential for converting the green revolution into an *evergreen revolution*. A study in eight Asian countries revealed that of the additional 117 million tons of rice produced between 1965 and 1988, 34 million tons can be directly attributed to irrigation. Even the remaining attributed to new varieties and fertilizer would not have been possible without water. Irrigation water has helped to increase not only crop productivity but cropping intensity, thereby leading to an increase in yield per day. In the tropics and sub-tropics, where there is abundant sunshine during most of the year, multiple cropping techniques have spread fast, both because of irrigation projects and the availability of photo-intensitive crop varieties. This has facilitated crop-livestock integration, through the introduction of fodder crops in the rotation.

Some of the urgent steps needed in the area of irrigation water conservation and sustainable use are:

Harvest and conserve rain water;

Promote conjuctive water use of river, rain, ground, sea and sewage water, in appropriate combinations;

Prevent unsustainable exploitation of the aquifer;

Ensure efficiency, economy and equity in water use through cooperative management of watersheds and command areas;

Regulate the expansion of water markets and water lords;

Introduce proactive measures to avoid water conflicts.

B. Economic Access

Government pricing policy, particularly with reference to electricity for pumping ground water, often results in inefficient and unsustainable exploitation of precious water resources. On the other hand, private ownership of ground water resources

leads to the emergence of water lords and water markets. A national policy relating to *access to water for all* should be designed in such a manner that first, irrigation does not result in long term harm to soil health and second, gender and social equity in sharing the available water is ensured. Participatory management of irrigation water resources, including systems of rotational distribution of water, will help to foster the equitable and efficient use of water. Pricing policies should signal the inter-generational equity aspects of water use.

Irrigation has been an important factor in poverty alleviation in several developing countries. When water is available, there is not only crop security but also opportunities for multiple cropping, mixed cropping and agro-forestry systems of land use. Irrigation has a multiplier effect on employment both at the production and post-harvest phases of agriculture. It makes Integrated Intensive Farming Systems (IIFS) possible. Irrigation water thus enhances purchasing power.

C. Environmental Access

This again is a multi-faceted issue. Sewage and industrial water recycling, including their incorporation in conjuctive water use systems will confer both public health and economic benefits. Ecological problems associated with unscientific water use such as water logging, salinisation and soil erosion are well known. Serious nutritional problems such as arsenic poisoning, due to the tapping of the deeper layers of the aquifer, have been reported in Bangladesh and the State of West Bengal in India.

Environmental and social problems are also serious in several major multi-purpose irrigation projects. For example, China's Three Gorges Dam over the Yangtze river will help to halt floods in the South of China and bring irrigation water to the northern part of the country. However, environmentalists have several concerns. Similarly, the Narmada project in India, designed to provide drinking water to 40 million people and irrigate 1.8 million ha, will lead to the displacement of nearly 250.000 people and to inundation of 117.000 hectares of land. It is obvious that every nation will have to weigh carefully the pros and cons of large multipurpose water projects and choose the ones which confer maximum social benefit with the least ecological harm. There is need for large numbers of professionals trained in Green Audit procedures with reference to irrigation projects. Opposing unsustainable development alone is not enough; there must be equal emphasis on proposing sustainable options. This is going to be a major challenge in the next century with reference to irrigation projects.

D. Social Access

This again has several dimensions. Gender inequity is most serious in the case of drinking water, since women are invariably entrusted with the responsibility of fetching water for domestic use. Destruction of forests leading to the disruption of hydrologic cycles has affected adversely the nutrition and livelihood security of women.

Social cohesion and cooperation in the harvesting, storage and use of water will help enormously to strengthen irrigation water security. In a recent study, published under the title "Dying Wisdom", Anil Agarwal and Sunita Narain (1997) [1] , illustrate the power of social action, characteristic of the past but fast vanishing now, with the following examples.

a) Jaisalmer. A district in the Thar desert of Rajasthan, India. Annual rainfall is 100 mm. During the drought year of 1987, the Government's piped water supply ran dry. But there was enough water for the people who stuck to their rainwater harvesting structures called kunds (small water conservation structures).

b) Cherrapunji, Meghalaya. A village in the northeast with annual rainfall of 15.000 mm. Yet this village suffers from water storage during summer months.

Thus, people's participation in water harvesting, conservation and efficient use will foster both sustainable food and drinking water security. However, there will be no cooperation in water saving unless there is equity in water sharing. Irrigation Water delivery systems and on-farm management of water can be made more efficient, if community-centred systems of water management are promoted. Globally, more than 50% of the cultivated area will continue to depend on rainfall and hence, rainwater management is vital for sustainable food security. In the past, famines were invariably associated with the failure of rainfall. Irrigation systems have helped to reduce variability in production from year to year and have provided insulation against total crop failure in years of drought.

IV. COMPETING DEMANDS FOR WATER

Currently, water use goes to four major sectors — domestic needs including drinking water, agriculture, industry and ecosystem conservation. In most calculations, the need for water to maintain ecosystems, particularly those rich in biodiversity, is not taken into consideration. For example, many mangrove forest ecosystems, which occur in the estuaries of major rivers, are adversely affected when the flow of fresh water goes down. Salinity then goes up and not all mangrove species can withstand a high degree of salinity. Indiscriminate deforestation disrupts hydrologic cycles and increases the frequency of floods and drought. Hence, water allocation policies should include adequate provision for safeguarding the integrity of critical ecosystems. Disruption of hydrologic cycles hastens the process of desertification, as is evident from the ravines of the sub-Himalayan zone. There is need to standardise methods for calculating the water requirements for the conservation and sustainable management of forests and natural ecosystems, so that this need can be integrated into sectoral assessments.

The need for policy making and implementation structures to deal with water allocation and use issues in a holistic manner is becoming urgent in many countries. This will be clear from the recent decision of the International Irrigation Management Institute (IIMI) in Sri Lanka to change its name to "International Water Management Institute (IMI)" in order to enable it to look at water problems in its totality. River basins are highly integrated hydrological systems with the same water flowing and recycling through the agricultural, domestic, industrial and environmental sectors.

The following aspects will need integrated attention while developing a holistic approach to water management.

Demand: While global demand projections are useful, what matters to individuals is the local availability of water. The need for water for household use and for agriculture, industry and ecosystem conservation will have to be assessed both locally

and nationally. The qualitative aspects of water should receive equal attention.

Supplies: Different methods of enhancing water availability will have to be promoted at the local and regional level. An appropriate mix of major, medium and mini-irrigation projects will have to be fostered. Conjunctive use of different sources of water such as rain, river, ground, sea and waste water will have to be promoted, as is being done effectively in countries like Israel. Computerised systems of water management and delivery need popularisation. Water Information Shops can be started in areas characterised by severe water scarcity.

Management: Efficient systems of water management, including equity in distribution and the control of pollution, will have to receive attention. Seasonal fluctuations in demand will have to be addressed through suitable management protocols.

Conflict resolution: Conflicts are likely to grow at the national and regional levels on sharing water. At the local level, conflicting inter-sectoral demands, of the kind described later, will have to be resolved. Suitable institutional structures will have to be developed for a proactive resolution of emerging conflicts. The Water Court operating in the city of Valencia in Spain for many centuries is a good example of a local initiative in resolving conflicts amicably. In the new millennium, conflicts are likely to arise between the need of water for human use and that needed for irrigation. There are also possibilities of conflicts between countries, if changes in precipitation and temperature occur as a result of climate change induced by greenhouse gas emissions. The Framework Convention on Climate provides a mechanism for cooperation among countries in preventing adverse changes in rainfall, temperature and sea level.

Technology development and dissemination: This has to receive high priority, since technologies are now available to harvest every drop of water and use it economically and efficiently. Local level water users' associations can help to save and share water based on the principles of equity and efficiency.

Public awareness, social mobilisation and information empowerment: This is an area of great importance, particularly in countries where a majority of farmers operate small holdings. In India and China, for example, the average size of holding is less than one hectare. Group cooperation will be essential under conditions of small and fragmented holdings for both water harvesting and efficient use. Without equity in water sharing, cooperation in water saving will not be forthcoming.

Resources: The requisite managerial, institutional and financial resources will have to be mobilised for achieving the above objectives. Institutional structures will be needed for demand-forecasting and management and for advice on efficient water use.

New Partnerships: Coalitions of all concerned — scientists and engineers, political leaders, mass media, civil society, farm families, private sector industry, womens' organizations and bilateral and multilateral donors — will have to be formed to tackle water problems on an one-by-one basis.

Population: With every increase in population, there is a decline in per capita availability of water, a situation which can be altered only by new technologies such as solar desalination of sea water. For example, water availability per capita in India was over 5000 cubic meters (m3) per annum in 1950. It now stands at hardly more than 2000 cubic meters per capita. By year 2025, per capita availability is projected at only 1500 cubic meters (Fig.1). Such quantitative data alone are not adequate to get a real picture of the water availability status. Pollution affects water quality both in rivers and ground water. Also, there are gross inequalities between basins and geographic regions. Water markets, if they are organised in a non-exploitative manner, can help to meet the minimum household and agricultural needs.

V. MANAGING COMPETING DEMANDS

Sandra Postel (World Watch Paper 132, September 1996) has described the problems faced in dividing waters for different uses. In a more recent paper (December 1997), Mark W Rosegrant of the International Food Policy Research Institute and Claudia Ringler of the International Irrigation Management Institute, have dealt with the global impacts of water reallocation from agriculture on food production. Their calculations indicate that the projected reductions in agricultural water availability will be substantial by 2020. The reduction can be as much as 24 percent in China and 21 percent in India. Their model also suggests that reallocation of water out of agriculture can have a dramatic impact on global food markets. In developing countries, yield growth for all cereals will slow from 1.20 percent annually to 1.07 percent per year during the period 1993 to 2020. The area decline during the same period will be from 0.29 to 0.23 percent. Rice will suffer most, since it needs larger quantities of irrigation water. Consequently, the average price of rice is projected to increase by 68 percent between 1993 and 2020.

In addition to direct impacts on agricultural production, water transfers can negatively affect business activities, fishing and hydropower generation. Under conditions of scarcity, water markets grow. They can be of benefit to those who do not own a well or other source of water, if they function in a regulated environment, where making profit out of water scarcity becomes unethical. Rosegrant and Ringler recommend policy reforms such as the establishment of secure water rights to users, the decentralization and privatization of water management functions to appropriate levels, pricing reform, markets in tradeable property rights, and the introduction of appropriate water saving technologies. While developing public policies for specific agro-ecological and socio-economic conditions, the trade-offs among various policy options will have to be carefully considered.

Often, local solutions will have to be found to manage water scarcity. Contingency plans and alternate cropping strategies will have to be developed for different water availability situations. Crop-saving irrigation methods will help to optimise yield under conditions of water scarcity. Most of these methods will require the active cooperation of all the families residing in a watershed. Management procedures relating to inter-sectoral availability of water should keep in view the needs of women. It is women who are mostly in charge of fetching and managing water at the household level. Hence, the gender dimension should be internalised in all technological and policy issues relating to water.

VI. MEETING THE CHALLENGE

Trends in water consumption indicate that demand for water for household and industrial uses in developing countries could double as a proportion of total water demand in the next 25 years. Scope for water supply expansion will at the same time be limited because development of irrigation and urban water supplies is becoming increasingly expensive, and often involves high costs in terms of environmental degradation and human resettlement. The countries experiencing water stress now as well as estimates of water withdrawal for different purposes are shown in figures 4 and 5. Water quality problems such as arsenic contamination of ground water are increasing in Taiwan, Chile, Mexico, China, Bangladesh and the West Bengal part of India. Without fundamental reform of water management, the rapid growth in urban water demand will require large transfers of water from irrigated agriculture, thereby threatening food security. Hence, water supply and demand should be managed in an integrated fashion, considering simultaneously all uses and sources. Particular attention will have to be paid to avoiding water pollution.

How can we accomplish this objective? At the global level several initiatives like organisation of a Global Water Partnership and a World Water Council have been taken in recent years. At a meeting held at Valencia in Spain in December 97, the participants recommended the establishment of an *International Water Centre* for undertaking research, analysis, appraisal, information dissemination, training and consultancy activities. Such a Centre could also specialise in water laws and help in resolving water disputes through analysis and information. It was felt that we urgently need a newinstrument for promoting sustainable water security in the world.

Charity begins at home — while global mechanisms and institutions are important, it is essential that every country sets up institutional structures to deal with national and local level problems. International Conflicts over water are often precipitated by a failure to meet local, provincial, national and regional water demands for household, agriculture and industrial uses as well as for environmental / ecosystem services. The various sources of water and sectoral needs are indicated in Fig. 2.

An institutional structure for dealing with the multiple dimensions of water management at the country level is proposed in Fig 3. I have suggested the title "*National Water Trust*" instead of the commonly used term *National Water Authority*, to emphasise that water management should be carried out in the trusteeship mode. *We must consider ourselves as trustees of water sources and not as owners.* This will help to instill the feeling that management of water should not only be in the interests of the present generation but also of the generations yet to be born. Thus, the guiding principle for the work of the National Water Trust will be intra- and inter-generated equity.

Provincial and local level units of the National Water Trust can be organised, according to needs. The National Water Trust will serve as the hub of a grid of institutions including policy making bodies. It will thus serve as the flagship of a national system for sustainable water security.

VII. WATER SECURITY : BRIDGE TO A MILLENNIUM OF HOPE

1998 marks the bicentenary of Thomas Malthus's essay on population. In 1798, Malthus warned "the period when the number of men surpass the means of subsistence has long since arrived". When Malthus wrote his essay, the global population was less than the current population of India alone, namely 970 million. There is adequate food in the world today at *current levels of purchasing power*. Hunger is presently more related to economic access than physical access. Irrigation water availability and management have played a pivotal role in keeping Malthusian predictions at bay. Our ability to maintain a satisfactory balance between population and food production will depend both upon population policies and food production strategies. Every nation will have to develop an appropriate mix of water supply augmentation and demand management through socially and ecologically constructed policies and technologies. Comprehensive policy reform that promotes efficient use of existing water supplies will be needed in most countries. The National Water Trust proposed in this paper would be of help in integrated planning and decision making.

Above all, cooperation between countries sharing the same river or water source will become increasingly important. This is also true for States within a country having a federal constitution. Differing perceptions on the value of artificial rainmaking is a case in point. National and international mechanisms for proactive action on potential water conflicts will have to be put in place. International cooperation is also essential for avoiding adverse changes in climate, particularly precipitation and sea levels, arising from the accumulation of greenhouse gases in the atmosphere. A major step in this direction has been taken at the Conference of Parties to the Framework Convention on Climate Change held at Kyoto in December, 97. Meanwhile, it will be prudent for all countries to be prepared for different weather probabilities based on computer simulation models. Both avoidance and mitigation strategies should be developed. It will be appropriate in this context to recall the words of Mahatma Gandhi.

"Nature provides for everybody's need but not for everybody's greed".

NOTES

[1] Agarwal Anil and Sunita Narain (eds)(1997). "Dying Wisdom : Rise, fall and potential of India's traditional water harvesting systems." Centre for Science and Environment, New Delhi pp.404

SKIFFS

JOSE BEJARANO

Along the beach skirting Ceuta's tuna-fishing grounds, the only sound to be heard at that time of day was that of the waves gently lapping the sand laden with the smell of diesel oil left by