WATER FOR FOOD

Introduction

Water is recycled continuously through transpiration through biomass and evaporation from land, river systems and oceans, besides precipitation through condensation, rain and snow. A river basin is a natural entity for planning beneficial uses of available waters from precipitation, which are highly variable in space and time. Where available precipitation is excessive, land has to be drained to get beneficial uses out of it. Often, some parts of a basin are surplus in availability, while some others face deficit. Integrated Water Resources Management is practiced to judiciously manage the needs. Intra and inter-basin transfer of water to remedy such imbalances has also been practiced by mankind for a long time. It may involve construction of storages for impounding runoff of floodwaters generated over a few storms sometimes spanning a few days in a year, enabling its use round the year. Diversion structures involving little or no storage may be constructed for withdrawals through canals and by pumping, where the river flow quantum is adequate. Storages wherever constructed always absorb and reduce flood peaks downstream, enabling better flood management.

Presently, irrigation covers about 277 million hectares (Mha) i.e. about 18% of world's arable land, but is responsible for around 40% of crop output and employs nearly 30% of population spread over rural areas. It uses about 70% of waters withdrawn from global river systems, 60% of which gets used consumptively, the rest predominantly returning to the river systems enabling its reuse downstream. Thus 30% of water withdrawn is put to other uses like drinking, municipal, industrial, hydropower generation, and recreation. Only a small part of this quantity is used up consumptively, while a large unconsumed part, treated or untreated, is returned to the river systems and reused. Drainage systems cover about 190 Mha i.e. about 12% of world's arable land, of which 130 Mha is rainfed and the rest irrigated. As river basin boundaries normally don't match with national or state administrative boundaries, basin wide development may be affected by conflicts and competing demands for sharing of available waters between regions or peoples for various beneficial uses. Plans would therefore invariably have to aim at integration of uses, demands, supplies, size of structures required, other available resources and institutional arrangements.

The Increasing Population Dilemma

The increasing global population has put a lot of pressure on water resources. Food situation as a result also calls for most appropriate utilization of the land and water resources, so as to provide food security, especially in the vulnerable regions.

Table 1 shows the population estimates in the world from 1950 to the present and the projections up to 2050.

World population is currently growing at a rate of about 1.2 per cent annually, implying a net addition of 76 million people per year totaling to 2.5 billion by 2050, which was incidentally the total world population in 1950 and which is also the current combined population of the two giants, China and India. Whereas today the population of the more developed regions of the world is rising only at an annual rate of 0.25 per cent, that of the less developed regions is increasing nearly six times as fast, i.e. at 1.46 per cent, and the subset of the 50 least developed countries is experiencing even more rapid population growth (2.4 per cent per year).

From the current figures of 6.5 billion, the world population is expected to touch a 7.9 billion mark by 2025 and 9.1 billion by 2050 under medium variant (UN, 2005). If high variant is considered then the population figure would touch 10.6 billion. Most of the addition (96%) to the population is expected to take place in the developing countries that already have a population share of 81% in 2005 which is expected to further rise to 84% in 2025 and to 86% by 2050, including 19% population to be living in least developed countries, while in more developed (industrialized) countries, it will be only 14% in 2050. Regionally, the population in Asia will rise to over 5.2 billion, while that in Africa will more than double from current 906 million to nearly 1.94 billion in 2050. Population in Europe (and also in Japan) will, however, decrease from its current figures of 728 million to 653 million (medium projection) in 2050, while in North America the rate of growth is expected to be maintained at 1%, rising from the current level of 331 million to 438 million. The cause for concern is that between 2005 and 2050, in some of the least developed countries many of which are food insecure, the population is projected to at least triple. Amongst them are Afghanistan, Burkina Faso, Burundi, Chad, Congo, the Democratic Republic of Congo, Guinea-Bissau, Liberia, Mali, Niger and Uganda (UN, 2005). It is in the developing, lesser developed and least developed countries that most of the water and food related problems exist and are likely to aggravate. These will be the areas to focus on in the coming years.

Table 1. Population of the world, major development groups and major areas in 1950, 1975, 2005 and 2050, by projection variants

Major area	Population (million)			Population in 2050 (million)	
	1950	1975	2005	Medium	High
World	2519	4074	6465	9076	10646
More developed regions	813	1047	1211	1236	1440
Less developed regions	1707	3027	5253	7840	9206
Least developed countries	201	356	759	1735	1994
Other less developed countries	1506	2671	4494	6104	7213
Africa	224	416	906	1937	2228
Asia	1396	2395	3905	5217	6161
Europe	547	676	728	653	764
Latin America and the Caribbean	167	322	561	783	930
Northern America	172	243	331	438	509
Oceania	13	21	33	48	55

(Source: UN, 2005)

The Food Scenario

Figure 1 below depicts the world cereal production and utilization status between the years 1993-2005. From the trend, it will be seen that while the production has been fluctuating, the utilization is gradually rising over the years. After 1999, cereal production has not been able to keep pace with the consumption, with the result that much of the availability-demand gap is being met from the reserves. This is not a healthy situation. The growth rate of demand for cereals is expected to rise to 1.4 percent a year up to 2015, slowing to 1.2 percent per year thereafter. In developing countries overall, cereal production is not expected to keep pace with demand. The net cereal deficits of these countries, which amounted to 103 million tonnes (MT) or 9 percent of consumption in 1997-99, could rise to 265 MT by 2030, when there is expected to be 14 percent of consumption. This gap will have to be bridged by increased surpluses from traditional grain exporters, and by new exports from the transition countries, which are expected to shift from being net importers to being net exporters (FAO). According to current forecast (FAO) the world cereal output in 2005 will not be

able to meet the requirements of 2006 and will be short by some 24 MT, bringing down the stocks to 425 MT.

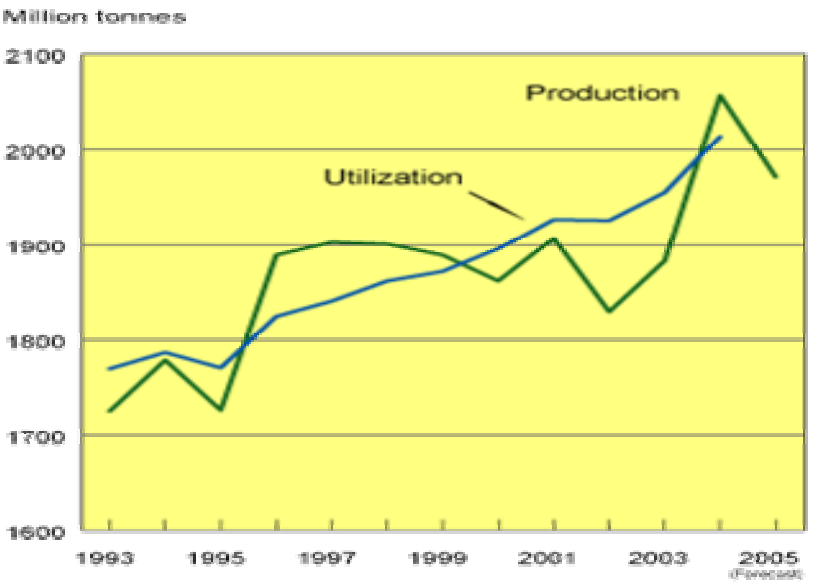


Figure 1. Global Cereal Production and Utilization (Mill. Tonnes) from 1993 – 2005 (FAO, 2005)

The mix of foods consumed - cereals, pulses, oils, fruits, vegetables, nuts, meat, dairy products, fish - and the level of calorie intake with a balanced nutritional diet is expected to undergo change with the steady increase in the standard of living even in the countries which are not 'developed' ones. Food needs will exceed projections, which are in proportion of growth in population. It is estimated with the increase of the population from 6 billion to over 8 billion in next 25 years, the present food production need to be doubled. Presently also, majority of world's population lives in emerging developing countries, comprising Asia (excluding Japan), Latin America, the Caribbean and some other small regions. Demands for water for growing more food will increase causing shortages in regions, which are hitherto comfortable with availability. The growth in shortage could be avoided only by developing the unharnessed potential or by decreasing the withdrawals and simultaneously increasing water use efficiency.

Large populous countries would continue to strive for maintaining self-sufficiency in food production, because their shortfalls in case of droughts, will be too large to be covered by world trade which remains at around 10% of total production and which shows signs of reduction. As developed world only has surplus food for trade, there is also a possibility that producers in developed world may move away from food production. Nevertheless, every country would attempt to increase productivity of cropped lands with water that could be made available by improving water use efficiency and by bringing additional lands under irrigation, employing better irrigation technology and through increased withdrawals where potential is yet available. Such effort should lead to maintaining or achieving food security. The concept of security encompasses not only food production, but relates to its storage, preservation, supply at reasonable and affordable prices, and adequate size of buffer stocks to take care of natural disasters. The aim of food security for Governments means co-ordination of effort of several Ministries/Departments and these often include (but not limited to), which include: water resources, irrigation, public works, agriculture, rural development, environment, health, commerce and trade, industry, chemicals and fertilizers.

Realization of targeting of food security round the world would call for commitment of stakeholders and political will of the country's leadership.

It is expected that more people either landless or otherwise would move away from the agriculture sector to the manufacturing and services sector to escape unemployment and poverty in rural areas. This shift could trigger consolidation of land holdings, and improved productivity from the landmass, which in turn could cause faster economic growth. Increased productivity could mean growing required cereal food from lesser area, release some of the area for higher value crops thus ensuring poverty alleviation for poor and marginal farmers. Making water available to achieve food sufficiency and security will also lead to rural well being through better livelihood, health, employment, stabilization of rural populations, education, transportation, communications and human productivity. It will help insure societies against natural disasters and provide a more sustainable livelihood. Irrigation, drainage and flood management will no longer remain options but will fulfill the core needs of society as well as ensuring protection of environment. As everybody lives downstream of somebody, the national planning shall, nevertheless, have to ensure availability of requisite quantities of water with right quality, down the streams in a river basin.

Undernourished Masses

The figure 2 below shows the region-wise distribution of undernourished population in the world.

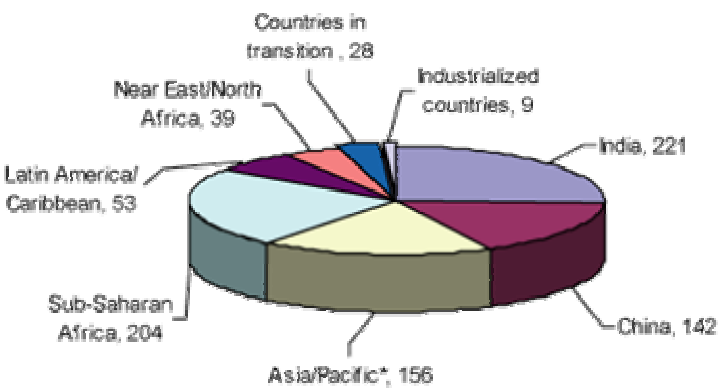


Figure 2. Undernourished People (millions) (2000-2002)

As per the current FAO estimates (FAO), the number of undernourished people in the world presently stands at 852 million, about 96% (815 million) of whom are in the developing countries, 3% (28 million) in the transition countries and 1% (9 million) in the developed countries. More than half of the total numbers of undernourished (60 percent) are living in Asia and the Pacific, followed by sub-Saharan Africa, which accounts for 24 percent of the total. In Asia and the Pacific, the incidence of undernourishment has halved over the past two decades on account of developmental activities. In sub-Saharan Africa and Latin America, however, the increase in population has outpaced reduction in the percentage incidence of undernourishment, resulting in an increase in absolute numbers of undernourished, while in the Near East and North Africa there has been no appreciable change in the incidence of undernourishment compared with the situation two decades back. While there has been a decrease in the proportion of undernourished people in the period 2000-2002 in Asia/Pacific, Latin America/Caribbean and Sub-Saharan Africa (where the rate of increase slowed down from 5 M per year to 2 M per year), the proportion in Near East/North Africa and in the countries in transition has increased, in comparison with the previous decade period 1990-1992. The two biggest population giants China and India relatively fared well. China reduced the number of undernourished by almost 50 million and India by 13 million up to the period 1992-1997, while in the rest of the world the figure increased by 34 million. During the second half of the decade (up to 2000-2002), however, the number of undernourished people fell by only 4 million in China, whereas in India the number rose by 18 million (FAO).

Hunger and Poverty

Poverty has many dimensions. It is a state of malnutrition and total lack of access to services and resources. It is most commonly indicated in terms of income of US $ 1 or US $ 2 per day based on 1993 purchasing power parity. There are 100 million people living with less than US$1 per day (2000 figure), majority of whom belonged to South Asia (39.2%), Sub-Saharan Africa (29.3%) and East Asia and the Pacific (23.7%). The number of people living with less than US$2 per day is over 2.8 billion (UNDP). As of 2006, the GDP per capita of the developed countries is estimated to be US$ 32090, against US$ 1530 for the developing countries. In 2015, the corresponding figures are estimated to become US$ 39700 and US$ 2080. This exemplifies the vast difference in the levels of economic growth in the two categories of countries.

Massive strides have been made in improving food security with the proportion of people living in developing countries, with average food intakes of below 2 200 kcal per day having fallen from 57 percent in 1964-66 to just 10 percent in 1997-99. Yet about one person out of six people in developing countries remains undernourished, totaling to 852 million of such people. Global progress in nutrition is expected to continue, in parallel with a reduction in poverty as projected by the World Bank. The incidence of under-nourishment is estimated to fall from 17 percent of the population of developing countries at present to 11 percent in 2015 and just 6 percent in 2030. By 2030, three-quarters of the population of the developing world could be living in countries where less than 5 percent of people are undernourished. Less than 8 percent live in such countries at present.

Hunger and malnutrition from childhood have significant debilitating repercussions on people, adversely affecting their physical capacity, thereby impacting on their productivity and socio-economic development. This aspect is therefore required to be addressed seriously. The value of increased production would be 5 times more than the cost of reducing the number of hungry people from 600 million to 400 million by 2015. An FAO study estimates that ‘an increase of just US$24 billion per year in public investment would make it possible to attain the WFS goal and reap US$120 billion in annual benefits’ (FAO). It considers various deficiencies to study costs of their treatment/reduction and corresponding accrual of benefits that were as much as 23 times more.

Task Force on Hunger has estimated that half of the hungry people are the smallholder farmers, the remaining being rural landless, urban poor, and other people making a living from forests and fish.

FAO estimates that almost 70 percent of the increase in food production is expected to come from higher yields, around 20 percent from expansion of arable land and around 10 percent from multiple cropping and shorter fallow periods in the developing countries. Further, 80 percent of increased crop production in developing countries will have to come from intensification : higher yields, increased multiple cropping and shorter fallow periods (FAO). However, to alleviate hunger in developing countries, increased agricultural production, whether from irrigated or rainfed agriculture, will have to go hand in hand with creation of gainful employment opportunities and better access to markets for agricultural products.

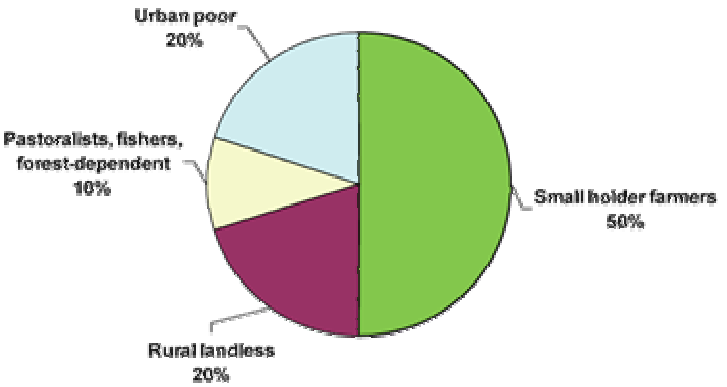


Figure 3. Category of Hungry People (Source : Hunger Task Force)

Message from the Second World Water Forum (WWF) 2000 and other Conferences

More than 80 sessions held at the Second WWF in 2000 in The Hague covered vast ground related to all facets of water. Issues of consensus that emerged for future charting of the course of actions were :

- assessment, monitoring and preparations for facing likely impacts of climate change on water availability - increase in floods and droughts - sea level rise - melting of snow and glaciers - desertification; water scarcity indicators as expounded by IWMI;
- need for integration of water resources development and management; need for both supply and demand management according to level of development - growing needs due to economic development and population growth of countries; need for different sizes of dams in a basin and in case of very large river basins - a sub-basin approach; scheme efficiency vis-à-vis basin efficiency and its optimisation;
- basinwide ecosystem approach; ensuring sustainability of human systems with ecosystems; sustainability is equivalent to durability and or resilience in face of natural vagaries and disasters; reclamation of waste lands; increasing water and land productivity by structural and non-structural measures;
- the crucial role played by large dams; critical role of dams in generation of hydro power and flood control; besides regeneration of ecosystems in hostile environment; need for inter-basin transfer of waters; need for resolution of problems related to water sharing within countries and between countries sharing rivers, interdependence of surface and ground waters and need to harness them optimally and conjunctively; artificial recharge of ground water where cost-effective;
- need to improve both surface and groundwater quality from both point and non-point sources of pollution; adoption of 'user pays', 'polluter cleans or pays' and 'equitable cost allocations' principles according to level of economic development and poverty level;
- level of cost recovery, balancing of prices of food- subsidies- water pricing keeping in view the need to support poor and marginal farmers; Integrated Water Resources Development and Management (IWRDM) and linkage with poverty alleviation; need for social audit;
- disallowing diversion of water from food crops to high value crops at the cost of food self sufficiency; limits of world trade in food; stakeholder participation, involvement of youth and women, lesser role for Governments as providers.

The highlights of other important conferences also indicate a major focus on water development especially in lesser developed areas and those facing extreme poverty.

Earlier in 1977, the Mar del Plata conference resulted in initiating a series of global activities in water. The International Drinking Water and Sanitation Decade (1981-1990) brought about a valuable extension of basic services to the poor.

The International Conference on Water and the Environment in Dublin in 1992 set out the four Dublin Principles. The UN Conference on the Environment and Development (UNCED) in 1992 produced Agenda 21, with its seven programme areas for action in freshwater. Both these conferences were landmark events that placed water at the centre of the sustainable development debate. Their findings are of relevance, even today.

The Hague Ministerial Declaration of March 2000 adopted following seven challenges as the basis for future action which have additionally been adopted as the basis for monitoring progress :

- Meeting basic needs – for safe and sufficient water and sanitation
- Securing the food supply – especially for the poor and vulnerable through the more effective use of water
- Protecting ecosystems – ensuring their integrity via sustainable water resource management
- Sharing water resources – promoting peaceful cooperation between different uses of water and between concerned states, through approaches such as sustainable river basin management
- Managing risks – to provide security from a range of water related hazards
- Valuing water – to manage water in the light of its different values (economic, social, environmental, cultural) and to move towards pricing water to recover the costs of service provision, taking account of equity and the needs of the poor and vulnerable
- Governing water use wisely – involving the public and the interests of all stakeholders.

The Commission for Sustainable Development (CSD) in 2002 later recommended that poverty eradication, changing unsustainable patterns of production and consumption and protecting and managing the natural resource base of economic and social development are overarching objectives of, and essential requirements for, sustainable development. Coming up to 2002 and the World Summit on Sustainable Development (WSSD), UN Secretary General Kofi Annan identified Water and sanitation, Energy, Health, Agriculture, Biodiversity (WEHAB) as integral to a coherent international approach to sustainable development. Water is considered essential for success in each of these focus areas. The WSSD also added the 2015 target of reducing by half the proportion of people without sanitation.

The 3rd World Water Forum and after

The 3rd World Water Forum and Ministerial Declaration (in Kyoto, Japan) in March 2003 further recognized the need for infrastructure development for food security in vulnerable countries and acknowledged irrigation as an effective means. The year 2003 was declared the International Year of Freshwater and later the decade 2005 to 2015 was proclaimed by the UN as the International Decade for Action – '***Water for Life***', in a bid to further bring about need for focused attention of the world for actions towards sustainable development of water resources.

Commission for Sustainable Development in its meetings in 2004 (CSD-12, 14-30 April, 2004) and 2005 (CSD-13, 11-22 April, 2005) stressed, among others, on improving access to safe drinking water, ensuring effective water sector management and investment in infrastructure development, improving regulatory frameworks and strengthening local governance and implementing irrigation projects with a focus on the poor, particularly in Africa.

Development implies use of resources. The UN recognized that these aims, which focus on poverty, education and health, cannot be achieved without adequate and equitable access to resources, the most fundamental of which are water and energy. The World Bank and other funding agencies also

reviewed in February 2003 their hitherto adopted policy of not supporting large infrastructure projects, after realizing that financing of large water infrastructures was necessary towards meeting the poverty alleviation needs which had unfortunately received a dent during the preceding few years. It is of course implied that all the set out targets should be aimed to be achieved with due regard to environmental sustainability.

Water Availability Scenario

Fresh-water is a finite, naturally renewable resource received by way of precipitation, but is significantly unevenly distributed in time and space. Out of an average of 110,000 km^3 of rain that falls over the continents annually, around one-third reaches the aquifers, rivers and lakes (blue water) of which only about 12,000 km^3 is considered readily available for human use. Current water withdrawal for municipal, industrial and agricultural use amounts to some 10 percent of the blue water resource. The remaining two-thirds forms soil moisture or returns to the atmosphere as consumptive water use (evaporation from wet soil and transpiration through plants). However, green water is a significant water resource, much larger volume-wise than the water replenishing streams, lakes and aquifers.

Demographic trends and changes in consumer food preferences necessitate that food production benefit from both green and blue water resources.

Hydro-climatological conditions of a region therefore set the limits for its availability. It is estimated that between 2000 and 2025, the global average annual water availability per capita will fall from 6600 m^3 to 4800 m^3 and due to uneven distribution of water resources, some 3 billion people will live in countries - wholly or partly arid or semi-arid having less than 1700 m^3 per capita water availability. Countries or regions are broadly considered water stressed when the annual per capita availability is between 1000 - 2000 m^3.

In 1990, eighteen countries in the world were ‘severely water scarce’ with less than 1000m^3 per capita, a number that could swell to 30 by the year 2025. Most of these are located in Asia and Africa, and are already facing food shortage. Further, there are 12 countries with availability less than 500 m^3. This number too is likely to increase to 19 by 2025. More than 1 billion people including one third of the population of China and India live in arid regions facing water scarcity. Similarly, 350 million people mostly in Sub-Saharan Africa face severe scarcity and it is difficult to think if they can do without massive water development projects to meet with their water needs.

Asia has a large variability in water availability due to the monsoon climate, which creates significant seasonal and spatial variations. Mongolia, Northern China, and Northwest and South India are some of the most water short regions of the world. Though some countries like Laos, Myanmar are water rich, on ‘per capita’ basis, many regions of Asia are already experiencing water stress. Central Asia is already using 85%, South Asia 48%, Northern China and Mongolia 25% of available water resources. Groundwater is also being used at places excessively both for drinking water and irrigation. Dependence on groundwater supplies has reached about 35% in Bangladesh, 32% in India, 30% in Pakistan, and 11% in China.

The Americas contain some of the world’s largest rivers and the countries sharing these rivers are generally “Water Rich”. Canada, USA, and a few other countries of the Americas as per IWMI, belong to the group, where available water resources are adequate. However, regional and temporal variations make even parts of these countries suffer from droughts, while on an annual basis, only 1% of the total volume of water is withdrawn in South America. United States has some of the highly productive rainfed lands in East and Mid West. Irrigation is extensively practiced in the three regions – California, the Pacific Northwest and the Great Plains. While the 1st two regions depend upon surface water withdrawals from rivers, the Great Plains are underlain with vast reserves of groundwater, which have been extensively exploited for extending irrigation. Throughout North America, ground water accounts for a significant portion of freshwater

withdrawals. Mexico and USA are particularly reliant on ground water, which accounts respectively for one third and one fifth of freshwater abstractions. However, over exploitation of ground water in United States, is now giving rise to some concern as well.

Europe has, in general, sufficient water resources to satisfy the needs of different users. The major part of the European continent is situated in the temperate humid zone. The mainland of Europe is blessed with precipitation throughout the year, although with decreasing quantities from west to east. However, far North and South do show a negative water balance. Irrigation management in South, Central and East Europe holds a dominant role within the group of water users.

Most of the Middle East and North African countries have an arid or semi arid climate. Availability of fresh water per capita is decreasing as population grows and water resource development has reached a ceiling in many countries. Fresh water resources vary from a low of 220 m^3 per capita in Jordan and 330 m^3 per capita in Palestine to 2000 m^3 for Turkey and Iran. The last two countries, however, contain regions with severe shortage. The region has four major international rivers – The Nile, Euphrates, Tigris and Jordan, on which major irrigation development is based. International cooperation shall be required for equitable development and sustainable management.

In case of East and South Africa, the region's withdrawal is only 4% of its total renewable water resources. The rainfall is highly unreliable due to its spatial and temporal variability resulting in frequent crop failure. The entire region can be classified as economically water scarce with the exception of South Africa, which is physically water scarce. The region has number of important shared rivers, which would require massive investment for development with international cooperation. The West African region also be classified as economically water scarce, suffering from extreme variability of availability which is getting reduced on per capita basis, due to rising population.

While per capita availability indicates a country's potential, the state of its utilisation indicates the level of development achieved and efficacy in its use. Even where water is available, the level of withdrawal depends upon the technological capability, the state of economy and the level of investment in the water sector. Most countries with limited availability, suffer from serious handicaps of economic development in general and food production in particular, making them dependent on import of food to feed the often large and rapidly growing population. Demands by rapidly growing industry and urban sectors, on the other hand, are causing reduction in availability for agriculture. This is particularly true for countries of East and South Asia where urban population is likely to increase by 50% by 2025. These countries have a climate dictated by monsoons, where significantly high and intense precipitation during limited rainy days in a year, results into heavy runoff and floods.

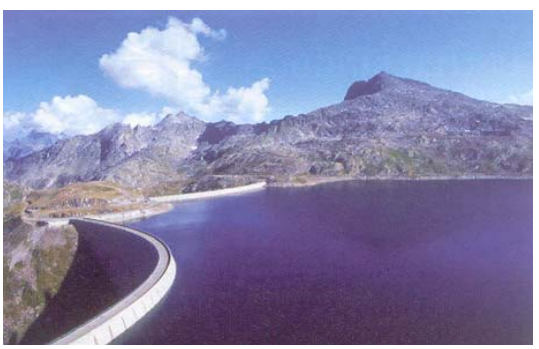
The global climate change is being studied by the Intergovernmental Panel for Climate Change (IPCC). The UN agencies are also keeping track of desertification processes and ways to combat them. The likely increase in variability in precipitation will cause increased need for storages - large and small. Also the possible increased snow melt and sea level rise will need close monitoring and call for simultaneous advance plans for mitigation.

Under its 'Country Policy Support Program', ICID had conducted studies in 4 river basins in India and China from 2003-2005. For the detailed water assessment in India, a water deficit basin in the west coast, namely the Sabarmati river basin, and a water rich basin in the east coast, namely the Brahmani river basin, were chosen. Policy interventions emerging from the studies in the context of integrated and sustainable water use included the following:

- To account for direct evapo-transpiration from rainfall and soil moisture, it is essential that *precipitation (or rainfall*), which forms the primary source of all waters on land, *rather than the terrestrial surface and ground water runoff* is to be recognised as the primary and real resource for water assessments.

- There is also the need for accounting of *additional water availability due to return flows*; and accounting of water *withdrawals* and *consumptive use* by sectors, separately and collectively towards an integrated and sustainable water management.
- The consumptive use, which results in the *depletion of resource*, needs to be managed through increases in efficiencies across all sectoral uses, and by curtailing specially its "*non-beneficial*" component of evapo-transpiration both from lands under natural use and from lands under agricultural use.
- While local harvesting of rain can to some extent be promoted, its usefulness in water short basins, where the existing reservoirs hardly fill up, is very limited as it impacts *negatively* on the filling of existing storages on the main river and its tributaries.
- Environmental water requirements need to include both the requirements (mostly consumptive) of the terrestrial eco-systems, as also the flow requirement (EFR) of the aquatic ecosystems. While environmental flow requirements (EFR) need to be recognised as valued requirements, acceptable methods (which consider the water regimes required by the different species, as also the tradeoffs, as preferred by the society, between the environmental and other uses), need to be developed.

Mismatch between Demand and Supply and Storage Needs



The present global water use for agriculture is about 70% of the total. The potential water resource available in various regions and countries to meet the requirement of 2025 is extremely varied. Many people argue for transfer of irrigation water to other sectors by improving water use efficiency. They also claim that demand management instead of supply management will solve the problems of future needs for irrigation expansion. What has become apparent during the vision study for WFFRD is that supply and demand management has to go hand in hand for removing the mismatch.

Globally, water supplies used in agricultural would have to be augmented by 15 - 20% over the next 25 years, even under favourable assumptions regarding improvements in irrigation efficiency and agronomic potential to meet food requirements. The assumption of just 17% increased withdrawals itself is idealistic without considering the fact that there are severe limitation in the capacity of developing countries to achieve maximum efficiency in irrigation schemes at present level of financial inputs in modernization and improvement of the scheme. The need for doubling the food production to meet future demands for 2050 will call for more gross area to be brought under cereal cultivation by accelerating the rate of development of storages of water resources, wherever potential is yet untapped. Such withdrawals with the help of storages, basin by basin, could help remove the mismatch between variable in-stream availability and demand besides meeting soil moisture crop requirement for crops round the year. Links may have to be provided between reservoirs to transfer water to cater to needs of deficit areas within a basin or across the basin boundaries.

It is well recognised that the cost of a minor storage or micro development is 3-5 times more than the cost of large storages per thousand cubic meter. Smaller the storage, more is evaporation loss, lower is dependability, larger the submergence for same withdrawals, and proportionately higher the siltation rates. It is not physically possible to create dam-based large storages easily at will, due to various constraints, especially proper locations, besides high costs. The region-wise construction of dams is seen to be skewed.

A report commissioned by the Governments of Norway and Sweden –"Making Water a Part of Economic Development -The Economic Benefits of Improved Water Management and Services" for CSD has amply emphasized the need for infrastructural development. It states that -

"The development of a sound, well-planned stock of water infrastructure is a critical component of economic growth, water resources management and improved access to water and sanitation services. Dams and reservoirs, both large and small, provide services such as power generation, flood control and water supply to agricultural and domestic users. These facilities provide opportunities to improve livelihoods, increase incomes and reduce vulnerability. Water canals, drainage and irrigation, are also part of the infrastructure stock that water management and services rely on. Water infrastructure provides water management services that even out the seasonal and inter-seasonal variations in availability and requirements."

The key points emerging from the report are :

- *"The public and private investment is needed to improve water storage capacity, both large and small-scale, and water resources management enhances countries' resilience to rainfall variability. Well-planned and efficiently managed water storage infrastructure is important for the provision of safe and secure water supply to households, agriculture and food production and for industry. Multipurpose dams can generate indirect economic benefits nearly as much as the direct economic benefits generated.*
- *Improved water storage capacity and water security is particularly required in climate zones characterized by big rainfall variation, such as low-income tropical countries. For example, Sub-Saharan Africa is subject to more climatic variability than most other countries, and at the same time has the least per capita water storage and buffer capacity to deal with climate and rainfall variability.*
- *The benefits of hydropower on economic growth and poverty alleviation are obvious. A comparison of Chinese counties with and without rural hydropower showed that the GDP of counties with completed primary electrification doubled with an annual growth rate of 15.3%, which was twice that of the national average. The annual average income per farmer increased 8.1% per year, which was 2.7% more than the national average.*
- *Variations of water supply. This is particularly important in monsoon climates or other climate zones characterized by big rainfall variation, such as low-income tropical countries. Without adequate water control infrastructure, the economy is more susceptible to water- related shocks.*
- *Vulnerability to Rainfall Variability : In India, water infrastructure development has evened out the seasonal demand for labour, resulting in major gains for the poor. "*

The present aggregate design storage capacity of world's large dams is about 6000 cubic kilometers (or Billion cu m, BCM) from about 45000 dams, but only 5% of these dams are in Africa, although majority of the serious water scarce and economically weaker countries are located there. Fig. shows the per capita storage. The role of funding agencies needs to be revisited, since small developing countries are relatively more vulnerable to pressures and they have no choice except to succumb to otherwise unacceptable conditions, thereby perpetually remaining in misery and hardship. Opposition to dams has adversely affected the hydel power installation and generation also. As of 2003, out of total hydro power capacity of approx. 728,500 MW in operation in the world, Africa had only 2.9 % share. Further, out of a technically and economically feasible hydro power development potential of 1,750,000 GWh/year in Africa, only 4.8 % is presently in operation (H&D World Atlas, 2003). This underlines the need for more water development as well as more hydel power generation in Africa for its socio-economic development that could be possible through construction of storages through dams. Situation in other developing countries is also more or less similar. According to FAO, storages will be required to the extent of at least 2180 km^3 in next 30 years at the rate of over 70 km^3 per year to meet the irrigational needs (220 km^3) in developing countries (requiring 14% more water), to replenish the aquifers (160 km^3) and to replace silted reservoirs (1800 km^3), over and above other measures like increasing the efficiency and achieving more production per drop. Figure 4 below shows the extent of investments in US $ (Billion) required in Africa.

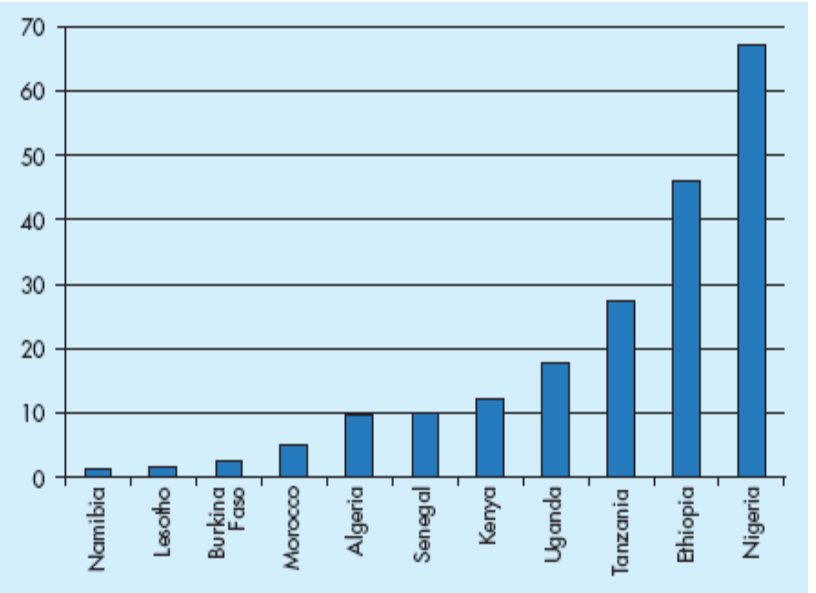


Figure 4. Water Storage Investment Requirements in Africa (USD Billions)

Though considerable scope for exploitation of groundwater exists in surplus surface water areas, this would ask for substantial investments on energy. A large component of groundwater is derived from surface water and hence both need to be considered conjunctively as renewable resource for optimising availability and use. Where surplus surface water exists which can not be stored, it runs off to seas. Catching it and using it for artificial recharge of groundwaters can be adopted in cases where such a storage is required and is reasonably possible. Watershed development is a relatively economic option. Its efficacy regarding quantities of water that can be recharged is however severely limited.

A discrete mix of mega to micro-scale surface water storages in addition to in-situ conservation measures are called for to augment availability in a cost-effective manner. The in-stream availability and need for storages varies for countries within a climatic zone viz. arid/semiarid, temperate humid and humid tropical. In each of these zones the strategy has to be different for rainfed and irrigated areas. Besides developing storages, augmentation of availability has to be achieved by improving efficiency of application in irrigated agriculture. Availability can also be augmented by recycling the used and wastewaters after due treatment.

As per the report cited above, water storage capacity per person is often cited as a proxy to water security and a measure of large and small-scale water infrastructure development. However there is a great disparity between different regions as seen in Figure 5. For example, Australia and Ethiopia have similar degrees of climate variability, but whereas Australia has over 4,700 cubic meters of water storage capacity per person, Ethiopia has 43 cubic meters as shown in the graph above. Uganda and Kenya have similarly low levels of water storage. The breakdown of dams per geographical region shows that in Africa has been left out in assuring water security, though there is a large scope for water infrastructure development. Numbers from the International Commission on Large Dams shows that only 5% of the world's dams are located in Africa whereas 33% are located in Asia. This does not however take into account local rain water harvesting technologies.

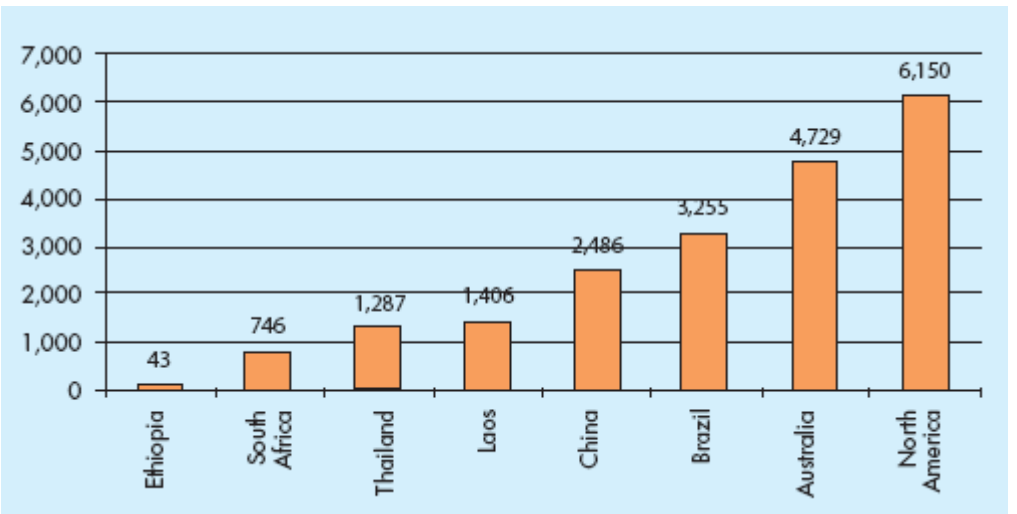


Figure 5. Per capita storages in different countries (cu m)

In a large percentage of ground abstraction for irrigated agriculture, it is seen that the use of electrical energy is inevitable. Development of hydropower capacity, in particular, is one strategy that will reduce economic dependence on fossil fuels and limit greenhouse gas emissions. The International Atomic and Energy Agency says the world will need almost 60% more energy in 2030 than in 2002, with economic growth in the developing world driving most of the increase. Thus, developing hydropower resources, particularly in the developing world, is a necessity. There are several economic benefits of electrical power in terms of economic growth and poverty alleviation. Energy services that allow for heating, cooking and illumination are not only a boon to the activities of daily life; they are also critical inputs to agriculture and the types of small-scale productive activities that are a significant component of rural and urban economies.

Dam projects are often a catalyst for economic growth and development and provide a host of benefits that are often indirect and more difficult to measure, but nonetheless significant. In the Punjab, India, a multipurpose dam (hydropower and irrigation) was found, in hindsight, to generate almost 1.43 times “indirect” value added via inter-industry linkages and consumption–induced effects, as “direct” value added through agricultural and electricity. The multiplier for the Sobradinho Dam in Brazil, was estimated from 2.0 to 2.4 depending on what assumptions are applied to the supply of labour and capital. This means that for every USD 1 invested there was a total economic return of USD 2 to USD 2.4. Traditional cost-analyses often do not, or are unable, to capture the multiplier effect of dam system developments.

In another study carried out by ICID through a Task Force on Appraisal of Procedures for Construction of New Dams in ICID countries, it has been seen that most of the countries have established institutional mechanisms for examining techno-economic feasibility, social acceptability and environmental safeguards to ensure that adverse effects are minimized and benefits enhanced from the water resources projects involving dams. Water resources projects as environment friendly projects since they have a potential to improve the quality of air, land and water as a result of developed green cover due to agriculture and plantations, hydropower generation (replacing fossil fuel based energy), improvement of health due to provision of freshwater resources, and availability of lakes for development of fisheries, and recreation. On the other hand, a clear prescription on how negative environmental impacts will be compensated would have to be an integral part of the decision to construct a dam.

The report has recommended that national policies on environment and development should be formulated, where they do not exist, to define the ultimate goals and objectives of developing water resources potential of the countries for the economic growth and well being of the civil society and

the responsibilities of the concerned departments to take care of the environmental and social aspects.

The Rehabilitation and Resettlement of the displaced persons should be guided by a national policy which should provide for the improvement of living standard of the people affected. There should be adequate provision for better land, better home, better community life and better employment for all project affected persons. The affected people should be used as a resource for the project, if necessary by imparting them training in required skills. The implementation of Rehabilitation & Resettlement should be carried out as an integral part of the project in association with the representatives of the affected communities and NGOs belonging to the affected area, since the needs of the affected persons can be best met by involving them or communicating with them or their representatives directly.

Basin-wise consideration of projects is important to ensure that a balanced development which does not adversely affect other interests guaranteed by existing developmental activities and projects, is finally achieved. The procedure for techno-economic appraisal should have in-built mechanism to ensure an approach that integrates the multiple objectives of development and management of land and water resources. The riparian countries should agree on an institutional and legal framework that aims at supporting the sustainable development of water and river basins.

NGOs and voluntary organizations should preferably be involved in a constructive manner to see that the environmental and social issues are properly addressed during the implementation of the project. They may help the Government in the process of nation building and improving the quality of life of the people. This is necessary particularly in those countries, which have been left behind economically and are facing the problems of poverty, hunger, malnutrition and unemployment.

Role of Irrigation in Food Security and Rural Development

As mentioned earlier, the rise in population in developing countries is much more rapid as compared to the developed world. With nearly the same water and land resources base, we shall have to grow enough food to additionally feed 2 billion people, considering the increased demand resulting from expected increase in the standard of living, there will be need to double the level of food production. In addition, this calls for flood control, flood protection and drainage measures to a significant extent.

Food crises faced by some 35 countries necessitating emergency assistance have doubled over the last 2 decades from 15 occurrences per year. Most of the crises were concentrated in Africa (rising three folds over the past two decades). Such crises were the result of past and present conflicts (like in Sudan) or droughts (as in Ethiopia, Eritrea, Uganda, Kenya, Somalia, etc.) or both (in general in East Africa, affecting over 13 million people). At least 13 countries of the above had over 35% of their population going hungry (FAO, 2004b). The United Nations Millennium Project's Task Force on Hunger has estimated that half of the hungry people are the smallholder farmers, the remaining being rural landless, urban poor, and other people making a living from forests and fish.

Bulk of the population in the developing world lives in rural areas. The proportion is reducing gradually. Also, the proportion of population employed in agriculture will gradually reduce due to its shift to the manufacturing and services sector. This also would cause greying of people engaged in agriculture. Still, the thrust of these sectors will continue to be towards agriculture. A small minority of the rural people in the developing world owns large farms. Majority has small land holdings. Others are landless and work as labourers in farm related activities. But the rural population is predominantly poor, unlike in the developed world, where the rural areas have developed fast by adoption of advanced technology in agriculture early on due to the industrial revolution and provision of irrigation and/or drainage facilities wherever needed and possible. Many countries

equate poverty only with calorie intake through food for adequate nutrition. Rural development and a secured livelihood for rural populations of today, therefore, are synonymous with eradication of poverty through employment generated from agriculture and related activities. Extension and modernisation with replacement of ageing systems to maintain sustainability of irrigation, drainage and flood protection along with other concomitant inputs are essential for this purpose.

Agriculture needs water, which is provided by rainfall fully at some places or in excess in some lands. In these cases, drainage of land is required to enable agriculture. In the latter cases where needs are partially met with by rainfall, supplemental irrigation would have to be provided through wells, canals, ponds, and tanks either by gravity flow or by pumping. Moisture in the soil profile being essential for dry food crop production, its availability has to be maintained at a desired level by replenishment either through local conservation measures or by irrigation, otherwise moisture stress leads to not only reduction in yield but sometime even to complete loss. For paddy cultivation generally a water layer of certain depth has to be maintained on the field. For rainfed agriculture, where failure of rainfall or long gaps between consecutive spells of rain ruin a crop, measures to increase moisture retention capability like tillage, mulching, etc. are often deployed. Supplemental irrigation however becomes necessary for survival of crops even in humid tropics in winter and summer if rains fail. For the arid and semi arid areas, irrigation is an essential input for farming, even during the rainy season. The provision of irrigation facilities which can make all the difference to a good harvest and watershed development of rainfed areas, together make the agriculture in a river basin sustainable and productive.

Failing to increase water, land and crop productivity will likely lead to more land being converted from natural vegetation, tropical forests, etc. into farming areas. This may harm biodiversity and ecological sustainability. Figures on water requirements in irrigated agriculture are often deceptive since the portion that does not return to the atmosphere can be reused, *in situ*, through lifting the groundwater, or by users down the river in the catchment.

Increasing Crop Productivity

In regions of water shortage, yield of irrigated land often is more than 2 to 3 times that of rainfed agriculture. The critical role of irrigation for food security in arid and semi arid areas is evident from the fact that almost one third of the globe area is accounted by arid and semi arid areas and yet the world has been able to largely feed its billions. Even in temperate and humid zones, although crops can be grown, timely irrigation during critical periods of growth, when plant is most sensitive to soil moisture deficit, yield of crops may double or even treble. In case of rainfed cropped areas, if assured or even supplemental irrigation is provided, it can make significant contribution to food production. The World Food Summit in 1996, estimated that 60% of extra food required to sustain the world in future must come from irrigated agriculture, which needs more investments and sustained efforts at expansion and improvements. The vision WFFRD also has similarly estimated increase in irrigated area even after assuming significant increase in water use efficiency. The challenge of improving the lot of poor rural population hinges on the success of these efforts. Rainfed areas with favourable soil moisture regime are already producing good yield of food crops. Rainfed areas which are water rich can grow additional food crops only with installation and improvement of drainage systems. Water deficit rainfed areas need exogenous water supplemented to a possible extent by rainwater harvesting. While water is an essential input for agriculture, it also needs other inputs like fertilisers, pesticides, seeds, cold-storage, animal power, animal husbandry services, market, transportation, electric power, credit, agricultural implements and services for maintenance. Even when productivity is enhanced by different inputs such as mechanization, fertilizers and pest control, the potential benefits can not be attained under excess moisture or salt concentration in the root zone. Thus investment in drainage not only has its direct impact of increasing crop yield but also maximizes the

benefits from other inputs. The irrigation and drainage schemes therefore not only play a critical role in increasing crop yield and improving rural household income, but also help in accelerating the pace of development of rural infrastructure through improved communications and road systems, better healthcare, education facilities for rural communities. Irrigation canals often serve as the only source of potable drinking water for the rural areas of the developing world. Properly functioning drainage channels may improve sanitation and disposal of wastewater in rural areas, where applicable.

The report entitled " Let it Reign: The New Water Paradigm for Global Food Security" commissioned by the Swedish International Development Cooperation Agency (SIDA) as input to the Commission on Sustainable Development (CSD) and its 2004–2005 focus on water and related issues, prepared by IWMI, IUCN, IFPRI, and SIWI, observes -*"Undeniably, irrigation is very important for overall food production. It reduces poverty through higher yields and incomes for farmers, and it is also crucial for society in general through increased employment directly in the sector and indirectly in related sectors, and through its impact on lowering food prices. By creating higher crop production levels, irrigation development has also saved millions of hectares of forest land from conversion to agriculture. Irrigated agriculture also plays a significant macroeconomic role in many countries since, inter alia, it generates significant foreign exchange. By virtue of their character, irrigation schemes have substantial multiplier effects through backward and forward linkage effects. Increasing water productivity in irrigation systems can be done through various measures including agronomic and on-farm water management practices, irrigation management techniques, innovative water pricing systems and incentives etc."*

Striving for Food Security

The planning for achieving the objective of food security in several countries must also focus on rural poverty alleviation, and generation of employment opportunities. Both have contributed to economic growth of such societies. Irrigation has played a major role in poverty alleviation and protection of rural people from natural disasters like droughts and famines. The poor landless segments have better employment opportunities in construction and maintenance works of irrigation schemes. The increased agricultural production mostly from irrigated areas and overall infrastructural improvements act as powerful magnets to attract investments in rural agro-based industries. The rural development has become synonymous with agricultural development. The close linkage becomes apparent every time drought strikes an agriculturally predominant area or a State, when the whole rural economy comes to a grinding halt due to set back in agricultural production. It has also been experienced that the lack of assured irrigation leading to unsatisfactory returns from agriculture, coupled with other handicaps, has caused growing tendency for switch over to non-agricultural occupations and migration from the rural to urban areas in search of better employment. The multiplier effect of irrigation arrests this tendency and helps improve even the urban environment because of reduction in pressure there, on the already dwindling water supply and other infrastructural facilities and helps maintain the ecological balance. In some water scarce areas, the available potential of water resources has still not been tapped due to several reasons including financial weakness. These causes have to be obviated. The absence of appropriate measures makes such areas more vulnerable to scarcity and growing demands due to population growth.

Though advances in bio-technology and genetic engineering may help to increase food production from available land and water resources, the irrigation and drainage expansion and modernisation shall have to play the pivotal role in increasing the food productivity per unit of land and water, as in past especially in the latter half of the 20th century. It is however necessary to ensure that irrigated agriculture remains a sustainable endeavour by addressing the problems of salinity, waterlogging, institutional deficiencies in ensuring equitable distribution of available water amongst all users and environmental sustainability. Such strategy would ensure that the production in food grains is not outpaced by the population growth. To maintain food security, sustainability or durability or resilience has to be ensured. One can look at sustainability: of infrastructure created; of resource base of land soil and water; of institutions created; of ecosystems and most importantly of people and their capacity to carry poverty or poverty alleviation.

The objective of 'Food self-sufficiency' is dominating planning and will continue to dominate it in the developing world for rural development. Ensuring sustainability of resources, facilities created, product of Integrated Water Resources Development and Management (IWRDM), is central to the food security and in turn to poverty alleviation and protection from famines, etc. Adequate operation and maintenance, modernisation and where required replacement of old schemes and most importantly addition of infrastructure constitutes the core programme for the future.

The improvement in water and land management will have to be supplemented with supporting measures like investments in rural roads, telephones, electricity connections and supply towards improving market access; investment in complementary services, such as access to education and health services and awareness about which foods to consume; setting up of organisation of food producers (farmers – associations, co-operatives, micro-credit groups, etc to help reduce costs for agricultural inputs, process agricultural outputs and create economies of scale for marketing; creation of opportunities and removal of trade distortions in the agriculture sector ; promotion of labour-saving technical substitutes and affordable technology for supplementary irrigation ; investment in research and extension for closing the productivity gap for smallholders; agricultural credit, etc.

According to ICID Task Force Report on Food Security and Trade, the country case studies suggest the following issues / approaches / policies that could be considered responsible for achieving food security: (1) restructuring of the public finances; (2) conducive institutional framework; (3) research and dissemination of new technologies; (4) emphasis on antipoverty policies; (5) holistic approach to agriculture; (6) provision of irrigation and high yielding varieties, fertilizers and pesticides; and (7) extensive social safety net's etc. Research and development (R&D) plays a crucial role in agricultural development by increasing agricultural production. If productivity increases are to become instruments of food security, it is necessary to: adopt IWRDM approach, ensure access to water, devote attention to labour-intensive practices, and bridge the gap between laboratory/research and field/farmers. The funding support for agricultural development has been declining. Therefore developed nations will have to be encouraged to increase funding under ODA and the governments in developing countries will have to provide more funds for R&D in order to continue efforts in providing new technology.

Improvement Requirements in Water Productivity

In the developing countries, while significant efforts are directed towards facilitating expansion of irrigated area through additional withdrawals by building storages and or diversion structures where practicable and through optimised use of ground water, attention is to be paid for improving the on-farm water management between desired water use efficiency and the one actually realised by improved technological interventions. Strategies have to be developed not only for ensuring maximum productivity per unit of water and unit of land but also to reduce the substantial gap between irrigation potential so far developed and utilised. Some claim that water scarce countries should aim at only high value crops for export while importing low value food crops, thus meaning import of virtual water. On the face of it, the concept sounds good but it has to be considered in depth in context of poverty incidence in such countries.

Whereas increasing water productivity calls for considerable changes in crop varieties, adequate steps are necessary to transfer the already developed and tested irrigation and drainage technologies from the developed world to the developing countries. An IWMI study of 50 irrigation systems round the world shows a wide variance in productivity. Considerable improvement in productivity is possible in some large systems with well-designed inputs. For example, in India an

average increase of yield from 2 to 4 ton/ha is achievable and would have to be achieved. It could make vast difference to the status of food sufficiency.

Some of the available options for improving the productivity of irrigated lands are listed below:

- establishing water users organisations for better involvement of farmers in management and collection of fees, reducing irrigation subsidies and/or introducing conservation oriented pricing, strengthening the training and extension services for dissemination of efficient technologies; in short deployment of technologies involving a discrete combination of structural and non structural measures is essential;
- improved operation and maintenance of irrigation and drainage systems. Using controlled groundwater table management to conserve water and improve the quality of drainage effluent;
- employing better techniques of water application like furrow irrigation instead of traditional flooding. Furrow dyking techniques help promote soil infiltration and reduce runoff. Employing surge irrigation techniques even in furrows gives better results;
- adopting water conservation methods like tillage, to reduce evaporation from land or changing the planting dates to match with periods of low evaporation rates and improving drainage by surface or sub surface methods and recycling of drainage and tail water;
- increasing use of pressurized irrigation, sprinkler and micro irrigation systems, instead of open gravity flow to apply water more uniformly, taking advantage of already developed low energy - precision application – systems to cut evaporation and wind-drift losses.
- Adopting better irrigation scheduling and improved canal operation to ensure supply, when it is most crucial to crop's yield;
- involving private sector companies in developing cost effective technologies and their promotion particularly in developing countries;
- promoting and adopting results of agronomic researches like:
- selecting crop varieties with high yield per unit of water;
- switching from crops consuming more water to those consuming less i.e. better matching crops to climate conditions and to quantity of water available;
- sequencing crops to maximize output under conditions of soil and water salinity;
- introducing water efficient crop varieties.

For IWRDM to become sustainable, it ought to have three important components, viz. equity, efficiency and economy in services provided. The three are interdependent. They bring in optimisation in use of natural resources, increase productivity per unit of land and per unit of water. They ensure that the fruits of IWRDM reach all stakeholders in an equitable manner when needed through supply of water when, where and in right quantity.

Low water use efficiency can be attributed to low level of on-farm irrigation technology, land management as well as deficiency of operation and maintenance. Lining of canals and distribution system or use of low pressure pipes for distribution wherever feasible as well as introduction of efficient on-farm facilities and practices can help achieve better efficiency. Adequate and efficient drainage is necessary to sustain high crop productivity and conserve land resources. It is also necessary to set up a system of real time monitoring of flows and water demand. Adoption of water saving sprinkler and drip irrigation systems may help to achieve not only better utilisation of scarce water resources, but also better output of crops due to application of the correct quantum of water at the critical stages of growth. Utmost economy in deployment of financial resources will therefore be a key word in the future. It would mean need for enhancement of productivity, water use efficiency, reversal of degradation of land and water resources already deployed. It also would mean enhancement of standards for new areas of irrigation and drainage and sustainable development of the rural area, for which financial resources ought to be earmarked.

According to the IWMI report, “supplemental irrigation of about 100 mm of water per year, i.e. around 15% of rainfall, potentially can double yields from, say, 1 to 2 t/ha. Such improvements mean that water productivity increases to 2000 m^3 water/tonne.

By creating higher crop production levels, irrigation development has saved millions of hectares of forest land from conversion to agriculture. Irrigated agriculture also plays a significant macroeconomic role in many countries since, among other things, it generates significant foreign exchange. By virtue of their character, irrigation schemes have substantial multiplier effects through backward and forward linkage effects. Increasing water productivity in irrigation systems can be done, amongst others, through:

- Agronomic and on-farm water management practices, *w*hich include different innovative on-farm water management practices such as alternate wetting and drying, systems of rice intensification, precision land levelling, mulching for increased water holding capacity of the soil, improved crop varieties, and precision water application technologies such as drip and sprinkler irrigation.
- Irrigation management measures like delivering more reliable water supplies to allow farmers to invest in improved on-farm management practices, delivering supplies more equitably, and making sure the poor and disadvantaged get their share of water.
- Innovative water pricing systems and incentives, such as innovative allocation, pricing, and incentive systems can be designed for efficient water use, cost recovery, and at the same time protect and increase farm income.
- More crop per drop and per unit of land has to be a joint strategy.
- The gap between potential created and that utilised is to be narrowed down urgently through structural and nonstructural measures.
- Shift from food crops to high value crops depends upon self-sufficiency needs of a country. It will be gradual with increase in productivity in cereal production.
- World trade in food is barely 10% of the total production and is showing signs of reduction.
- Achieving domestic higher productivity by shifting agricultural labour force to other sectors, by modernisation of agriculture and by land reforms is necessary.
- Establishment of Water Users' Associations and transfer of the operation and maintenance of distribution systems to them is necessary on a large scale.

Governance, Legal and Institutional Issues

Traditionally, the planning, development, withdrawal, uses and disposal of waters has mostly rested with governments of the individual countries particularly in the developing world. Irrigation of farms by means of water drawn through dams, canals and wells or drainage of waterlogged lands grew with active involvement of institutions and legal procedures set up on drainage by the governments. Functionaries of governments or institutions charged fees for the water supply and recovered them by way of land revenue or in kind, by way of levy in form of farm produce. Water disputes were heard by government or institution functionaries and resolved as per law of the land.

Irrigation, drainage and flood control of agricultural lands, which are all intricately related with ‘water for food’ are likely to be continued to be governed by governments in the countries of the developing world. Legal positions also might not undergo much change, excepting that the concepts of water rights will be debated along-with other rights on natural resources. But the main likely change will relate to basic human rights like right to food, water, employment and livelihood. All required changes in the institutions will flow from these changes. An overall change in complexion of the sector will occur as all shades of rural development activities are woven around ‘water’. While centralisation at apex level because of the scale and range of activities involved may continue, there will be much more decentralisation lower down to facilitate the final use of water for

rural development. Even in case of environmental concerns, a holistic view may be possible, if centralisation at national level exists in developing and lesser developed countries. But it will need complete decentralisation, as one goes to local ground level. On the whole, a much more participatory process involving stakeholders will evolve, for not only the decision making, but also for implementation, operation and maintenance.

'Water for food' is a socio-economic proposition after its technological complexities are unravelled and accommodated in the vision. But in many cases, the complexities have hindered economical and efficient use of water. Therefore, institutional reform has become a central issue in the water sector in most of the countries. Following institutional and legal aspects are under debate:

- absence of a comprehensive water policy covering all types of consumptive and non-consumptive uses and institutional arrangements for implementation. A number of countries have accumulated a body of legislations, either in the form of comprehensive water codes or sector by sector legislations like irrigation acts drainage acts, etc. There is urgent need to enact a comprehensive water related land legislation, clarifying surface, and groundwater rights of land cultivators, establishing an appropriate administrative machinery for implementation, etc. This type of legislation is necessary for providing a framework for sound decision making;
- need for the irrigation sector to not only overcome and face sectoral competition for water, but also to address social and environmental issues. For this purpose, it has to devise a viable policy, adopt appropriate technology packages and project management system and carry out institutional changes and reforms;
- putting in place an appropriate mechanism for conflict resolution both for intra basin and inter basin water sharing and transfers. Tackling equity issues providing for consideration of environmental impacts.
- need is seen for reduction of governmental role in IWRDM from being a provider to be a facilitator, from planning to operation and maintenance, gradually changing complexion of 'Water' as a social good to an economic good.
- water rights of people for both surface and ground water use; private or public good.
- setting up of viable basin authorities, water users' associations, conflict resolution mechanisms, evolution of guidelines for equitable allocations - sharing of resources - costs and benefits of IWRDM.
- water quality preservation acts, laws and guidelines covering policies like 'polluters clean or else pay for polluting waters', 'users in one form or the other', 'recycling and reuse'.

Financing Water Resources Development and Management

Basin wide IWRDM calls for correct assessment of both surface and ground water resources at basin and sub-basin level, in terms of quantity as well as quality, their sharing, development, conservation, abstraction, recycling and reuse, in context of equity for users. The IWRDM thus encompasses formulation of a financing policy, from development of 'water master plans' to ensure optimum utilisation and implementation, to pricing, cost recovery, and ensuring adequate finances for operation and maintenance, safety, modernisation, and replacement. Financing is required at all stages of IWRDM. It covers institution building, capacity building, decision support systems, information technology, automation, research and development, economic analysis, risk analysis and other aspects.

Large scale funding is required to provide for projected additional withdrawals of water as well as for the requirements regarding drainage and flood protection. But on the water management side, again lot remains to be done. Lack of regular annual maintenance results in systems falling into disrepair, increasing thereby the likelihood of breaches, and silting of distribution channels and congestion of drains. There is urgent need for modernisation of several large irrigation schemes in

Asia besides replacement of old schemes, which will not only improve efficiency of performance, but also result in water savings which can be used for bringing more areas under irrigation which were uncommanded earlier. Financing of such schemes has a great potential to increase agricultural production. Sometimes, relatively small outlays on modernization, for instance on head-works, distribution structures and drainage outlets, can help raise production substantially even in small irrigation schemes. Participatory approach whereby farmers get motivated to offer their services in kind, if not in cash, helps greatly in modernisation efforts and has to be attempted in a big way in future.

The need for a higher level of funding for the irrigation, drainage and flood protection sector in the next 25 years is apparent. One estimate calls for enhancement of present level of funding for irrigation by at least 40%, not only for new infrastructure but also for replacement, modernisation of ageing systems and imparting sustainability to them. It is indeed heartening that the major lending agencies have clearly recognized the need for funding large infrastructure, especially with a view to reducing poverty and meeting food demands in the developing and least developed countries.

Service Charges

Many of the findings from the report of another Task Force set up by ICID on Issues and Principles of Sustainability of Irrigation and Drainage Services relate to local experiences on charging for services in irrigation, drainage and flood control. The policies and mechanisms for charging that have been successfully used over a long period by self-sufficient Water Service Entities (WSEs) indicate that:

1. Irrigation and drainage systems constructed by farmers or local villagers prior to the era of major government involvement and where an informal or formal water rights system existed, remain physically and financially self-sufficient.
2. Users of both the very small informal WSEs and the larger formal WSEs devised and funded the construction of the facilities and their operation, maintenance and replacement.
3. One characteristic of physically and financially self-sufficient WSEs is that service charges are levied to all beneficiaries/customers at a rate that recovers all financial costs of service – construction, operation, maintenance, management, replacement and borrowing -- and nothing more. The only excluded cost may be recovery of investment if it did not remain with the WSE. None include a component to provide for ‘profits’ nor any representation of the opportunity cost of the water.
4. Charges for bulk water supply provided by another WSE are incorporated together with the distribution WSE’s costs into the charges that the WSE levies to its individual customers.
5. There are no model WSEs of any type that base service charges upon the free market, opportunity costs, marginal costs, economic costs or assessments against bordering properties. This is also true of urban services except for a few cases where WSEs charge a modified marginal cost to urban areas located outside of the WSE’s legal service area.

Benchmarking in Irrigation and Drainage Projects

Benchmarking is a valuable tool that has been found to be of considerable use in enhancing performance in both public and private sector organisations. Its application in the irrigation and drainage sector is in its infancy. Benchmarking in the public sector in general and the irrigation sector in particular is a more complex task than in many other sectors. Irrigation and drainage is always subject to site-specific characteristics, and key to the success of benchmarking is the identification of the main drivers that apply in each situation.

Benchmarking must be understood as an on-going process which must form part of the strategic management of the organisation. This wider environment includes an enabling socio-political environment, and support from key stakeholders. The support or drivers for change in this sector is coming from a number of areas, such as increasing pressure on available water resources due to population growth. Whilst changes may be required in the irrigation and drainage sector in general,

it will be down to individual scheme managers to implement and take ownership of the benchmarking programme for their schemes. It will largely be their commitment and performance that will drive the success or otherwise of the process.

An international benchmarking initiative in the irrigation and drainage sector began four years ago supported by the WB, IPTRID, IWMI, ICID and FAO. Several countries have commenced the implementation of national benchmarking activities within the context of the initiative including Australia, Mexico, India, China, Egypt, Malaysia, Pakistan, France and Spain. Whilst this initiative has spurred several agencies and countries into establishing a systematic data collection framework, few agencies have been able to complete the implementation process whereby benchmarking results are incorporated into the management process of the agency. A common set of features is beginning to emerge from these organisations. These include:

- Well developed strategic plans in which benchmarking play an important role in guiding the direction of the organization
- Commitment to excellence in service provision
- Effective user participation in the management and operation of the system
- Effective policies for water resources and environmental management.

There are a number of initiatives underway to promote and evaluate the role of benchmarking in the I&D sector. The future success of benchmarking in the sector will depend on coordinating these initiatives to avoid establishing a multiplicity of competing benchmarking “standards” and approaches.

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