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BANGLADESH WATER VISION 2025

BANGLADESH WATER PARTNERSHIP

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INTRODUCTION

Bangladesh is richly endowed with water resources, but these are seasonal as well as variable. Water resources planning and management must take into account the dual problem of flooding and water shortage along with the competitive demands of various water using sectors including agriculture, domestic, fisheries, industry, navigation, and environment. National water planning in Bangladesh dates back to 1964 when a 20-year Master Plan was prepared with emphasis on large-scale flood control, drainage and/or irrigation projects. The World Bank conducted a land and water sector study in 1972, which advocated small and medium-scale projects through minor irrigation technology. In 1983, the government initiated a National Water Plan (NWP) preparation exercise, which was completed in 1986, and later updated in 1991. After the devastating floods of 1987 and 1988, a five-year (1990-1995) Flood Action Plan (FAP) was launched with focus on flood mitigation. However, it was gradually recognized that the FAP studies should pay attention to integrated water management, and not just flood problem. Besides, earlier water management plans focused too heavily on agricultural development, neglecting the water needs of other sectors – especially the social and environmental impacts of the water resources development interventions.

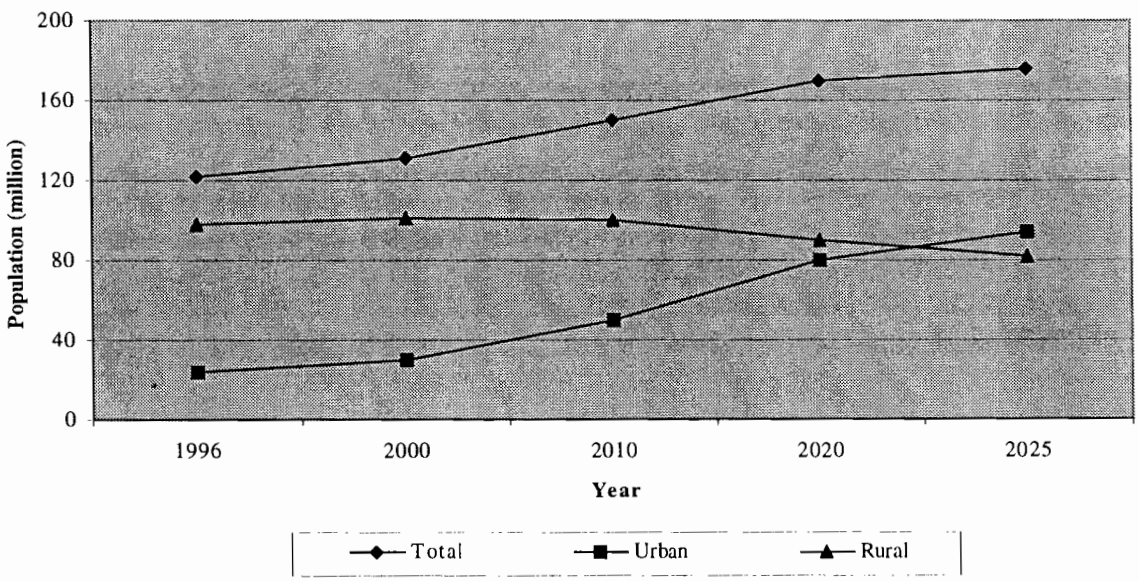
Following a FAP recommendation, the preparation of a comprehensive National Water Management Plan (NWMP) was initiated in March 1998, and the plan (to the year 2025) is expected to be completed by March 2001. Meanwhile, the government has formulated and approved the National Water Policy, which lays down the broad principles of development of water resources and their rational utilization by all elements of society.

Prepared by the Bangladesh Water Vision Team.

SOCIO-ECONOMIC OVERVIEW

Arguably the most critical problem faced by Bangladesh is the large size of its population. Population pressures have added to the stress on natural resources, including water, and contributed to their over-exploitation. However, the country has succeeded in significantly reducing the population growth rate over the years. In 1973, the total population was 74 million, increasing at the rate of 3.0 per cent per annum. The population growth rate was down to 2.17 per cent by 1991 and, currently, to below 2 per cent. But, in absolute terms, the population has increased by 52 million or more in 25 years since 1973. The national goal is to reach a zero population growth status by 2045. The estimated population of the country, as of 1998, is about 126 million with a population density of about 850 persons per sq. km. Despite steadily declining fertility as a result of intensified efforts for population control, the country's population is expected to exceed 176 million by 2025, when the population density will rise to about 1200 persons per sq. km. The effects of population growth will continue to be most severely felt in the urban sector, where the growth rate during the past two decades has been between five and six per cent per annum and is likely to be similar for many years in future. Currently, the urban population accounts for about 20 per cent of the total national population; and the proportion is expected to rise to 53 per cent by 2025.

Population Projection



Bangladesh has remained an agrarian society. Nearly 75 per cent of the population are directly or indirectly dependent on agriculture, although this sector contributes only about 30 per cent to the national GDP. Agriculture is still the main user of water, and its share in water demand will further increase concurrently with efforts to attain food security through increased foodgrain production. At the same time, the sectoral contribution of industries to the GDP is expected to increase, thereby raising water demand by this sector too.

As a result of growing landlessness and lack of employment opportunities in the rural areas, pauperization has increased and there has been a steady stream of rural to urban migration. Because of lack of access to resources and income earning opportunities, the large number of people, 60 million or more, are in a continuous state of food vulnerability. A World Bank assessment based on the 1995-96 Household Expenditure Survey found 53 per cent of the country's population as poor (below minimum calorie intake). Bangladesh Bureau of Statistics (BBS) estimates the food poverty ratio to be slightly lower at 48 per cent, as of 1995/96. Poverty alleviation efforts, therefore, constitute a major thrust in the country's development agenda. But for poverty alleviation an accelerated economic growth is a crucial necessity. Of course, poverty has many dimensions in addition to shortage of food, which include the fulfillment of other basic needs, equitable access to opportunities, quality of life, and freedom of choice. Environmental sustainability is another important aspect.

Women are more disadvantaged than men. Traditionally, socio-cultural norms have limited their access to education, skill, training, health care, and employment. Only in recent times, the socio-economic status of women are slowly changing, though gender equality is still a distant goal.

The water vision of Bangladesh, therefore, has to be cast in the context of the overall national development goal that revolves around the themes of poverty alleviation, sustainable development, and social progress.

STATUS OF WATER AND LAND RESOURCES

The water ecosystem of Bangladesh comprises the tributaries and distributaries of three major river systems: the Ganges–Padma, the Brahmaputra–Jamuna, and the Meghna, and numerous perennial and seasonal wetlands like *haors*, *baors* and *beels*. All the three major river systems originate outside the country. In fact, out of some 230 rivers in the country, 57 are transboundary rivers – 54 coming from India and three from Myanmar. Owing to the fact that about 93 per cent of the surface water enters Bangladesh from outside the borders, there are uncertainties regarding the quantum of supply of water, with serious planning implications for the management of water and water-dependent sectors. At present, the sharing of the Ganges waters has been agreed upon through a treaty with India signed in December 1996, but a sharing arrangement for other international rivers is still awaited.

Bangladesh has three broad types of landscapes: floodplains (80%), terraces (8%) and hills (12%). The total area of the country is 147,570 sq. km., 6.7 per cent of which consists of rivers and inland water bodies. Land is the most basic resource in Bangladesh being the main factor of crop production. The country has about 8.74 million hectares of cultivated land, which is about two-thirds of its total area. Of the net cultivable area, 33.3 per cent is single cropped, 45.0 per cent is double cropped, 11.5 per cent triple cropped, and 10.2 per cent is cultivable waste and current fallow. The overall cropping intensity is 1.76. The three cropping seasons approximately coincide with the three meteorological seasons: Kharif I (pre-monsoon), Kharif II (monsoon) and Rabi (winter or dry). Aus, aman and boro are the three rice varieties grown respectively in those three cropping seasons. Aman is the leading rice crop, occupying about 56.0 per cent of the total area under rice, followed by boro (27.0 per cent), and aus (17.0 per cent). A notable aspect of the pattern of growth since the late 1980s in crop agriculture is the increasing importance of dry season HYV boro rice. Given the aim of increased food production to feed a growing population, area under HYV boro rice expanded through the introduction of modern irrigation and reclamation of marginal lands *i.e.* wetlands.

WATER SUPPLY ESTIMATION

The natural surface water resources in Bangladesh are mainly obtainable from the country's dense network of river systems, which include a combination of upstream inflows and runoff generated from rainfall within the country. Preliminary estimates at the inception phase of the NWMP indicate that cross-border flows into the country amount to around 1010 billion cubic meters (BCM), and an additional amount of 340 BCM is generated from local rainfall, averaging 2300 mm. Of this total quantum of available water (1350 BCM), about 190 BCM of water is lost in the atmosphere through evaporation and evapotranspiration, while the balance of 1160 BCM is available for use or flows into the Bay of Bengal. Eighty per cent of this huge flow of water is concentrated in the five-month monsoon period of June to October.

Streamflows are only a part of the surface water availability, and a complete picture, incorporating surface inflows, rainfall, evapotranspiration, percolation to underground aquifer, diversion for irrigation and other consumptive uses, can only be obtained through hydrologic simulation in a water balance model.

The quaternary alluvium of Bangladesh constitutes a huge aquifer with reasonably good transmission and storage properties. Heavy rainfall and annual inundation help the groundwater to be substantially recharged annually. The first assessment of groundwater was made in 1984. Subsequently, the Master Plan Organization (MPO) made three estimates in 1991: potential, usable, and available recharge. These estimates suggested that the available recharge of groundwater was 21 BCM. More recently, the National Minor Irrigation Development Project (NMIDP) developed models to forecast growth in minor irrigation through groundwater, using less conservative assumptions for recharge than the MPO. It acknowledges, however, that more information on groundwater is required to make reliable projections beyond the next 10-15 years. Particular attention also needs to be given to the issue of arsenic contamination of groundwater.

In future, over a 25-year planning horizon, the volume of water available and its spatial/temporal distribution are expected to change. Such changes will be in response to a

combination of factors, especially due to human interventions within the country and in upper riparians and changes in land use pattern and water demand by various sectors. It is also expected that the impact of climate change and sea level rise will have significant implications concerning both the temporal and spatial availability of water. General Circulation Modeling revealed that monsoon precipitation will increase by 11 and 27 per cent under moderate and severe climate change scenarios respectively, while there will be no appreciable winter precipitation. Furthermore, the index of aridity in winter will increase manifold leading to much pronounced moisture stress for soil and vegetation, particularly in the western parts of the country. Hence, the real picture of water availability can be assessed only through an understanding of conjunctive water use planning.

WATER DEMAND ESTIMATION

In Bangladesh, six sectors are the major users of water, viz., agriculture (for irrigation), domestic or municipal, fisheries, navigation, industry, and environment (including salinity control). The National Water Plan of 1991 took into consideration the water demands of all these sectors. However, the plan did not attempt to make reliable estimates of water demand other than by agriculture and domestic uses. Demands for navigation, fisheries and salinity control – which are difficult to estimate in quantitative terms – were grouped into a single category.

The 1991 plan projected a water demand for all purposes (domestic, irrigation, fisheries, navigation, industrial, and salinity control) for the year 2018 at 24,370 million cubic meters during the critical dry month of March. The supply from regional and domestic sources in terms of both surface and ground water for March 2018 was estimated at 23,490 million cubic meters—producing a shortfall of 880 million cubic meters. In terms of specific sectoral demands, agriculture accounts for 58.6 per cent; navigation, salinity and fisheries 40.7 per cent; and domestic and industry 0.7 per cent. The NWMP is expected to make more detailed estimates of projected demand and supply of water for the year 2025. Projected supply in the dry season critical month of March by 2025 might not be greatly different from

the projections for 2018, while the projected demand will be higher, especially in the agriculture, domestic and industrial sectors on account of population increase and economic growth. However, the rate of increase in these sectors is expected to register a declining trend in response to demand management practices like conservation, water use efficiency, and recycling.

It is to be noted here that, under climate change scenario, evapotranspiration will increase and the river systems will suffer in winter due to acute low flow conditions. As a result, the winter demand for irrigation, salinity control, and channel maintenance will increase significantly leading to increased shortfall of water supply.

ANALYTICAL BACKGROUND OF WATER VISION FOR 2025: SECTORS AND ISSUES

The principal factor influencing the vision exercise for Bangladesh's water resources is the steady increase in demand especially in domestic and agriculture sectors, particularly in response to rapidly increased population. Demand for other uses of water will also increase as the economy grows. The predominant concern, therefore, is to plan responses to the steadily rising demand for water – not only for various water-using sectors, but also to maintain ecological sustainability in the water ecosystem. In accordance with the Terms of Reference of the Bangladesh Water Partnership (GWP), the formulation of a water vision is attempted with focus on three principal themes: (a) water for people (domestic/municipal use); (b) water for food (irrigation for crop production); and (c) water for nature (environmental sustainability). In addition, water needs of other water-using sectors are also reviewed and the implications of various issues entailed concerning the vision are examined. In Bangladesh, the strategy of water resource development has so far centred around flood control and irrigation expansion to promote food grain production. Not denying the importance of food production and food security, it is now widely recognized that conflicts among alternative and competitive uses of water are becoming sharper as population and the demand for limited supplies of water have been increasing. It is, therefore, necessary to formulate a long-term vision for integrated water resource management (IWRM) to address

the demands of all water-using sectors and maintain a sustainable environment. IWRM is defined by the GWP as a process which aims to ensure the coordinated development and management of water, land, and related resources to maximize economic and social welfare without compromising the sustainability of vital ecosystems. Hence, the water vision should reflect in a holistic manner a clear perspective of the management of the water ecosystem in the country by taking into account seasonal variations in availability, alternative uses and demands, mechanisms of water supply and demand management strategies, and the guidelines provided by the National Water Policy.

Domestic Sector

The National Water Policy gives top priority (in allocation terms) to domestic water supplies. In the rural areas, substantial programmes have been taken up to provide safe and reliable water supplies. By 1997, a total of 1.21 million tubewells were sunk through the joint efforts of the Department of Public Health Engineering (DPHE) and NGOs. It is estimated that an average of 105 people or 20 households are served by one tubewell in rural areas. Hand tubewells are supplemented – as drinking water sources – by deep set shallow tubewells or Tara pumps, and deep tubewells, which are primarily meant for irrigation. The progress has been significant; almost 95 per cent of the rural population now have access to tubewell water.

In urban areas, however, the situation is more critical, and the problem is going to be more severe in future due to the growth of the urban population at an annual rate of six per cent or so. In Dhaka – with a current population of about nine million – 71 per cent of the households have access to piped water. Given a current daily water demand of about 1,400 million litres in Dhaka, and assuming an increase of one per cent in consumption and a doubling of the population, the projected daily demand by 2025 will reach around 2,660 million litres. The supply scenarios, however, look problematic. In Chittagong and other smaller urban centres, less than half the households have access to safe water. With the proportion of urban population accounting for 53 per cent of the total population – as against the current proportion of 20 per cent — by 2025, special and coordinated efforts will be needed to extend access to safe or potable water in urban centres.

Rapid urbanization will continue to be a dominant phenomenon in Bangladesh over the next 25 years. In the absence of a coherent strategy, a chaotic situation could develop in terms of services and governance. Even if it were assumed that the urban population, which is currently growing at about 6 per cent per annum, will experience a somewhat lower rate of growth in the next decade, the proportion of the urban population would likely reach 33 per cent by 2010, 47 per cent by 2020, and 53 per cent by 2025. This would put an extremely heavy burden on domestic water demand as the period covered by this vision exercise goes forward. By 2025, the population of Dhaka alone might be between 18 and 20 million, with water demand far exceeding the available supply. With a view to meeting the rising water demand in Dhaka, the task of restoration and preservation of lakes and other waterbodies within the city limits would need to be undertaken to serve as retention ponds. Assuming an average daily per capita water consumption of 160 litres in metropolitan cities and 100 litres in other urban centres, the total urban water demand in 2025 will be around 11.4 million cubic metres per day. In order to ensure access to safe water and improved sanitation, the issue of supplying this amount of water to the urban areas must be given due priority.

The NWMP (under preparation) is expected to give serious attention to the issue of future demand of water for domestic use. The National Water Plan of 1991 had projected domestic water demand in 2005 for rural, urban, and metropolitan areas. These projections are extrapolated below for 2025, assuming an average annual increase of one per cent in per capita consumption.

Rural Areas:	50 litre per capita per day (lpcd) in 1990 and 69 lpcd in 2025
Urban Areas:	100 lpcd in 1990 and 126 lpcd in 2025
Metropolitan Areas:	160 lpcd in 1990 and 186 lpcd in 2025

Since almost 95 per cent of drinking water in Bangladesh is derived from groundwater sources, increased abstraction to meet increasing demands might cause environmental problems like lowering of the watertable and saline intrusion. An additional problem is the recent detection of arsenic contamination of groundwater, which necessitated a re-thinking of the strategy to supply safe water from underground sources. The potential linkage between arsenic and heavy abstractions of groundwater, if demonstrated, would radically alter the strategies for ensuring supply of safe drinking water. The alternative is to revert to surface

water for domestic consumption – an alarming spectre in the context of health and morbidity. The dilemma before the water planners is, therefore, a very difficult one in the coming years.

Compared with providing safe water, it has proved more difficult to ensure hygienic sanitation. People are less aware of the need for sanitary latrines, and are less ready to invest in them. The first comprehensive government promotion started in 1978, and the proportion of households using sanitary latrines rose from 1 per cent to 44 per cent between 1980 and 1995. The diffusion rate was slow due partly to behavioural pattern and partly to costs. However, the vision for 2025 should aim at providing full sanitation services for the entire population through extensive communication campaigns and by innovating less expensive sanitary latrines.

Agricultural Sector

Food self-sufficiency is of prime importance to Bangladesh. The introduction of HYV rice and the expansion of irrigation have both contributed to increased food production over the past two decades. However, in a normal year, the country is still deficit in foodgrain production by 1.5 to 2 million tons. There is therefore a clear need for Bangladesh to expand foodgrain production as the total population continues to increase. However, there are regional inequalities in per capita foodgrain production within the country, which need to be addressed through appropriate policies.

Essentially, a major strategy to increase foodgrain production will be through the expansion of irrigation coverage in terms of installed capacity, improvement in capacity utilization and increase in cropping intensity. Irrigation, therefore, is expected to contribute heavily to a surge in water demand in the next 25 years. Of the total irrigable land in the country (7.6 million ha), only 4.0 million hectares were irrigated in 1996/97. Based on the 1991 National Water Plan estimates of irrigation expansion, irrigated area would reach its maximum potential limit by 2025. However, in reality, this target does not seem attainable. The best that can be achieved in foodgrain production, consistent with a cost-effective and environment-friendly expansion of irrigation along with commensurate supplies of complementary inputs may not be enough for attaining food self-sufficiency as population

increases over the period under review. Hence, other means of achieving national food security should be kept under regular review and adopted as appropriate.

The main source of irrigation water in recent years has been groundwater (68.5 per cent in 1996/97). A question needs to be asked if this is a risky over-dependence, and whether a balanced conjunctive use of surface and ground water should be encouraged. The second option might seem more pragmatic in view of the arsenic problem in groundwater. Expansion of surface water irrigation by low lift pumps (LLP) has stagnated in recent years, largely due to reduction of transboundary stream flows, shrinkage of wetlands, and reduction of river recharge due to over-extraction of groundwater. On the other hand, irrigated area has doubled in the last decade owing to the rapid expansion of shallow tubewell (STW). STWs are both affordable and a profitable investment for farmers. Abstraction of groundwater – in the absence of any regulatory framework – will result in a continued decline in dry season watertable depths. The alternative is force mode deep tubewell (DTW), which is an expensive technology and, without subsidy, is not within the affordable limits of the farmers. Recent estimates by the National Minor Irrigation Development Project (NMIDP) suggest that by setting STWs at progressively greater depths, this technology can continue to expand. The NWMP is expected to assess the present irrigation water use and make projections for its future levels on the basis of the water supply status and the extent of irrigable land, demand for irrigated crops, and the relative profitability of irrigation modes. The plan will also take note of the National Water Policy's mandate to focus on increasing irrigation efficiency through drainage–water recycling, rotational irrigation, water conserving cropping pattern, and conjunctive use of surface and ground water.

Environment Sector

Most of the country's environmental resources are linked to the water ecosystem. Hence, it is vital that the development and management of water resources include measures to protect, restore and preserve the environment. Quality and quantity of water are inter-linked issues for maintaining a balanced environment. Poor water quality endangers public health and natural ecosystem. Other environmental problems – often related to inadequate water quantity – include sedimentation, saline intrusion, and wetland and bio-diversity loss.

In Bangladesh, water requirements for environmental protection fall into the following categories: (a) prevention of saline intrusion, (b) conservation of the Sundarbans; (c) maintenance and resuscitation of wetlands; (d) dilution of pollutants and effluents; and (e) maintenance/restoration of channel morphology.

In coastal areas, the salinity front advances and retreats on a seasonal basis in response to huge seasonal variation in freshwater flows in the estuaries. About 10 per cent of the southwest experiences increased salinity in the wet season, which rises to 40 per cent in the dry season. Salinity problem has deteriorated in southwestern Bangladesh as a result of the upstream abstraction of the Ganges waters. The flow reduction also adversely affected the hydromorphological conditions in the Ganges distributaries, including the threatened detachment of the Gorai off-take.

In December 1996, the governments of Bangladesh and India signed a Treaty on the dry season sharing of the Ganges Waters. The Treaty is for a duration of 30 years, renewable on the basis of mutual consent. Under the Treaty, specified quantities of water are to be released at Farakka for downstream flow into Bangladesh between 1 January and 31 May. The Ganges Water Treaty has provided Bangladesh with an opportunity for environmental restoration of the Ganges Dependent Area (GDA), *i.e.* southwestern Bangladesh. A major endeavour to that end is the Gorai Restoration Project now under implementation. This project is principally aimed at maintaining a connection of the Gorai with the Ganges during low flow months to ensure that it does not become cut-off permanently through a combined strategy of dredging and training works/control structures. But the Gorai excavation alone is unlikely to be of much avail in terms of effective harnessing of the available lean season Ganges flows following the Ganges Treaty.

Assured in-stream flows in the Ganges, resulting from Ganges Treaty, has offered Bangladesh the potential for surface water augmentation in the GDA through the construction of a barrage on the Ganges between Hardinge Bridge and the Ganges-Brahmaputra/Jamuna confluence. Although barrage construction has a long gestation period, this would be the most potential means to abstract large quantities of water from the Ganges through maintaining the dry season water level in the river at a controlled height at or near bank-full level and

resuscitate the shrinking distributaries in the GDA. Special emphasis needs, therefore, to be given to appropriate steps towards the Ganges Barrage construction in order to mitigate the adverse environmental conditions and revitalise agriculture and other water-using sectors in the southwest.

The Sundarbans, the largest mangrove forest in the world, can only be conserved and protected through augmenting flows into the channels of the southwest. The natural ecosystem of this forest is threatened by freshwater flow reduction from the north and migration of salinity front from the south. Dry season surface water flow augmentation will be essential to combat this degradation. Flows will also be required to restore and maintain the shrinking wetlands throughout the country, and to improve water quality through dilution of suspended solids, and industrial and agrochemcial pollutants in high density zones. The National Water Plan of 1991 had allocated about 40 per cent of the total national water requirements to salinity control, together with fisheries and navigation sectors. The NWMP is expected to estimate water demands for specific environmental parameters by using hydrodynamic models.

The National Water Policy is committed to ensure that all water management agencies give full consideration to environmental protection, restoration and enhancement in accordance with the guidelines of the National Environment Management Action Plan (NEMAP). The NEMAP was designed through an innovative, participatory process — in line with Agenda 21 of the Rio Earth Summit. Subsequent to the completion of the NEMAP, the UNDP, Dhaka has initiated a 5-year programme in December 1998 for its implementation, entitled Sustainable Environment Management Programme (SEMP). The components of SEMP include such water related issues as regional resource sharing, coastal land use and ecosystem, wetland management, riverine charland sustainability, and water supply, sanitation and urban waste water disposal. These activities can serve as valuable instruments towards achieving the goals of water vision.

Fisheries Sector

Water requirements for the fisheries (capture as well as culture fisheries) sector *vis-a-vis* water availability have substantial implications for future water management. Average per capita fish availability in the country is about 7.5 kg., and up to 80 per cent of animal protein in the national diet is derived from fish alone.

Fish availability in Bangladesh has declined over the past 15 years due to a combination of the following factors: (a) reduction and modification of the habitat as a result of flood protection schemes; (b) pollution of waterbodies by industrial effluents and agrochemicals; and (c) overfishing, and harvesting of small fish-fries. The problem is further compounded by the limited access of the rural poor to inland water bodies. The National Water Policy places higher priority on fisheries in terms of allocation of water compared to agriculture, and specifically states that water development plans shall not interrupt fish migration. The policy also stresses the need to preserve wetlands and to ensure their linkage with perennial flows.

Water requirements for fisheries comprise the requirements for riverine and flood plain capture fisheries, freshwater aquaculture, and brackish water shrimp and prawn production. To estimate the water requirements for capture or open water fisheries is a complex task because of the pronounced seasonal variation in fishing grounds. Related to this task is the principal question as to whether culture or pond fisheries be progressively encouraged as opposed to capture fisheries in order to halt the trend of diminishing fish output. The answer to this question will need a clear policy decision in order to formulate a water demand scenario for the fisheries sector. Moreover, the vision to revitalize the fisheries sector should include, in its mission strategies, interventions aimed at protection and rehabilitation of degraded wetlands as special ecological zones, thereby minimizing the loss of or even enhancing scope of capture fisheries.

Navigation Sector

Inland navigation is of substantial economic importance to Bangladesh because its numerous water courses provide the cheapest means of transportation. Food grains, jute and jute goods, fertilizer, cement, coal, stone and sand etc. are the principal commodities

transported by river while, throughout the country, country boats provide a network of facilities for passenger movement. Of late, flow reduction and siltation have reduced the navigability of many channels. Specific amounts of water are required to maintain the Least Available Depths (LAD) in classified routes for inland navigation.

Navigation water requirements take the same form as capture fisheries, and the 1991 plan had thus grouped it along with fisheries sector. The demands in both cases are in the form of specifications in terms of certain dimensions of supply (including depth and sedimentation rates) rather than discharge. With a view to rejuvenating water transport in the country, it is essential to ensure that water development schemes cause minimal damage to the navigability of channels and, where necessary, adequate mitigation measures are undertaken. Periodic dredging might be required to retain minimum stream flows and restore the required draught for different categories of vessels.

Industrial Sector

Water is essential for most industries. It is needed, in varying quantities, for raw material processing, boiler cooling and effluent discharge. Industrial plants obtain water from various sources. Some industries receive water from municipal supplies through the urban distribution network, and, hence, the 1991 National Water Plan had grouped domestic and industrial water requirements under one component. Certain industries, however, have provisions of supply installed *in situ* from surface or groundwater sources; and these industries often tend to pollute water by discharging untreated effluents.

Increasing salinity in surface and ground water in the southwestern region has become a serious constraint on industrial growth. The ability of some industries to use river water for cooling has been constrained and large quantities of fresh water have to be imported by barge for industrial use. Fresh water flow, therefore, must be increased to push the salinity front south and dilute the effluents if a sustainable water ecosystem is to be ensured for industrial development.

The National Water Policy (NWP) has highlighted the effluent discharge problem as a critical water management issue, and set broad guidelines to prevent water pollution caused by industries. It is expected that industrial expansion (including energy production) will continue in Bangladesh over the next 25 years, and water demand in this sector will also rise, although the proportion will still remain small compared to agriculture. Nonetheless, besides strict enforcement of effluent disposal requirements, the NWP states that zoning regulations will be established and enforced for industrial location in consideration of fresh water availability.

Integrated Flood Management

Seasonal flooding is a recurrent phenomenon in Bangladesh. About 22 per cent of the country's land area is flooded in the wet season even in a normal year, and about two-thirds considered flood-prone. Floods have often been credited with contributing to soil fertility through silt deposition. But the damage to life, crops and property from recurrent floods has demonstrated the need for a long term and integrated approach to flood management. The approach should consist of a combination of structural and non-structural methods to mitigate flood damages and, at the same time, retain the beneficial effects of inundation. However, flood mitigation measures must not be considered in isolation of other components of water resource development. These should be part of an integrated water management plan, along with environment, fisheries, drainage, navigation and household supply.

Flood is also in reality a Ganges-Brahmaputra-Meghna (GBM) regional issue. Hence, flood mitigation measures should also be addressed in the regional context. Bangladesh, being the lowest riparian of the GBM river systems, faces the brunt of the fury of floods, while all other countries of the region also suffer from flooding of different levels of severity. Hence, there is a need for active cooperation amongst the countries of the GBM region for flood management. A comprehensive scheme of collection, transmission and exchange of real time hydrametororological data among the GBM countries will promote efficiency in flood forecasting and disaster preparedness in Bangladesh.

Regional Perspective

Since the Ganges-Brahmaputra-Meghna river basins are spread over five countries, there is a great potential for regional cooperation in optimal harnessing of the water resources, and this issue of cooperation should form part of a long term water vision for Bangladesh. Potentials for such cooperation exist concerning supply augmentation, sharing of common or transboundary rivers, and flood forecasting (mentioned in the preceding sub-section).

The Ganges Water Sharing Treaty singed in December 1996 provides for Bangladesh to receive an agreed quantum of water during the dry season (January-May) for a 30-year period. The Treaty also provides for joint monitoring and consultation to ensure that it is properly implemented. It also includes an article that states that the issue of augmentation of the dry season flow of the Ganges will be taken up in the course of time.

However, there are 53 other rivers which flow into Bangldesh from India for which agreements are yet to be reached. After the signing of the Ganges Treaty, the Indo-Bangladesh Joint Rivers Commission set up a Joint Committee of Experts (JCE) to examine the issue of water sharing of other common rivers in phases. It was agreed to take up the cases of seven rivers (Teesta, Manu, Khowai, Gumti, Muhuri, Dharala and Dudhkumar) in the first phase and top priority was accorded to the Teesta. Efforts to reach an agreement for sharing of the waters of these and other common rivers should form part of the national water vision so that the country is assured of a quantum of supply during the lean season.

Bangladesh can also take an initiative for GBM regional cooperation towards converting the potential of augmenting lean season supplies of the Ganges and other rivers, for the benefit of all the coriparians, including Bangladesh. Scope of augmenting the Ganges flows at Farakka through the construction of a reservoir on the Sunkosh river in Bhutan is known to be high and may be examined. Similarly, the proposed Sapta Kosi High Dam on the Kosi river (a tributary of the Ganges) in Nepal could bring significant benefits to Bangladesh (as the lower riparian) in terms of flow augmentation. Bangladesh can collaborate with Nepal and India in the construction of this dam for mutual benefits.

Institutions and Policies

Institutional weaknesses in the water management sector are now being addressed through efforts in capacity building measures. The premiere water policy and planning institution in Bangladesh is the Water Resources Planning Organization (WARPO). It has the mandate to formulate water plans, with adequate public consultation, for utilization and conservation of water by all, and is now engaged in the preparation of the National Water Management Plan. Project planning, development, implementation, and maintenance are the responsibility of the Bangladesh Water Development Board (BWDB), while similar tasks with respect to small scale water development projects are handled by the Local Government Engineering Department (LGED). Local governments are mandated to plan and implement water projects within their geographical jurisdiction. Other water institutions in the public sector include Water and Sewerage Authority, Department of Public Health Engineering, Department of Fisheries and Inland Water Transport Authority. In order to increase the efficiency and capacity of these institutions for ensuring sustainable water management and development, fuller coordination and cooperation are essential with respect to legal and planning frameworks, development and implementation, and operation and maintenance. Simultaneously, private sector involvement in providing water services should also be explored and encouraged.

The National Water Policy, adopted in 1998, should serve as the cornerstone for the development and utilization of water resources over the time horizon to 2025. The policy may be reviewed periodically, and revised as necessary. The objectives of the National Water Policy include efforts to ensure water availability to all, introduce appropriate institutional changes, and develop a legal and regulatory environment for sound environmental management. The policies outlined for various water-using sectors must be purposefully followed with a view to attaining institutional strength and providing direction for efficient water management. The government is planning to effect major institutional reforms, but special efforts will be needed for developing and reorganizing the relevant water institutions to stress local level planning, people's participation, accountability, and long-term sustainability.

Water sector planning in Bangladesh is now changing from a top-down technocratic approach to a bottom-up/grassroots-up approach. Owing to various conflicting interests in water use, a genuine participatory water management strategy for the country is vital. People's (stockholders') participation at all stages of the project cycle should form one of the key elements in water resource planning. It is essential to institutionalize participatory planning and implementation as a continuing process. Moreover, the lessons learnt during the formulation of Flood Action Plan regarding lack of accountability, transparency, and public involvement may serve as a starter for embarking on a process to develop a pro-people water management agenda. Such an approach should focus on utilizing the knowledge and experiences of various water users, and ensuring the incorporation of people's needs and preferences in the water management strategies.

One of the objectives of the National Water Policy is to enhance the role of women in water management. In Bangladesh, women play a vital role as water drawers and water managers. They are responsible for collecting water and for controlling its domestic use; they also oversee the sanitary arrangements. It is the women who have the knowledge of the location, reliability and quality of the local water sources. It is, therefore, essential that the water planners recognize the importance of mainstreaming women in water resource development and management and their knowledge, gained as water managers at the household and community levels, be utilized properly. In fact, increased female participation must be encouraged at the planning, implementing and evaluation stages of water sector development programmes.

Demand Management

Demand management is a complex process in water resource management because of the controversy over allocation, and the difficulty of enforcing rules and regulations on water conservation. As a public and economic good, the following water demand management approaches are needed in Bangladesh for the sustainable development of this increasingly scarce resource.

Water rights and allocation. The ownership of water vests in the state, the individual has only water use rights. Bangladesh is characterized by the absence of well-defined rights of

water use. Besides, there is considerable interdependence of decisions about water usage across space and time; and, at the sectoral level, there are also many competing and conflicting uses of water. A comprehensive scheme should be developed to regulate the use of water through prioritizing sectoral allocation, regulating and monitoring the installation and application of water abstraction structures, and ensuring the minimum requirement for stream channel maintenance. Existing laws and regulations relating to water rights, user responsibilities, water licensing, and administrative aspects are not adequately enforced. The principal legal inadequacy is the lack of a comprehensive legal framework that create water and drainage rights and the facilities for upholding of those rights. The gaps in laws have to be filled up through enacting new laws and updating/expanding existing laws as necessary, while a pragmatic enforcement mechanism must be evolved. Bangladesh should formulate detailed allocation objectives in economic, social and environmental terms that may be readily understood by the people, and can be implemented through public and private actions.

Water markets. Defining and enforcing water use rights is a prerequisite for the private sector water market to develop. In principle, water markets should result in an economic allocation of available water. However, a market-based allocation system would depend on the existence of an efficient water distribution system, an efficient information system that disseminates information on supply and demand conditions, and an appropriate regulatory framework. These prerequisites are not in existence as they should be in Bangladesh. Yet, a fairly well developed water market system is in operation in the tubewell irrigation sector, which is the largest water user in the country. Unofficial water market also operates among the urban poor who do not have access to piped water and buy water from private suppliers. The government can facilitate, by putting in place the necessary prerequisites, such water markets to flourish based on the dynamics of supply and demand as well as the principles of equity, fair play, and the users' ability to pay.

Cost recovery. Cost recovery charges can be used as a tool for water demand management. The recovery of operation and maintenance costs in public sector water projects in Bangladesh has always been very unsatisfactory. Cost recovery rate needs to be improved and water conservation maximized by charging water rates on the basis of the users' ability to pay which, in turn, will depend on the reliability and adequacy of water supply and good

maintenance. Some empirical studies suggest that all categories of farmers (large and small) have been able and willing to pay when they receive benefits from irrigation. In order for the government to attain a satisfactory performance level, the management in the public water sector projects should demonstrate business-like professionalism in the delivery of services.

Water use efficiency and pollution control. Increasing dry season water scarcity is a distinct possibilities in Bangladesh. Hence, efforts to raise water use efficiency — especially in irrigation — should be an essential demand management approach. The National Water Policy lays special emphasis on measures to increase efficiency of water use in irrigation. Such measures could include drainage water recycling, rotational irrigation, adoption of water conserving crop technology, conjunctive use of surface and ground water, and better management of canals to reduce wastage. For household use, the practice of the simple, but productive, means of rain water harvesting may be encouraged as an indigenous conservation measure.

A regular programme of water quality monitoring is vital to ensure adequate supply of safe water for all. A major concern in this regard is industrial pollution, which, if not strictly controlled, is going to increase with industrial growth. The National Water Policy advocates the enforcement of "polluter pays principle" in order to reduce, prevent and mitigate water pollution as a demand management measure. Effluent treatment is necessary for all types of industries. And, adequate supply of water needs to be ensured in the channels during the dry season with a view to diluting the high concentrations of pollutants.

Conflict Resolution

The very vastness of the quantity of water gives it an aura of an unlimited resource. But this is clearly not so, especially because there are different claimants to this resource with different, often competitive, objectives. Hence, during water shortage periods, conflicts do and will arise among different claimants. The stakeholders in the water sector include both the users and the managers (planning and implementing agencies), and the conflicts in this sector are threefold: among different categories of users; between users and managers; and among different managers or planning and implementation agencies.

Mechanisms for resolution of conflicts among stakeholders are, at present, weak and inadequate. There is little or no coordination among the various agencies involved in water use, nor are their responsibilities clearly specified and known to each other. For example, the agencies dealing with irrigation, fisheries, navigation or flood control seldom work in tandem; and the consequence is that the conflicts arising at the grassroots level among the users remain unresolved. Besides, the local government ordinances assign to the local government bodies the responsibility of planning and implementing water sector projects in their respective areas, yet, in practice, they still play no role.

The need, therefore, is to evolve a framework of guidelines and legal provisions, which can be involved as necessary, for avoidance/prevention and resolution of conflicts among water sector stakeholders. Such framework will have to be based on a participatory approach, transparency and accountability in the whole process, involving all stakeholders (users and managers) at appropriate levels. In addition, clear-cut guidelines will need to be framed to define the nature and type of coordination between local government bodies and central government agencies as well as among different central government agencies involved in water utilization. This will ensure a strong mechanism for both avoidance and resolution of conflicts.

THE WATER VISION 2025

The Vision Statement

The overall vision for Bangladesh towards 2025 is a nation which is democratic, economically self-reliant, driven by coherent, secure, just and equitable principles, and consists of citizens whose capabilities and potentials are developed to a high degree. The vision for the country's water sector encompasses issues concerning the management of the country's scarce water resources aimed at the development of its economy, uplifting the living conditions of its people, maintaining ecosystem and environmental harmony, and so on.

By the year 2025 Bangladesh will

- Provide balanced food for all
- Become a foodgrain exporting country by meeting its internal demand
- Provide adequate animal protein (including fish) for all
- Ensure environment-friendly and sustainable agriculture and aquaculture (including shrimp)
- Restore and enhance Ramsar designated wetlands and protect other wetlands from degradation
- Ensure that river basin (catchment) management involves local people and local government agencies
- Augment the flows of the Ganges and its tributaries, thereby reducing saline intrusion in the GDA
- Provide clean (pollution/arsenic free) piped water for all, at affordable prices, particularly reducing the burden on women and the poor
- Reduce dependence on ground water in the winter months through improved management and conservation
- Put in place aquifer-recharge facilitating technological interventions
- Ensure access of all people to appropriate sanitation facilities
- Make sure that effluent treatment becomes an integral part of all industrial processes
- Stabilize river courses, thereby preventing river bank erosion
- Build capacity to minimize loss of lives and assets consequent upon water-based disasters

- Assure navigation in its inland routes
- Upgrade sea-port facilities to offer gateway to South Asia
- Build and enhance institutional and human capacity for planning and managing water resources involving state-of-the-art technologies
- Foster GBM regional cooperation involving
    - building of upstream storage reservoirs for multi-purpose uses
    - sharing of all common rivers with the upper riparians
    - sharing of real time information regarding disaster forecasting and early warning, and
    - creation of a properly functioning GBM Regional River Basins Authority involving the regional countries, ensuring best possible benefits to all the countries as well as all stakeshoders within each.

Drivers

'Drivers' are the elements, either indigenous or exogenous, which would influence the conditions towards achieving the visionary goals. Scenarios are constructed by making assumptions as to how the drivers will shape up in future. These drivers may fall under a number of categories: demography, societal well-being and ability, institutional capacity, technology, economy, ecological harmony etc. There might be several elements under each category, which interacting in different ways and in different combinations, would drive the various water vision elements towards the goals envisaged. In this sense, those elements define the instruments that may be specified and acted upon towards shaping the future.

Demography. The demographic issues (drivers) is an important determinant of the total quantum of water needed. The following drivers are envisaged to have significant influence on water demand:

i) Size of the population (water users)

ii) Density of population

iii) Rate of urbanization

iv) Rate of rural-urban migration

Economy. Economic factors have significant influence on water consumption and demand. High rate of industrialization often leads to higher demands for water for the

purposes of processing and cooling, while people tend to require more fresh water for household and drinking purposes as their incomes increase. Economic growth and income distribution are both important considerations relating to the level and pattern of demand for water. The following economic drivers are thus identified:

i) Per capita income
ii) Poverty ratio
iii) Rate of investment (% of GDP)

Societal forces: people's well-being and ability. A vision must be concerned with social progress encompassing all citizens and with equity and social justice underpinning the development process. The important drivers under this category include the following:

i) Proportion of people receiving piped water
ii) Proportion of people enjoying appropriate sanitary facilities
iii) Proportion of people receiving health-care facilities
iv) Status of women involvement in water management
v) Literacy rate
vi) Access to employment, particularly of the poor and the disadvantaged
vii) Social equity

Technology. Technology, which has already reached phenomenal levels of advancement in many fields including information technology and more technological advancements are likely to come on stream in future, will continue to have a profound influence on shaping the future of the planet and the lives and living of its inhabitants in the future. In the coming decades many of the prevailing water related problems will likely be solved by the introduction of modern technologies, *e.g.* land reclamation from the sea, biogenetic engineering, artificial recharge of groundwater systems etc. The following are important areas for technological drivers to make large impacts on:

i) Agricultural organisation and technology (seed, water, tools and machinery, fertilizers, pesticide, etc.)
ii) Water use (irrigation and drainage) efficiency in agriculture
iii) Development of drought resistant high value crops
iv) Development of salinity resistant crops
v) Use of agricultural biotechnology

vi) Water and sewage treatment

vii) Efficient harnessing and distribution of water

viii) Effluent (pollution) management

ix) Land reclamation and resettlement

x) State of disaster warning and preparedness

Ecological harmony. Sustainability of the natural resource base depends on environmental balance. Drivers that impact on sustainability of the resource base, which is crucial for sustainable development, and which should be addressed in terms of mitigation, adaptation, conservation, and enhancement, would include the following:

i) Water quality in all water bodies

ii) Drainage conditions

iii) Flood and drought vulnerability

iv) Salinity intrusion

v) Status of channel maintenance

vi) Proportion of forested areas

vii) Status of bio-diversity

viii) Status of wetlands

ix) Status of land degradation

x) Status of air pollution

Governance. Good governance is a pre-requisite for developing a just and cohesive society. The following drivers help create an ambience of good governance through transparency, accountability and participation of all members of society, especially the disadvantaged segments including women and the poor. In addition, human capability and appropriate institutional and legal frameworks need to be developed to foster democratic values and practices. The following are among they key areas to focus on in the context of governance drivers:

i) State of community participation in watershed management

ii) Political commitment to efficient water management

iii) Level of public awareness regarding water conservation and management

iv) State of public-private partnership in water resources management at the grassroots

v) Capacity of the institutional framework for water planning and management

vi) Legal provisions in place that govern water planning and management

vii) Extent of involvement of local government bodies in planning and managing water sector projects

viii) Efficiency of decision making frameworks

ix) Status of regional cooperation in harnessing and managing common water resources

x) Efficiency in the implementation of decision/projects/programmes

The elements identified under each driver category point, where necessary, to the instruments to be designed, and put in place towards shaping the future in the particular respect in a certain desirable fashion. For example, when population is growing rapidly, it is necessary to institute/strengthen policies/programmes to reduce the population growth rate as fast as possible; when healthcare is inadequate, instruments are needed to be formulated/adjusted/strengthened toward improving it; in the case of inefficiency, appropriate policies and steps need to be designed and implemented to improve the situation; and so on.

Scenarios

Considering the vision drivers identified above, three scenarios are postulated based on the general definitions of the scenarios provided by the World Commission on Water in the 21st Century. The scenarios are presented in Table 1 below.

Table1: Drivers underpinning the water vision and three scenarios

Issues and Drivers	units/status	Present	CWW	WCW	SWW
Demography					
1 Size of population	million	126	190	200	180
2 Density of population	h/km^2	850	1285	1350	1015
3 Rate of urbanization	% of population	20	50	65	50
4 Rate of rural-urban migration	million	1~1.5	2	2.5	1.5
Economy					
1 Per capita income	US$	250	800	500	1200
2 Poverty ratio	%	53	60	60	<10
3 Rate of industrial/commercial investment	% of GDP	15-16	18-19	15-19	26-28
Societal well-being & ability					
1 People receiving piped water	% of population	<5	<35	<35	100
2 People enjoying sanitary facility	% of population	<40	<65	50	100
3 People receiving health-care	% of population	<60	<85	75	100
4 Status of women	status	Poor	Improved	Poor	Equal to their spouses
5 Literacy rate	% of population	53	85	75	100
6 Equity level/status	status	Poor	Moderate	Poor	High
7 Access to employment	% of labour force	65	65-70	50-60	>90
Technology					
1 Agricultural organisation and technology	status	Low	Moderately improved	Low	Greatly improved
2 Water use efficiency in agriculture	status	Very low	Moderate	Low	High
3 Water and sewage treatment	status	Very low	Moderate	Low	High
4 Water harnessing & distribution	efficiency	Relatively low	Moderately improved	Low-moderate	High
5 Effluent management	status	Very poor	Moderate	Poor	High
6 Land reclamation & resettlement	status	Insignificant	Insignificant	Insignificant	Significant area reclaimed
7 Drought resistant economic crops	status	Non-existent	Possibly some	None	Certainly some
8 Salinity resistant crops	status	Non-existent	Possibly some	None	Certainly some
9 State of disaster warning	status	Not satisfactory	Improved but still wanting	Weak	Fully & satisfactorily functional
10 Use of agricultural bio-technology	status	Poor	Relatively high	Moderate	High

Table 1 continued

Issues and Drivers	units	Present	CWW	WCW	SWW
Ecological harmony					
1 Water quality in water bodies	status	Mixed (good, poor, deteriorationg)	Perhaps somewhat worse	Much worse	Mostly satisfactory
2 Drainage conditions	status	Unsatisfactory	Moderately improved	As at present or wrose	Satisfactorily improved
3 Flood and drought vulnerability	status	Substantial	Moderate	High	Low
4 Levelof saline intrusion	status	Substantial and increasing	Somewhat increased	Increased significantly	Decreased significantly
5 Status of channel maintenance	status	Moderate	Moderate	Poor	Improved
6 Forested areas	% of total land area	<6	<10	<5	>15
7 Bio-diversity	overall status	Generally rich, but degrading	Somewhat improved	Degradation continued	Significantly improved
8 Land quality	status	Generally fertile, but degrading fast	Degradation checked	Degradation continued	Improved
9 Wetlands	status	Area shrinking, quality degrading	Somewhat improved	Will degrade further	Significantly improved
10 Air pollution (urban)	overall status	Generally degrading	Somewhat improved	Will degrade further	Significantly improved
Governance					
1 Community participation	status	Poor	Moderate	Moderate	Improved
2 Political commitment	status	Poor	Poor	Poor	High
3 Public awareness	status	Poor	Moderate	Poor	High
4 Public-private partnership	status	Poor	Moderate	Poor	High
5 Institutional capacity	status	Weak	Weak	Weak	Improved
6 Legal provisions/enforcement	status	Many gaps and weaknesses	Somewhat removed	Will become entrenched	Satisfactory
7 Involvement of local government	status	Weak	Moderate	Poor	Improved and vibrant
8 Decision making framework	status	Centralised, progress-restraining	Slightly improved	Worse	Significantly improved
9 Regional cooperation	status	Low	Moderate	Low	High
10 Implementation of decisions	status	Generally poor	Poor, somewhat improved	Poor, perhaps worse	Significantly improved

Notes: These scenarios are based on the general definitions given by the Secretariat of World Commossion on Water for the 21st Century. The definitions are presented below.
The **CWW** (Conventional Water World) is essentially a *business-as-usual* scenario with a slight optimistic note concerning some assumptions on the autonomous development and use of new and emerging technologies and concerning the benefits of improving integrated water management. However, it is assumed that the prevailing key water problems would not be resolved under the CWW scenario. It is also assumed that the world would be in a state where the resilience of the natural and socio-economic systems are being tested to the limit. The **WCW** (Water Crisis World) scenario explores a combination of a lower dissemination of the new technologies with the possible consequences of events leading to higher vulnerability of the systems. The **SWW** (Sustainable Water World) describes the future we aspire to.

Implications of the Scenarios Envisioned

The Conventional Water World (CWW) is a concomitant of a national scenario that the country would still be struggling with very limited progress. Although food crop production may continue to grow in response to increased use of high yielding varieties and improved management at the farm level, the overall production would not be sufficient to achieve and maintain food self-sufficiency. There will be some progress in education and public health fields as a result of both government and civil society efforts. Industrial employment would increase somewhat. Environmental condition would also improve somewhat given better awareness-based public sector and civil society activities. The status of governance would still be rather poor, despite relatively higher participation of the general public in decision making, mainly through electoral processes. Moderate improvements in technology-driven relatively efficient use of water would be counteracted by persisting poor regulatory and institutional capacity for maintaining quality of water, especially in the case of treating industrial effluents, keeping in view increasingly higher levels of industrial and commercial activities. In general, the achievements in dealing with water related issues under CWW would not be adequate to ensure sustainable development.

A Water Crisis World (WCW) is a part of a national scenario that development activities in various sectors would fail, more often than not, to address the national goals and peoples' needs. It will be characterised by ineffective governance. Sufferings of the people at large would widen and intensify. Poor management would lead to further deterioration of the resource base and increased conflicts concerning access to and control over resources. Higher demands for food would not be met and there would be increased social inequity, higher levels of malnutrition, acute poverty and unemployment, and increased social tensions. Ecological harmony would be at higher risks. A highly undesirable scenario.

In contrast, the Sustainable Water World (SWW) is a constituent of a national scenario built around the theme of sustainable national development. There shall be significant achievements in most sectors of the economy and society. Economic growth would be achieved with the industrial sector making good strides and the agricultural sector continuing to make contributions commensurate with its potential. Natural resources, including water, would be used optimally, distributed equitably, and managed efficiently.

Human capabilities would flourish to achieve higher levels of success in various fields of human endeavour, supported by appropriate policies and institutions. The use of technologies, as appropriate, coupled with good democratic governance would ensure an ecologically sound, accelerated, and equitable development trajectory.

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