INTEGRATED WATER RESOURCES MANAGEMENT (IWRM): MAXIMISE USAGE AND MINIMISE WASTAGE OF WATER RESOURCES

Research Article

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Abstract

Following the implementation of GWP (Global Water Partnership) in 1996 by UN the countries around the world began to implement the principles of IWRM to minimize water waste and maximize its beneficial use. The Ministry of Local Government, Rural Development and Cooperative in Bangladesh also adapted the idea and created IWRM unit in 2003 through WARPO, CEGIC and IWM. Bangladesh is going through serious shortages of fresh water resources. Major reasons are: diversion of natural river flow in the upstream area; rapid siltation on river beds which have seriously reduced water holding capacity causing regular floods destroying crops, making people homeless and even loosing many lives, destroying economic progress; and change of climate pattern, seawater encroachment due to sea level rise destroying fresh water resources and cropping lands due to climate change impact and greenhouse gas emission. To overcome these issues the country must adapt the following steps: implementation of IWRM practices to its maximum capacity. IWRM will include surface water, groundwater, waste water and sewage water resources to design its maximum utilization. In addition WSUD techniques; urgent dredging of rivers; positive negotiation with the neighbors for surface water sharing and storing excess surface water during monsoon at series of reservoirs built in upstream locations and use them during dry season. The biggest task of Bangladesh IWRM is to educate all stake holders; establish proper coordination among all water management sectors and train up end users to transform them as guardian angels of water conservation.

Key words

GWP, WSUD, Dredging, Rainwater Harvest, Water Accounting, Awareness Rising, Implementation of IWRM

2/5/2019 **Source of Support:** None | **No Conflict of Interest:** Declared

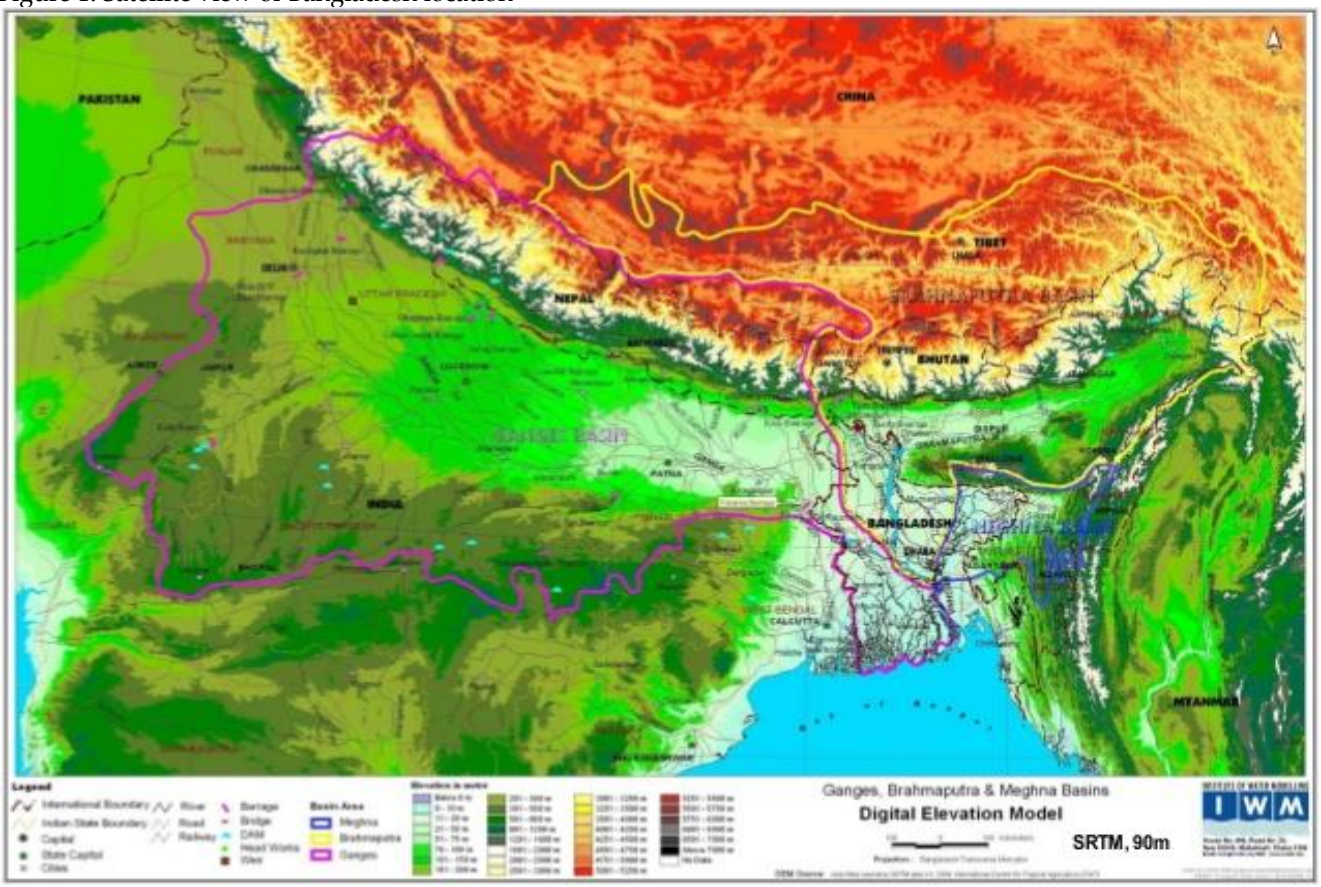
INTRODUCTION

It seems likely as the amount of fresh water is decreasing systematically and the population is increasing exponentially around the globe particularly in Asia. The deltaic origin of the country and its global disposition (Figure 1) made Bangladesh the unique. Bangladesh used to be known as land of rivers and some of the rivers are so wide that anyone would call it a mini ocean as the other bank is not visible through naked eye. All the rivers have its origin at the Himalayas, Shillong Plateau and foot hills of Arakan-Yoma mountain Ranges including China.

LOCATION, PURPOSE AND SCOPE OF IWRM

Bangladesh is located at the mouth of Bay of Bengal. One of the largest deltas in the world (Figure 2). Historically the country never had any shortages of surface water and all rivers that flow into Bangladesh comes from India. To save the country Indian Government had constructed Farakka Barrage on the Ganges and many other rivers disrupting natural flow of the rivers and diverting them for the developmental activities which require lots of water. This practices has become detrimental to Bangladesh's river natural water flow which has been restricted and regulated upstream as a result during dry season Bangladesh gets very little water in comparison with demand and during rainy season too much water is diverted to Bangladesh causing floods every year.

Figure 1: Satellite view of Bangladesh location



(Source: Flood Management in Bangladesh - CCAFS | CGIAR program - Climate Change, Agriculture and Food Security. http://www.slideshare.net/cgiarclimate/flood-management-in-bangladesh-pd-cdmpii-upd-28-nov13)

Figure 2: Satellite view of Bangladesh location

(Source: Flood Management in Bangladesh - CCAFS | CGIAR program - Climate Change, Agriculture and Food Security. http://www.slideshare.net/cgiarclimate/flood-management-in-bangladesh-pd-cdmpii-upd-28-nov13)

As a result over the years the surface flow of surface water have reduced to a dangerous level which have reduced the quantity of surface water flow into Bangladesh at a level no longer enough to meet the ever increasing national demand of Bangladesh. Bangladesh is currently going through an economic boom and the demand of water has sky rocketed. To meet the demand the country is over exploiting its ground water resources and in many locations ground water mining is taking place particularly around Dhaka city where nearly 20 million people lives and which is considered as the economic power house of the country. Groundwater mining is unsustainable and cannot continue indefinitely. On that context the concept of Integrated Water Resources Management (IWRM) has received worldwide recognition. It is the only way to minimise water losses and maximise its proper utilization.

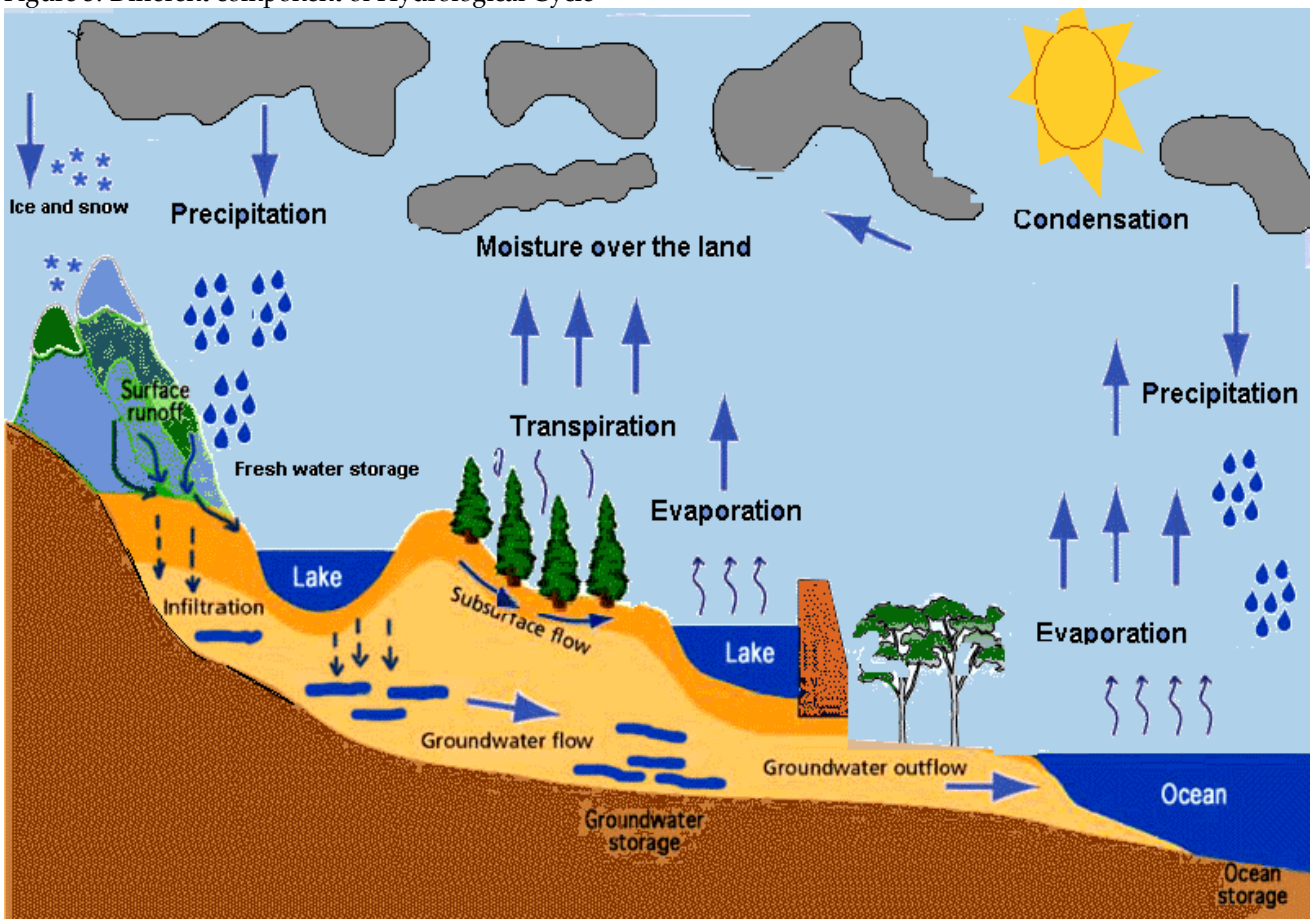
Bangladesh economy was and still is primarily based on agricultural food production. Its GDP is principally linked with agricultural production although it is steadily trying to diversify through other sectors particularly through the export of manpower, garments, ship building and medicine as well as increased tourism. But as of now more than 80 % employment comes from agricultural sector. Therefore the demand for water is of utmost importance. Booming agricultural industry, construction industry, rapidly growing small scale industrialization and growing population requires huge amount of water. In a very simple way it can be said that water has become the life blood for the country's economic development and the country must come up with a rational solution to support these growing demands.

Implementation of IWRM is the most viable answer. The relationship between Land, water, Environment and the life forms (Figure 3, Figure 4 and Figure 5) are inseparable therefore one has to deal with them in combination to bring IWRM into a success.

HYDROLOGIC CYCLE AND MAJOR HYDROLOGICAL REGIONS OF BANGLADESH

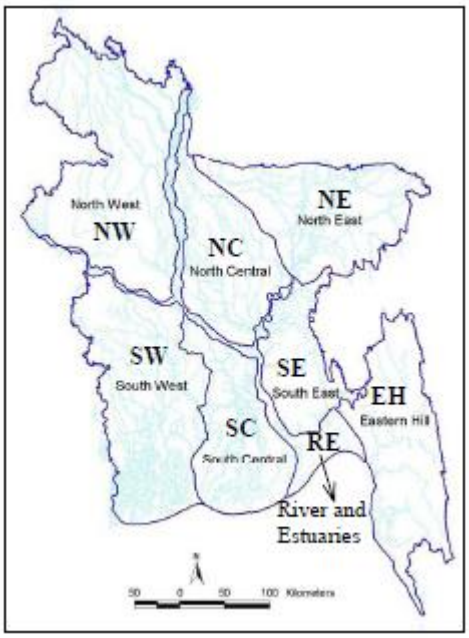
The various components of global hydrological cycle are shown in Figure 3 and pictorially explain how they are interlinked and its mode of operation. Based on the Disposition, Nature and Flow Characteristics of the major Rivers 8 different hydrological regions (Figure 4) has been identified utilizing natural divides.

Figure 3: Different component of Hydrological Cycle



(Source: http://answers.tutorvista.com/138884/biology-hydrological-cycle.html).

Figure 4: Hydrological Regions of Bangladesh



(Source: LGER, WARPO report, 2003)

As mentioned earlier that most of the major rived has its origin outside Bangladesh and its natural flow has been modified with artificial barrages in India the river flow has been reduced to a dangerously low level and in some instances some of the rivers have died permanently. This artificial condition has produced serious imbalance to the natural ecosystem and a major threat to our national economy. Brief descriptions of some of the major problems are mentioned below:

Navigation

Navigation has been the worst hit as it is one of the principal modes of transporting food, construction materials, and human population. All major rivers have developed thousands of Sand bars (Balu Char) due to the reduction of flow and rapid siltation causing serious problems in navigation. It is now taking more time than before on the other hand the man on wheel is always in tension whether the ships/boats/cruises are going to hit a sand bars particularly at night time. It is dangerous and passengers are travelling with fear of being attacked by robbers and dacoits in the middle of the night and there are many instances of this type of incidences happening. Dredging is required to many rivers at any cost and at the same time negotiation with neighboring India must be an ongoing issue until a solution to the problem is found.

Surface Water Irrigation

Bangladesh is principally an agriculture based country due to its deltaic disposition and very fertile soil condition. From time immemorial these agricultural lands has been irrigated by surface water but the steady gradual decline of surface water at a must faster rate it is no longer possible to maintain continuity. A paradigm shift has taken place farmers are now most of the time dependent on ground water and the farmers have no idea that groundwater is a finite resources and over exploitation will do more harm than good in the long run. Agriculture being the biggest employment sector (about 80 %). To keep this sector growing water supply must be increased and at this critical time IWRM is the only option to maximize water availability.

Fisheries

Like the navigation fisheries has been greatly affected and natural fish production has been affected and the availability of fresh water fish from rivers has gone down to its minimum level. Mother fish require deep water environment during breeding season to lay their eggs and for the eggs to hatch to become fish larva and eventually big fish require deep water environment. A solution must be found through regional cooperation otherwise more difficult time is coming in the near future. Existing and new fishermen are now engaged in large number for artificial fish farming in abandoned ponds, lakes and bills (haors) for their survival. Although we are getting plenty of cultivated fish in the market but their production cost is very high and fishes are sold in the market at a price beyond the buying power of poor people.

Groundwater Resources of Bangladesh

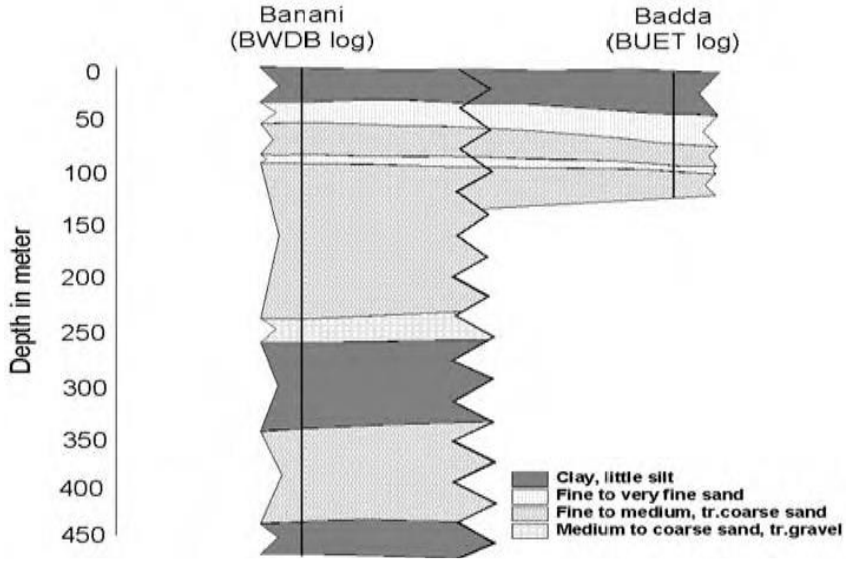
Fortunately with the blessings of Monsoonal climate Bangladesh receives plenty of rain water as well as river water and occasionally too much water when too much rain is added causing frequent flooding every year. When big flood affects the country more than 80 % of the land goes under water damaging crops, livestock's and millions of people become homeless and lot of people losses their life as well. On the positive side the agricultural lands gets its renewed fertility, natural ecosystems gets a new life and groundwater gets plenty of recharge through filtration and deep percolation from the rain and floodwater in addition with the recharge at the outcrops located along the eastern and north eastern borders of the country and India. Based on depth and geologic formation 4 different potential aquifers (Table. 1) has been identified (LGED 2003). Shallow aquifer in many parts of the country has already dried (Table. 1 and Figure 5) and groundwater level is declining sharply.

Table. 1. Different Aquifer identified in Bangladesh

Aquifer	Depth Meter	Geological era
Upper shallow aquifer	up to 50 m	Recent
Low aquifer	50- 100 m	Holocene.
Deep aquifer	250-500 m	Tertiary.
Deeper aquifer	500-1500 m	Miocene

(Source: WARPO, CEGIS and IWM Unit, LGED 2003. Analytical framework for the planning of Integrated Water Resources Management (Ministry of Water Resources and Local Government and Cooperatives).

Figure 5: Pleistocene Dupi Tila aquifer of Dhaka city (Zahid et al, 2004)



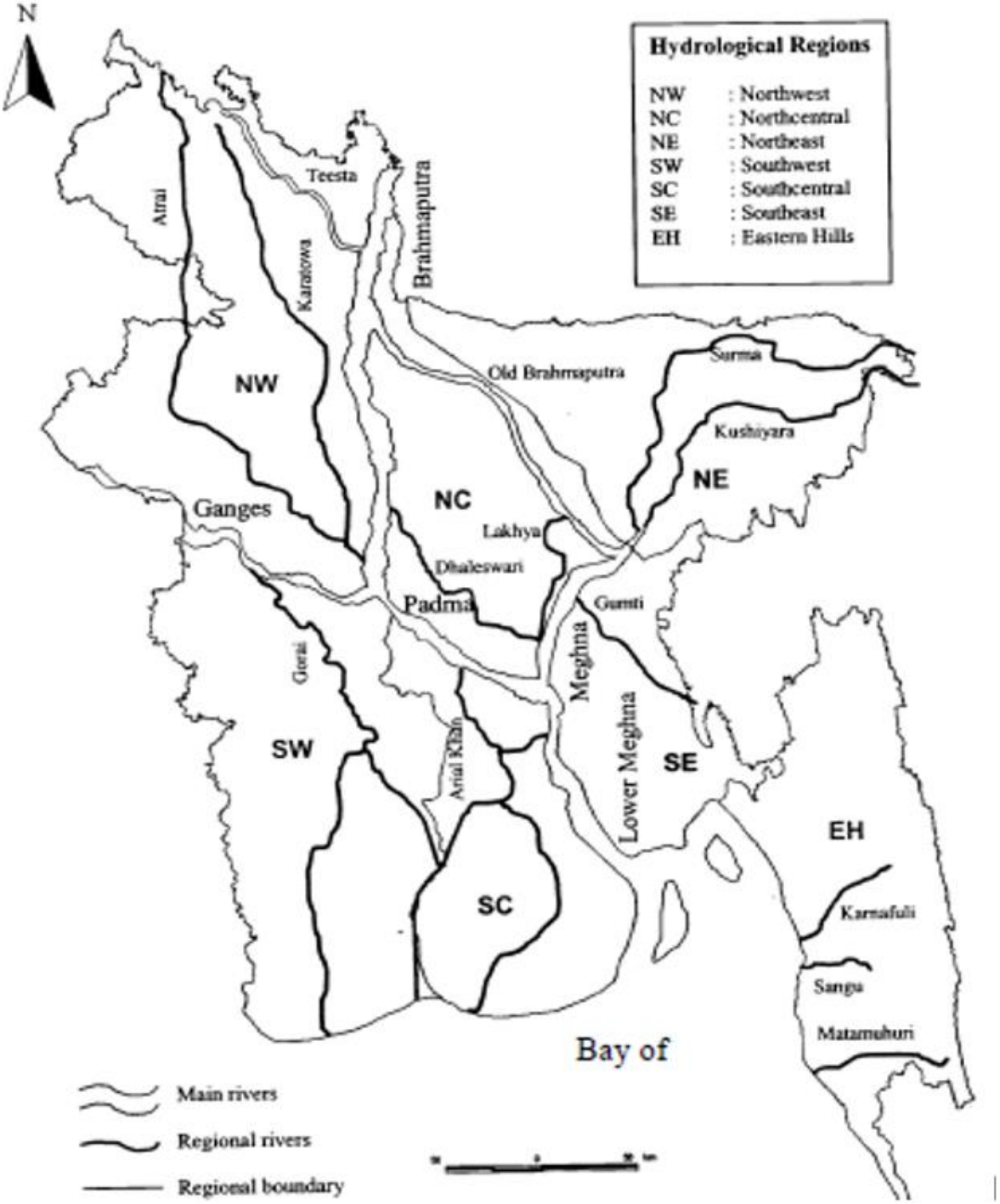
The aquifer has been contaminated with heavy metals like Arsenic which is a serious health hazard and contamination with saline water due to sea water intrusion. In the Urban areas groundwater table have gone down sharply to a dangerously level. The Groundwater level in the Dhaka city has dropped by 6m (Figure 6 and 7) during the last 7 years due to excessive water mining (Ahmed, 2011).

Groundwater and Surface water are hydraulically connected and one resource complements the other. The major river network (Figure 3, 4 and 5) maintains a very intimate and delicate relationship for each other's existence. It is therefore very important to protect both for our national interests.

Other Sectors

The list goes on and Forestry is shrinking at a much faster rate (particularly the size of the mangrove Forest at Sundarbans is decreasing at an alarming rate; for example in 1776 the size of Sundarbans was 11, 256 sq. km. and it is now 5, 467 sk. km. As per census in 2015 through the courtesy of The Daily Prothom Alo 3 September, 2016), Natural vegetation has declined as ground water level has gone down, natural water supply to microorganism has gone down to an alarming level, Birds community is on a decline, and native animal kingdom facing extinction creating serous ecological imbalance as all these flora, fauna and all other life forms are fully dependent on the supply of fresh water. IWRM is particularly important to protect our most fertile cultivated land of the world from desertification, a condition that makes the land inhabitable for the future generations and ecological catastrophe is waiting to happen.

Figure 6: Main Rivers, Regional Rivers and Hydrological Regions of Bangladesh



(Source: WARPO, CEGIS, IWM report, 2003.Analytical framework for the planning of Integrated Water Resources Management, Ministry of Water Resources and Local Government and Cooperatives).

MAJOR CAUSES OF FRESH WATER SCARCITY

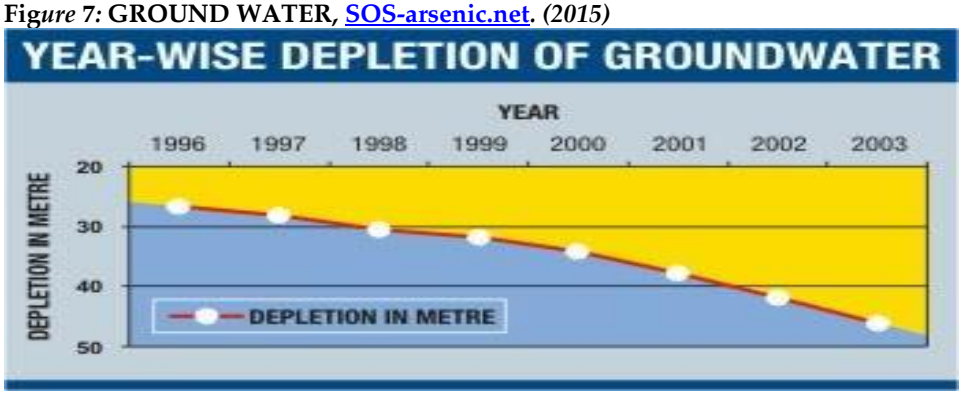
Rapid Western Industrialization and its Consequences

It is now well known and established fact that the so called western industrial revolution is the principal contributor of climate change, catastrophic greenhouse gas effects, ozone layer depletion and creation of acid rain. The impacts are very visible and are reflected by changing climate pattern, steady rise of global temperature, sea level rise and contamination of fresh water by sea water intrusion and other major health concerns. Ironically developing countries are worst hit by this climate change impacts and it is now accepted by the IPCC that Bangladesh is one of worst casualty of the climate change, greenhouse gas effects and global warming.

Unilateral Withdrawal of River Water

Bangladesh was used to be called as a land of rivers which is not true anymore. Out of 58 rivers flowing over Bangladesh 54 rivers are coming from India but unfortunately India has constructed artificial barrages on most of them seriously reducing the normal flow of rivers in Bangladesh. Because of this artificial diversion of river flows siltation on river beds have increased many folds. The mighty rivers have developed thousands of sand bars due to over siltation, smaller rivers are getting dry and some of them are already dead. As the country is going through agricultural, construction and industrial boom these sectors has increasingly become dependent on groundwater which is a finite resource (Alam, 1991 & 2011) and can only support to a certain extent without damaging the resources. Some urban areas particularly at the capital city of Dhaka groundwater mining is taking place on a regular basis to meet the ever increasing demand in all sectors. As a consequence the upper layer of aquifers have gone dry and saline and iron rich ground water (Alam 1991 & 2016; Ahmed, R, 2011) is coming up which will do more harm than good. Ahmed Reaz (2011) has also reported that ground water level has also dropped 6m (Figure 6) in 7 years which is very alarming. If urgent measures are not taken to reverse the situation then groundwater will not be available in the near future and ecological balance will be destroyed, all developmental activities will suddenly stop, land subsidence might takes due to land stabilization of the upper aquifer layers a consequence would be disastrous for the country and will open the door for a civilization to demise gradually.

Fig*ure 7:* GROUND WATER, SOS-arsenic.net. *(2015)*



(Source: http://sos-arsenic.net/english/groundwater/index.html).

Immediate dialogue is needed with all our neighbouring countries who share common rivers particularly India to find an amicable solution for all parties to augment river flows during winter season when there is no rain. The other important issue is how to cash in huge amount of excess water that showers from the sky during monsoon season frequently creating floods by constructing series of reservoir upstream and use them during lean season by all parties.

Uncontrolled Population Growth in Asia

According to the United Nations, in 2006 global population was 6.6 billion and that figure has gone up to 7.3 billion in 2016. China has 1.357 billion in 3013 and India had 1.252 billion in 2013. China and India together accounts about 36% of world population.

On a global scale world population is going up by nearly 1 billion in 10 years and on the other hand the industrial development worldwide is growing at a much higher rate which is good news. But both of these sectors require much increased amount of water to keep sustainable development going which the world does not produce. In Bangladesh 10 years (2006) ago total population was 150 million (approx.) and in 2016 the population is 163 million with growth rate of 1.70 (approx.) which is quite high. This country cannot afford to take any more people and the government must try to bring it down to zero growth rate as soon as possible and then keep heading towards negative population. Right now the country is going through a period of fresh water crisis as a result of development boom and increased population. The population of the EU was 508 million as of 2015 which is less than 11% of global population. In a nut shell global population is increasing and the quantity of fresh water is shrinking.

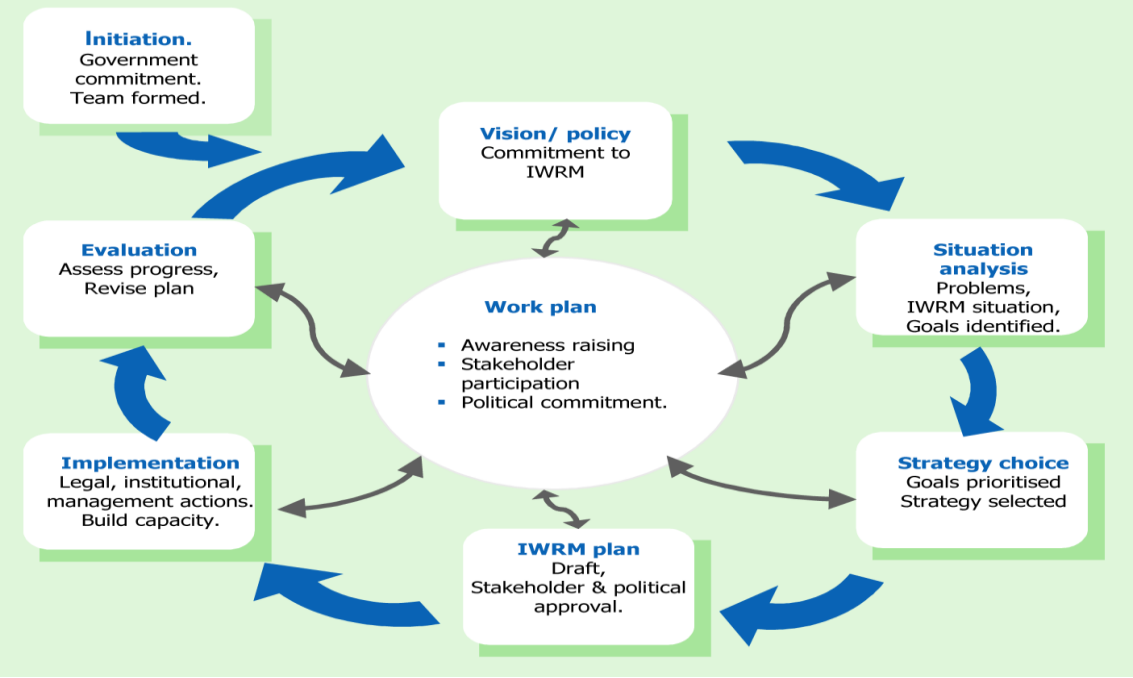
Economic Boom in Asia

Industrial development revolution is taking place all over Asia and currently Bangladesh is enjoying a GDP of 7% and according to the Head of World Bank this country has become a model for the world for sustainable development. But the bad news is both section 4.3 & 4.4 requires huge amount of excess water than the world is currently producing. To meet these challenges the UN has had begun GWP (Global Water Partnership) in 1996. That program has prompted the world to develop IWRM practices to maximise the uses of the available resources and to minimise water losses to its absolute minimum.

INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

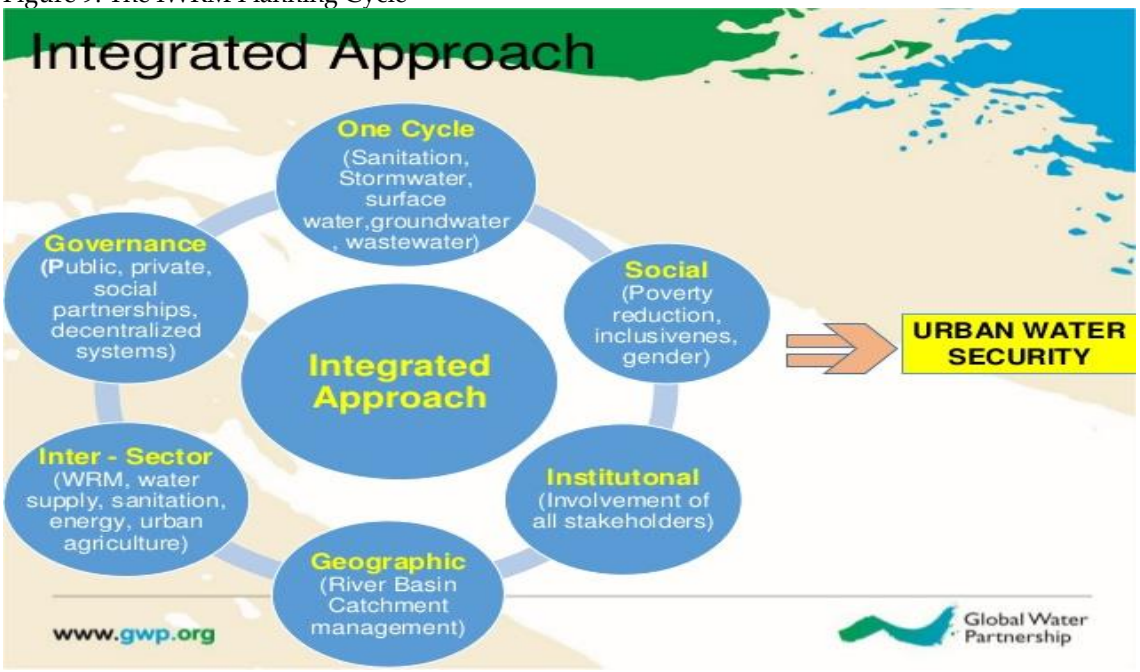
It is recognized that freshwater ecosystems is crucial for economic development and environmental stability to create sustainable development. Delivery of suitable quality and quantity of water is vital to maintain healthy ecosystem. The traditional fragmented approach is no longer viable to meet the ever growing needs of fresh water by all quarters (agriculture, industry, urban water supply, energy production, construction industry and others) and a more holistic and coordinated approach of water management is essential (Source: Cap-Net, 2005). The Integrated Water Resources Management (IWRM, Figure 8 and 9) approach that has been accepted internationally as the way forward for efficient, equitable, and sustainable development and management of the world's limited water resources (UNDP, 1996). Based on the "global water partnership strategy 2004–2008" five principles has been identified and adapted and they are known as Dublin Principles.

Figure 8: Water in different phases



(Source: Fig 6.1 Integrated Water Resources Management Plans (Source: Cap-Net, 2005)

Figure 9: The IWRM Planning Cycle

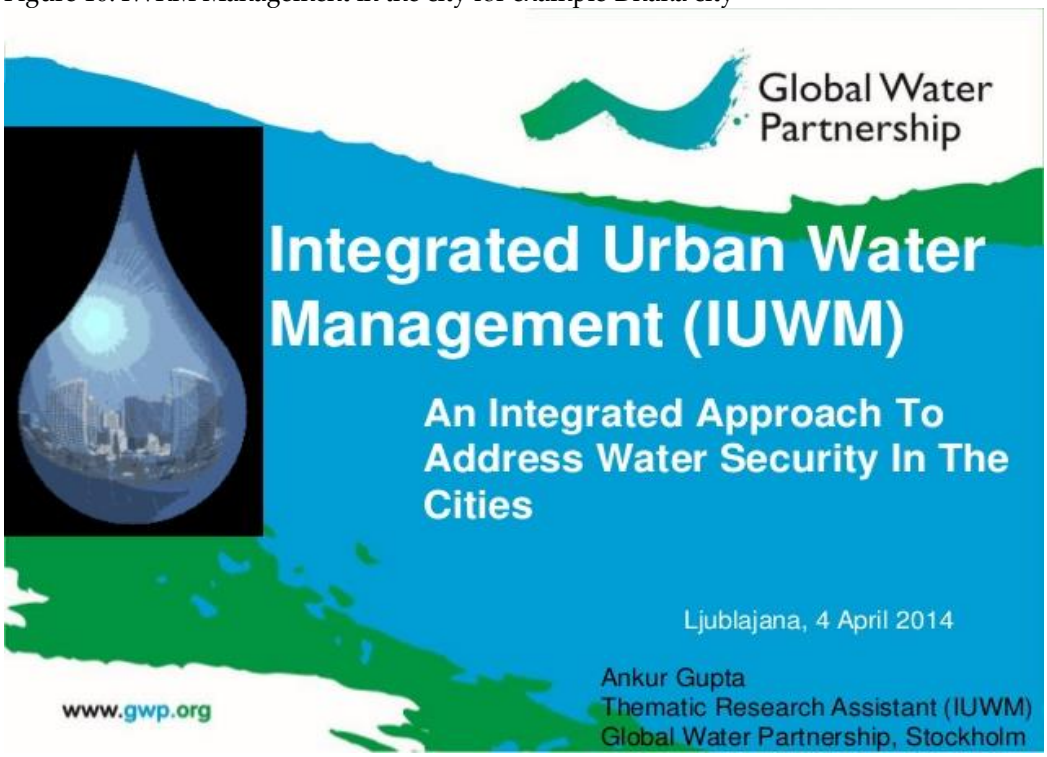


(Source: http://www.slideshare.net/gwpceewaterpartnership/sust-san-workshop-integrated-urban-water-management).

The Dublin principles aims were to bring out the following output globally through cooperation, technical assistance and financial aid to the developing countries. Bangladesh being one of the worst hit by Climate Change impact should get assistance on a priority basis.

Output 1: IWRM water policy and strategy development facilitated at relevant levels
Output 2: IWRM programs and tools developed in response to regional and country needs
Output 3: Linkages between GWP and other frameworks, sectors and issues ensured
Output 4: GWP partnerships established and consolidated at relevant levels
Output 5: GWP network effectively developed and managed.

Figure 10: IWRM Management in the city for example Dhaka city



(Source: http://www.slideshare.net/gwpceewaterpartnership/sust-san-workshop-integrated-urban-water-management).

The above three figures (Figure 8, 9 and 10) provides a very clear picture to the readers about the water cycles, existence of water in different phases and how integrated water resources management program is designed and how it will benefit the global community.

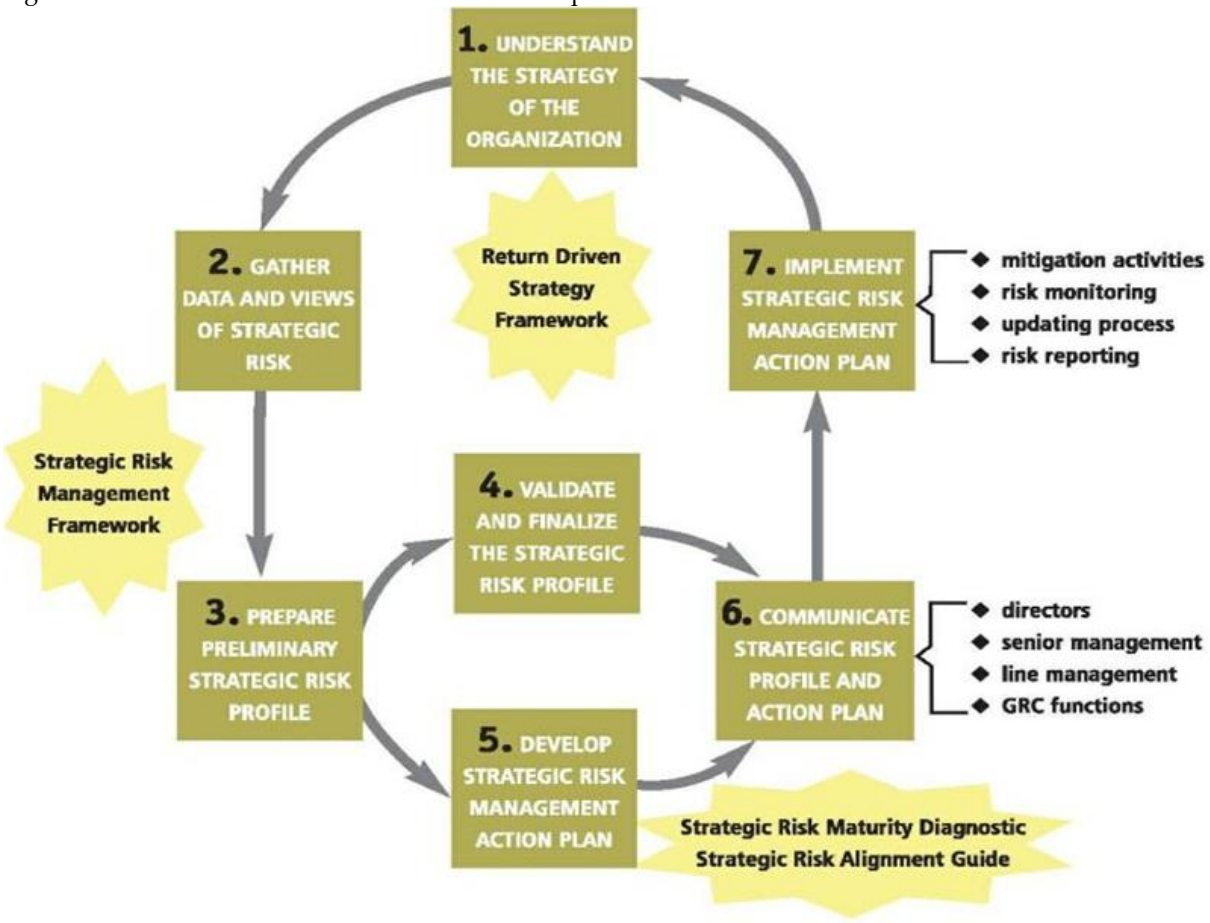
What are IWRM and Its Commitment?

The Global Water Partnership (GWP) is a UNDP initiative began in 1996. It has created an international network whose vision is to create a water secure world. GWP mission was to promote, educate and adhere the principles of Integrated Water Resources Management (IWRM) around the globe and wherever required provide technical and financial support to achieve that goal. GWP initiative hatched by UNDP is absolutely vital for Bangladesh which is dangerously overpopulated and whose fresh water sources are shrinking at a much faster rate due to increased population and development boom. Implementation of IWRM (GWP, 2004-08) principles and practices in every sphere of water usage is vital for the existence of the country.

The GWP defines integrated water resources management as a process that "promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". UNDPs main responses are: 1. Trans boundary Waters Programmes; 2. UNDP Water Governance Facility at Stockholm International Water Institute; 3. Cap-Net-Network for Capacity Building in IWRM; 4. Mainstreaming Human Rights and Gender Equality; Small Island Developing States IWRM Programme; and Promoting IWRM in Central Asia. Of these initiatives Trans boundary Waters Programmes are very vital and directly applicable for the surface water resources of Bangladesh as all major rivers that flows over Bangladesh has its origin in another country and UNDPs direct mediation is very much in need to achieve its fair share otherwise the country will become bankrupt in its water resources and a major catastrophe is inevitable.

The so called Dublin principles (International Conference on Water and the Environment) in 1992 strongly recommended the IWRM stressing the needs to improve the water management practices. In its current framework IWRM rests upon three principles: 1. Social Equity; 2. Economic Efficiency; and 3. Ecological Sustainability.

Figure 11: Risk Assessment based on Dublin Principles



(Source: The Dublin Statement (1992). on water and sustainable development. www.wmo.int/pages/prog/hwrp/.../icwedece.html. World meteorological organization).

IWRM approach focuses on three basic pillars (Figure 11) and explicitly aims at avoiding a fragmented approach by considering the following aspects: 1. Through an Enabling Environment; 2. Through the Roles of Institutions; and 3. Through Management Instruments. The following conditions: 1. Political Will and Commitment; 2. Capacity Development; 3. Adequate Investment, Financial Stability and Sustainable Cost Recovery; and 4. Comprehensive monitoring and Evaluation. As a developing country Bangladesh neither have the Technical Knowhow nor it has the Financial Strength for its proper implementation. In these regards UNDP can play a very effective role in its proper implementation through technical cooperation and financial assistance.

What are the Benefits?

The UN sponsored initiative "Water for Life 2005 – 2015" featuring International Decade for Action by United Nations Department of Economics and Social Affairs (UNDESA) has outlined the benefits and the necessity of IWRM in the best possible way for global understanding and to take action individually and collectively to reap the benefit and to save the world from catastrophic consequences.

IWRM IN BANGLADESH – A REVIEW

Major water resources development projects began in 1960s. The was involved as a groundwater consultant for National Water Resources Master Plan Project of Bangladesh financed by World Bank before leaving for London, England (University College London) in September 1985, to pursue higher studies in Groundwater Resources Management, where the author has completed a Postgraduate Diploma and a PhD. The large scale multidisciplinary project was carried out by the then Ministry of Agriculture and was supervised by HARZA Engineering Company International (a US Consulting Engineering Farm) appointed by the World Bank.

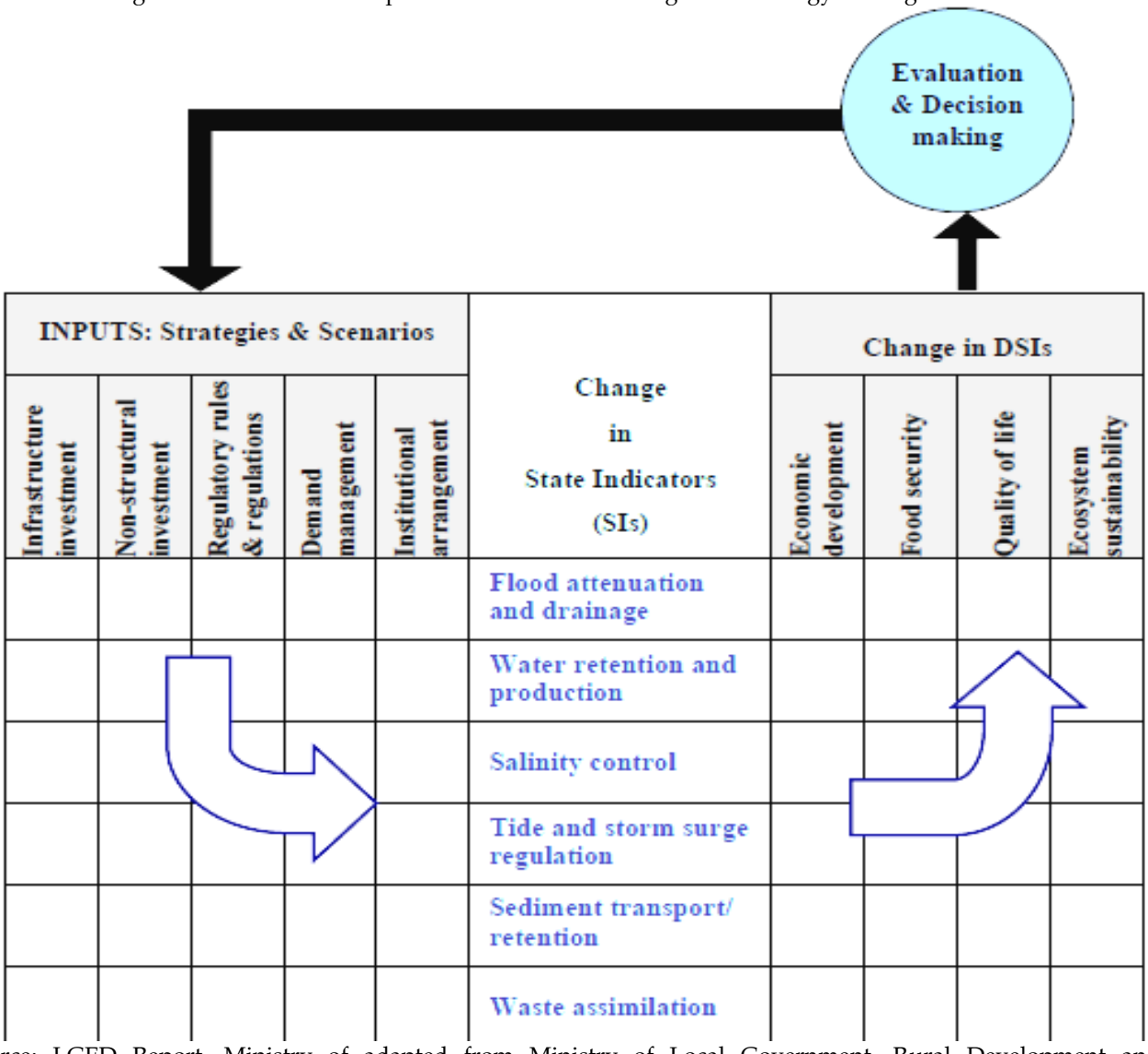
The IWRM Unit was established in the LGED (Local Government and Engineering Department) in March, 2003 under the Ministry of Local Government, Rural Development and Cooperatives. The IWRM Unit has outlined a Management Framework and analytical framework (Figure 12) for the planning of Integrated Water Resources Management. This project consists of different subsequent phases: inception, design, development and application.

Analytical Framework for the Planning of Integrated Water Resources Management" was initiated in 2001 and was produced by the work group of WARPO (Water Resources Planning Organization), CEGIS (Centre for Environmental and Geographic Information Services) and IWM (Institute of Water Modelling).

The design phase started in January 2003 that includes the review of the analytical framework design and implementation plan was done by Dr. Adri Verwey and the review for IWRM planning was done by Prof. Eelco Van Beek of Delft Hydraulics (Mission Reports, June 2003). GEGIS, together with IWM, described the specifications of water resources state indicators (Figure 12, 13 and 15).

The principal function of IWRM unit was to guide and supervise LGEDs water development activities, promote better coordination between inter-related agencies, maintain liaison with external agencies and donors and above all adhere to the principles of IWRM. Educate all stakeholders about the necessity and benefits of IWRM practices particularly the end users who have very little understanding about conservation of water resources and its finite nature. The main purpose is to minimize wastages and maximize utilization and eventually become the guardian angel to protect water resources.

Figure 12: Existing National IWRM Conceptual Framework for Management Strategy in Bangladesh



(Source: LGED Report, Ministry of adapted from Ministry of Local Government, Rural Development and Cooperatives, 2003)

WATER MANAGEMENT CHALLENGES IN BANGLADESH

Major part of Bangladesh is a Deltaic Plain created by the confluence of the mighty Ganges, Meghna and Brahmaputra rivers and is washed by the Bay of Bengal. More than 80 % of the country is amazingly flat land and is comprised of very fertile land ideal for agricultural food production. The entire country is criss-crossed by the tributaries and distributaries of the three major rivers: The Ganges, The Meghna and The Brahmaputra. It is also one of the most populous countries of the world with a population of about 160 million. Being a Deltaic plain its elevation is very low and nearly 60 % of the country is lower than 6m above sea level. The main problems in water management arise due to various reasons and the most notable reasons are: (a). The sources of all the major and minor rivers are either the Himalayas or India and to a lesser extent Myanmar as such the country have no control on the flows. This problem is compounded by the unilateral withdrawal of river water by India through construction of Barrages on most of the rivers drastically reducing the natural flow of rivers; (b). The reduction of flow have expedited the siltation problem on river beds reducing storing capacity thereby creating more frequent floods which has become a regular phenomenon and big flow to our national economy; (c). There is no potential for construction of reservoirs within the country; (d). Frequent flood events that occurs in Bangladesh regularly; and (d). The impact of Climate Change and greenhouse gas effect.

From the Management point of view main water management problems are : the lack of fund, inadequacy of technical expertise, dependency on foreign aid (e.g. UN bodies, EC Countries, The US and other countries and organizations), Inefficient management, lack of integrity and of course corruption.

Lot of small scale management scheme has been initiated by individuals but they fall way short of the practice of Integrated Water Resources Management. The Government has to take the lead and bring everyone on the table and devise a conceptual model that is suitable for Bangladesh to work out a profitable IWRM.

WAY FORWARD TO MAKE IWRM MEANINGFUL IN BANGLADESH

Although some works has been done to proceed in the right direction but lot of works needs to be done to make IWRM successful in Bangladesh. On top of that the principles of WSUD (Water Sensitive Urban Design) program must be added towards achieving IWRM. A number of important steps needs to be taken for successful IWRM such as: (1). Water resources accounting i.e. how much water (both surface water and groundwater) is available at this very moment and the usage including the projected demand; (2) System losses is a very big problem in Bangladesh therefore it is of utmost important that these losses are identified and appropriate measures are taken to rectify them; (3). Estimation of demand in all sectors; (4). Modernization of existing management practices with improved skills, technique and technology; (4). Step by Step eradication of corrupt practices; (5). Improved communication, coordination and cooperation between all major water dependent sectors and stakeholders; (6). Industry sector is growing significantly so is increasing water demand. The industry sector must start introducing closed pipe system of operation and recycle, reuse water in every opportunity to reduce water demand and which will eventually make their business profitable by reducing waste disposal and waste management; (7). Government must encourage and provide incentives where possible to introduce LEAN management technique in the service and manufacturing sector. This will help enormously to minimize losses to its minimum and will make the business demand driven rather than becoming stock pile driven; (8). It is very important that in Bangladesh strong Regulatory requirements are developed for all developmental activity and mechanisms are developed that everyone engaged in developmental activities are bound to follow regulatory requirements. Make every one accountable and introduce polluter pay principles.

CONCLUSION

Ii is absolutely vital that Bangladesh develops, maintain, practices and adheres to a modern IWRM management system linking all stakeholders at its earliest opportunity to avoid serious consequences. In the face of continuous decline of surface water due to artificial diversion of natural flow by the construction of barrages on most major rivers outside the country has changed the surface water landscape from a country of rivers with too much water turning to dead rivers with no water in many rivers. Climate change is an established fact and it has caused enormous damage to our global ecosystem. The global community has become united to take actions to protect our ecosystem. The IPCC has recognized that Bangladesh is one of the worst suffer of Climate Change and greenhouse gas effects;, it is therefore an obligation to the global community to assist Bangladesh in real terms to handle the impacts through technical and financial assistance sooner than later to achieve global benefits. On top of that Bangladesh is going through a period of economic boom which has sky rocketed the demand of water resources. This situation has put tremendous pressure on ground water resources as a result ground water mining is taking place in major urban areas. The agriculture which is the backbone of the country and all other developmental activities are now primarily dependent on ground water. This groundwater resource is a finite resource and can only

support up to a particular point. In one hand we need to keep going with our economic development boom on the other hand we have to save our precious finite groundwater resource. Under such circumstances the country has no other option but to implement IWRM in its full capacity to sustain economic development program. A nationwide water balance exercise needs to be done urgently linking all major water dependent sectors showing actual and potential demand and availability to assess existing state of resources and find ways how the current deficits and the growing demands can be met saving our most vital water resources and to make IWRM implementation more effective.

RECOMMENDATIONS

The author would like to put forward the following recommendations: 1. Get involved in meaningful dialogue with our neighbours and work out a permanent fair water sharing plan with the mediation of UN if required. UN being the proponent of GWP can bring meaningful result for all countries to bring win-win situation for all neighbouring countries dependent on common rivers. 2. Most major river has reached to its old stage due to siltation for thousands of years which has accelerated in recent years due to artificial diversion of natural river flow hence all these rivers requires urgent dredging to improve the flow of rivers and to increase the water holding capacity. If dredging is done it will augment the river water flow to meet the ever increasing water demand to keep going the development boom; 3. Identify and rectify all system losses through skills development, installation of modern technology and implementation of state-of-the art management system; 4. Existing corrupt practices is acting like cancer and it must be uprooted through proper education, incentives and by making everyone accountable in their specified role; 5. Government must come up with an effective incentive plan so that industries are encouraged to adopts closed IWRM system minimizing water losses; 6. Government must initiate nationwide campaign to educate all water users so that instead of wasting water resources they become the guardian angels to protect our finite water resources; 7. Nationwide campaign to initiate wastewater treatment plant, recycle and reuse them over and over again to keep our economic development program uninterrupted while protecting our precious water resources; 8. Introduce effective measures to stop groundwater mining and gradually reversing the trend by reducing groundwater usage and in selected location like Dhaka city introduce mechanism to recharge groundwater to stop declining groundwater level any further rather help rising groundwater level to keep ecological balance; 9. Introduce the concepts and principles of ecologically sustainable development in academic curriculum at school, college and university level so that everyone can understand how important the water resources if for our survival and for future generations; 10. Devise, implement, monitor and audit IWRM in every sphere of developmental activity. 11. Although a good system is in place but its implementation has not reached yet to its satisfactory level to achieve good result in IWRM. Following measure will speed up the process to achieve good IWRM outcome: modernization of water supply system in urban areas as well as rapidly expanding urban areas which were previously designated as rural areas is vital. The existing systems are worn-out and out-dated; WSUD will bring life in the urban areas and will make great contribution in saving precious water resources and achieving IWRM; 12. The monsoonal climatic condition is another barrier which is bringing too much rain in the Monsoonal season and no rain at all during winter season. To handle such situations the following measures are needed: Establishment of Rain Water Catching Systems all over the country in local regional and urban level as early as possible; 13. Construction of water reservoirs either inside the country or outside to store huge amount of excess water that most frequently creates floods in Bangladesh during monsoonal season and can be used in winter when there is a serious shortage of fresh water in the absence of rain; 14. Further improvement of technical knowledge, technological upgrade, and awareness rising of people of all walks of life will expedite the proper implementation of IWRM.

REFERENCES

Ahmed, Reaz (2011). Study sees excessive withdrawal of water as the reason; saline water will make inroads if trend continues. The Daily Star, 25 October, 3011.

Alam, S. M. M. (1991). Step – drawdown tests, Determining well performance and hydraulic parameters. Journal of Water Resources Development. Vol. 7, No. 4, pp 259-266.

Alam, S. M. M. (2011). Hydrogeochemical evolution of groundwater of part of Ganges-Meghna. Accepted 9 November 2010, published 22 June 2011, Published by the Journal of AQUA mundi, by Scribo, in Italy. Am03029: 071 - 082.

Alam, S. M. M. (2016). Understanding of Ground Water – Surface Water relationship through the analysis of ground water flow system of part of Bengal Delta. Accepted for publication by the "Ideal Journal of Environmental Science and Management" (IJESAM).

Delft hydraulics (2003). Architecture design of the Computational Framework for IWRM planning in Bangladesh: Peter Gijsbers (WL | Delft hydraulics), October 2003

eWater Source — Australia's national hydrological modelling platform - Integrated Water Resources Management (IWRM) combined with water policy and governance capability. (Source: http://ewater.org.au/products/ewater-source).

Flood Management in Bangladesh - CCAFS | CGIAR program - Climate Change, Agriculture and Food Security. (Source: http://www.slideshare.net/cgiarclimate/flood-management-in-bangladesh-pd-cdmpii-upd-28-nov13.

Global Population. (Source: https://www.google.com/search?q=global+population&ie=utf-8&oe=utf-8&client=firefox-b&client=firefox-b-ab#q=global+popul).

Global water partnership strategy 2004–2008. (Source: global water partnership strategy 2004–2008 - IRC-www.ircwash.org/sites/default/files/GWP-2003-Strategy.pdf.

GoB (1998). Bangladesh Water and Flood Management Strategy.

Gupta, Ankur. (2014). Integrated Urban Water Management (IWRM). Global Water Partnership. www.gwp.org. (Source: SustSan workshop: Integrated Urban Water Management by Ankur ...)

Hugh Turral et al (2009). Much Ado about the Murray: the Drama of Restraining Water Use. 1. 28 Newry Street, North Carlton, Melbourne, Australia; 2. The Australian National University.

IWRM Unit, LGED (2003). Analytical framework for the planning of Integrated Water Resources Management (Ministry of Water Resources and Local Government and Cooperatives.

Nyambod, Emmanuel M. and Huq, Nazmul (2010). Integrated Water Resources Management and Poverty Eradication –Policy Analysis of Bangladesh and Cameroon. (source: Journal of Water Resources and Protection. Vol. 2 No. 3, Article ID: 1489, 8 pages DOI:10.4236/jwarp.2010.23021).

SOS-arsenic.net. (2015). GROUND WATER (Source: http://sos-arsenic.net/english/groundwater/index.html).

The Dublin Statement (1992). on water and sustainable development. www.wmo.int/pages/prog/hwrp/.../icwedece.html. world meteorological organization.

UNDESA (2005-2015). International Decade for Action " Water For Life (integrated Water Resources Management).

UNEP (2008). Status Report on Integrated Water Resources Management and Water Efficiency Plans. Prepared for the 16th session of the Commission on Sustainable Development. (www.unwater.org/downloads/UNW_Status_Report_IWRM.pdf).

World Population Clock: 7.5 Billion People (2016) - Worldometers www.worldometers.info/world-population/.

Zahid, Anwar and Ahmed, Syed R U. (2004). Groundwater Resources Development in Bangladesh: Contribution to Irrigation for Food Security and Constraints to Sustainability. Ground Water Hydrology Division, Bangladesh Water Development Board, Dhaka, Bangladesh.

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