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Groundwater situations and IWRM to overcome climate change induced challenges in a drought prone area of Bangladesh

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Abstract: Bangladesh is extremely vulnerable to climate change because of its geographical location and climatic variation. People in Bangladesh are suffering from several natural hazards due to adverse impact of climate change. The north-western region of Bangladesh is a severe drought prone area and it is happening in almost every year. This country experienced major droughts in 1973, 1978-79, 1981-82, 1989, 1992 and 1994-95. Change of people's livelihood is the consequence of recurrence drought around this area which has a direct impact on national food security and economic status. This paper aims to study the importance of implementing Integrated Water Resources management (IWRM) approach for sustainable development around the area and the way to include this issue in the under construction national IWRM plan by the government. Globally IWRM is accepted for the management of water resources to ensure sustainable development. Bangladesh government is developing national IWRM plan to address water related issues including drought. Though drought has sometimes equalled or more devastation capacity than any other natural hazards in Bangladesh but it is still a neglected issue in the policy making from the government. In context of IWRM strategies there still need to meet some specific requirements to include drought issue in the national IWRM plan. Without any action plan like other natural hazards and relevant governmental institutions including this issue to national IWRM plan is still debatable. A successful implementation of IWRM framework has several steps and Bangladesh should follow these.

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1. Introduction

Global water resources provide different products including food crops, livestock, fish, and timber products. They are also sourcing various ecological services ranging from purification of air and water to conservation of biological diversity, and decomposition of organic matter to recycling of nutrients (WRI, 2000). The world's freshwater resources are confined and due to rapid population growth, increased economic activity and increasing pollution related to this economic growth the finite resource is under pressure. Along with the development of economic activity over the last few decades the rate of greenhouse gas emissions also increased dramatically which is also responsible for multifaceted climate change including global warming and drought. Recently stress to freshwater not only comes through discharging pollutant directly to the water bodies but also due to climate change. Water scarcity including aridity, desertification, drought and water shortage is becoming an alarming situation for many developing as well as developed countries (Rosegrant et al., 2009). The drought occurrences have been generally closely related to a lack of precipitation combined with high temperatures, which are major consequences of climate change.

Agriculture plays a key role in economic development of country. For achieving the Millennium Development Goals (MDGs) with eradicating hunger and poverty, growth in the agricultural sector is essential. Usually 1300m3 capita-1 year-1 freshwater is required to produce an adequate diet which is the highest amount than any other economic sector (Rockström, 2010). Global water consumption is expected to increase up to 21% by 2050. Crop production from irrigated agriculture is predicted to rise by 53% during 2000-2050. (Rosegrant et al., 2009). Additionally, more than a billion of poor people in the rural areas do not have the access to affordable irrigation, sanitation, households or drinking purposes. However to improve the livelihood of the poor people for achieving long-term economic growth in a developing country water resources management is an important issue. Making available water sources in regions, with unreliable or insufficient rainfall, can

make a huge difference to peoples' lives, as the majority of rural poor depends on agriculture (Merrey et al., 2005). Environment is another issue needs to be considered in the time of water resources management. Water management policies and plans development time environment is least considered and more often neglected when it comes to implementation (Leendertse et al, 2008). So, for sustainable development, i.e., developments in social, economic and environmental it needs to select such kind of management policy for water resources that encompasses all the dimensions.

For ensuring sustainable water use, Integrated Water Resources Management (IWRM) has been accepted globally as a framework to water resources management. However, the framework is very difficult to establish but China has already begun to adopt IWRM concepts for achieving sustainability in China and the rest of the world (Liu and Yang, 2012). Namibia has included IWRM in school curricula with an ambition to make its future citizens who will embrace, defend and implement IWRM (van der Zaag, 2005). Balancing the competing demands for water and facilitating collaboration between political entities and agencies this framework can provide the best solution (Carrera-Hernandez, 2008). Isolation of water resources management from other resources is the reason for continuous degradation of water resources and increasing water scarcity. Use of water resources through efficient and environmentally sound approach can ensure the sustainable use of water. Only IWRM can fulfil the criteria which has main focus on satisfy the water demands as well as to safeguard freshwater. The main concern of integrated water resources management is to fulfil the water demand and supply. The achievement of sustainable IWRM approach depends on the proper dealing of water supply, waste treatment, sanitation, irrigation schemes, drainage and watershed conservation. To get benefits from IWRM regular interaction, uses and interest of independent groups are necessary (Ako et al, 2010).

Bangladesh is extremely vulnerable to climate change. One of the main reasons of its vulnerability is its geographical location. Moreover higher population density with a major component of population below or close to the poverty level makes it more vulnerable. Livelihoods of most of the people are related to climate sensitive sector, particularly rural agriculture and fisheries and that makes it more vulnerable to climate change (Climate Change Cell, 2006). Due to climate change the temperature is increasing and the rainfall patterns is also changing. Because of this climatic change Bangladesh is facing severe drought in its many regions. Repeated drought is causing considerable damage and loss to agriculture sector. Damage in agricultural sector has direct impact to many other sectors as they are closely related. The Northwest region of Bangladesh is suffering from drought almost every year. Maximum land of this area is based on rainfed agriculture. Shifting the distribution pattern of rainfall has adverse impacts on agricultural production. Limited sources of water are hindering the agricultural practices around the area. People in this area are changing their livelihood from agriculture to other type of works those are not related to water. Sometimes people in this area remain unemployed because of the lack of water thus affect the economic status of their life. Moreover, due to lack of water, farmers are changing their paddy field to other type drought tolerant tree gardening particularly Jujube and Mango gardening. This can result the shortage of rice production and might cause food crisis in this country (Rouf et al, 2010).

This paper aims to evaluate the significance of IWRM approach to ensure sustainable development around the drought prone area of Bangladesh and the way to make it possible.

1.1 Integrated Water Resources Management (IWRM)

The central concept of IWRM started from the 1992 International Conference on Water and the Environment, in Dublin. Later it has been promoted at international environmental and freshwater conferences in Rio de Janeiro (1992), The Hague (2000), Bonn (2001), Johannesburg (2002), Kyoto (2003), and Mexico (2006). This discourse relied on engineering and sectorial solutions instead of the traditional approaches to water resources management (Dombrowsky, 2008). In general, there are different understandings of what is meant by IWRM but an inclusive definition was given by Global Water Partnership (GWP):

"IWRM is a process to promote 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" (GWP, 2000).

In order to better understand it is helpful to analyse the key issues that define IWRM of Dublin Principles instead of relying only on the definition given by GWP. Dublin Principles incorporates both conventional and non-conventional opportunities for integrating water supply and demand including water

conservation and demand management dealings (Turton et al., 2007). Four principles, known as the Dublin Principles, which emerged from the conference, have now become the foundation of the debate on international approaches to water policies (UNESCO 2003). These are:

- Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment.
- Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels.
- Women play a central part in the provision, management and safeguarding of water.
- Water has an economic value in all its competing uses and should be recognized as an economic good.

According to the first principle there should be an institutional framework to integrate water with other natural resources and ecosystem to address the worlds freshwater that are both finite and vulnerable. This would be able to synchronize human economic, social and political systems those are responsible to create water demands, determine land use and generate water-borne waste. Integrating the management of natural and human system is beneficial but the real challenge is to implement this practice (GWP, 2000). The second principle gives emphasis to engage all stakeholders in the decision making process because lives and livelihoods of everyone are affected by water. Government should take initiative to construct a mechanism at national, river basin and community levels to ensure active participation of all stakeholders (GWP, 2000).

The third principle indicates the importance of involving women in decision making process. Women are responsible for domestic water use and in some cases agricultural water use also. They can play an important role in collecting and safeguarding water. So, it is essential to investigate a suitable mechanism that can involve women in decision making process related to IWRM (GWP, 2000).

The fourth principle refers to the value of water as an economic good. To control people's behaviour for water conservation there should apply a charge to the users (GWP, 2000).

1.2 Drought Events in Bangladesh

Drought has become a recurrent natural phenomenon of north-western Bangladesh (i.e., Barind Tract) in recent decades. Barind Tract covers most parts of the greater Dinajpur, Rangpur, Pabna, Rajshahi, Bogra, Joypurhat and Naogaon districts of Rajshahi division (Banglapedia, 2006).

The drought prone area of Bangladesh is suffering from devastating and recurrent droughts almost every year. Substantial damage, loss of agricultural production and related sectors are caused by the recurrent drought. Sometimes drought impacts are much larger than the any other natural hazards in Bangladesh. Bangladesh experienced major droughts in 1973, 1978-79, 1981-82, 1989, 1992 and 1994-95 (Selvaraju et al, 2006). Bangladesh faced a great flood in the year of 1974 which caused considerable damage in the food grain production. On the contrary this country also experienced a severe drought in 1978-79 that caused roughly 50 to 100 percent more losses in the food grain production. This comparison proves that drought can be same or in some cases more devastating than a major flood or cyclone (Paul, 1998).

Farmers in the north-western districts of Bangladesh usually suffer from drought every year. Reduced crop production is a result of drought that cause other socio-economic crisis like unemployment problem and limited sources of income. Increased food price is also the result of drought around this area. 3.5 million tones shortfall of rice and wheat production was the cause of major droughts of 1994-95 in the north-western districts of Bangladesh (Selvaraju et al, 2006).

Thus the drought impact was severe in the past and there is a possibility to be it more intense because of climate change. According to Selvaraju et al (2006), future climate variability and change means additional threat to drought-prone environments. To address this issue people in this area needs advance technology and new management approach to ensure sustainable livelihood.

2. Methods and Materials

2.1 Geographical Description of Study Area

The considered area needs to take initiative for water resources management situated in the north-western region of the country and this area is the most vulnerable to drought. The two upazila (sub-district) of Naogaon district Shapahar and Porsha have been selected as study area. The selected areas are mainly covering Barind Tract, Punarbhava floodplain and Ganges river floodplain area (CEGIS and FAO, 2006)

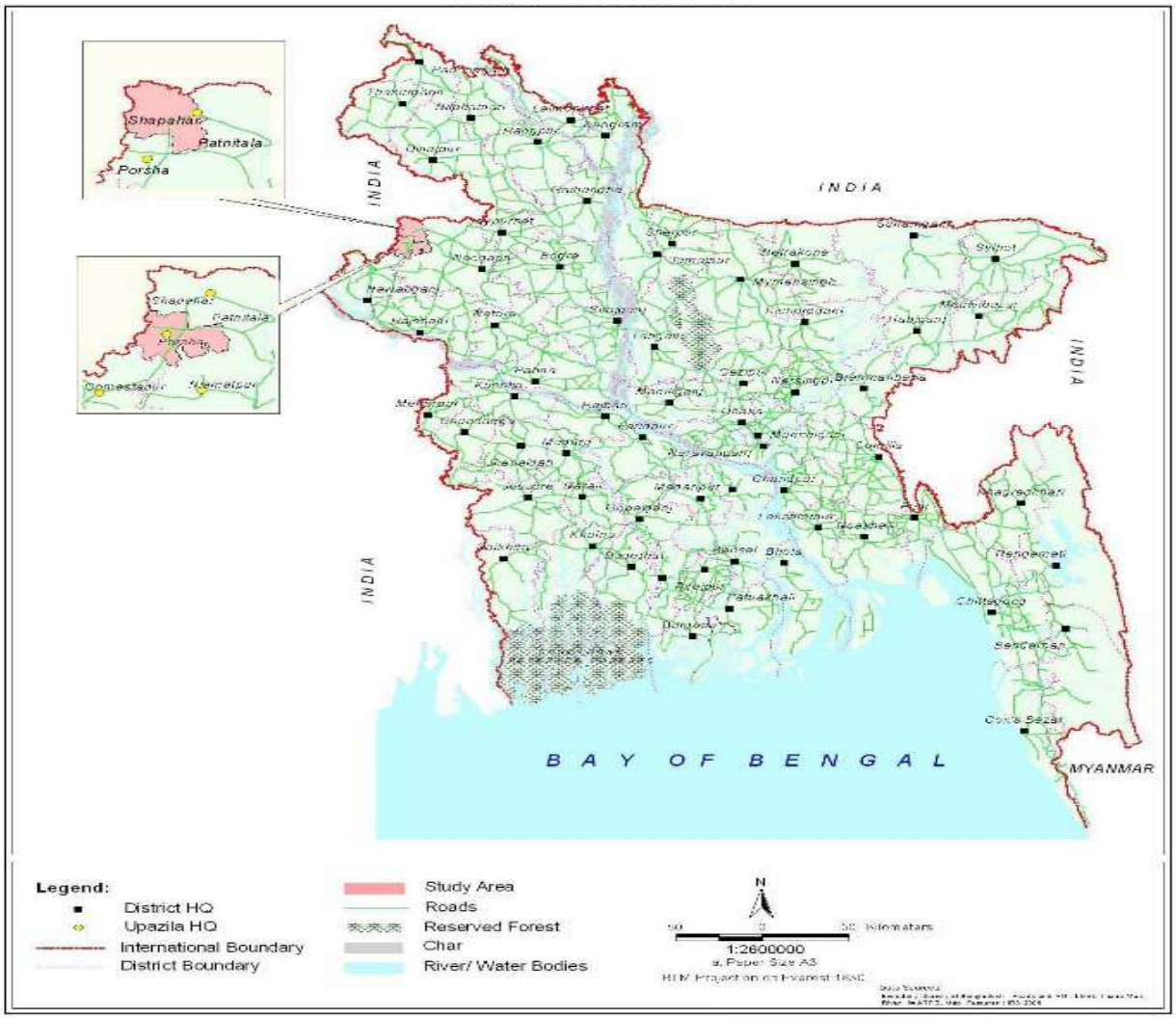

Figure 1. Location of the Study Area

During the dry season of the year the amount of rainfall around this area is only 400-500 mm and the surplus in the monsoon season. In the monsoon period almost 80% rainfall occurs and the amount ranges between 1400-1500 mm. The mean annual temperature is around 250^{o}C and varies from 16-35 ^{o}C.

Sunshine hour ranges 6.7-7 h and the mean annual humidity is around 72% in the study area (CEGIS and FAO, 2006). There is an increasing trend of temperature and rainfall during the recent decades in this area (Rouf et al., 2010; CEGIS and FAO, 2006).

2.2 Data Collection & Analysis

In order to develop the correlation between rainfall and groundwater level of the study area; both data were collected from Bangladesh Water Development Board (BWDB) from 1971 to 2008. Trend of groundwater level for both upazillas was analysed by normal time series plot. Data were collected from BWDB. Groundwater level at Porsha upazilla (Well ID GT6479043, 24°99" North 88°6" East) was plotted on the time series graph and added a smooth line to determine the trend of groundwater level. In the same way groundwater level at Shapahar upazilla (Well ID GT6486051, 25°1" North 88°57" East) was observed.

3. Results and Discussion

3.1 Existing Water Sources

The Barind tract in Northwest region of Bangladesh is characteristically dry (Semi-arid region). Elevated land feature covered with a thick clay layer although up to a depth of 30m in some places and underlying a sand layer, which serves as the aquifer (CEGIS, 2006; FAO, 2006 and Islam, 1997).

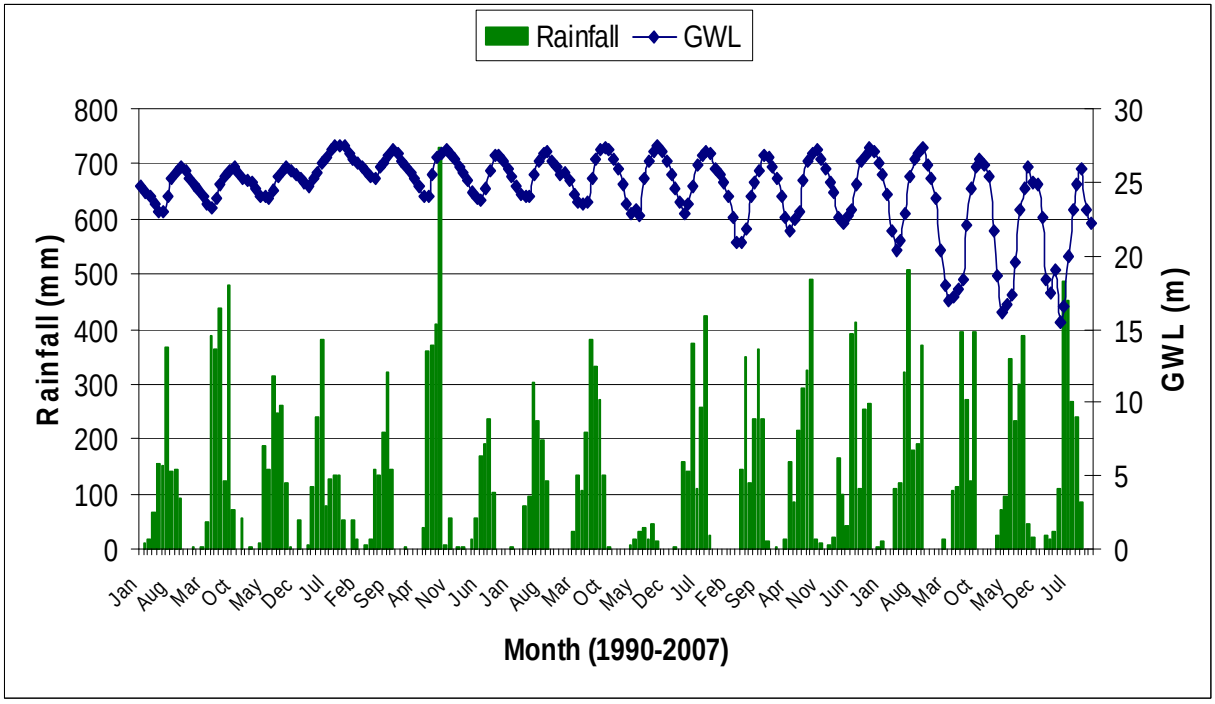

Figure 2. Relation between Precipitation and Groundwater Level (Shapahar).

Natural recharge in this region is quite uncertain because of the thick clay layer and the aquifer may be treated as the confined one (Islam 1997). From 1985 to onwards the irrigation coverage is increased at large scale and this cause the rapid and remarkable depletion of groundwater table around this area. The surface water flow shows a decreasing trend of the Mohananda and the Punarbhava rivers during the dry season (CEGIS and FAO, 2006). Though the country has huge and renewable groundwater sources but river flows represents the only reliable sources to mitigate drought problem in this region. According to National Water Management Plan (NWMP) using Deep Tube Well (DTW) with full development is only possible option for irrigation (WARPO, 2001). So, this area is severely drought prone for high temperature, low rainfall intensity at cropping time. Development of this area is closely related with the intensive use of vast land, which is now underutilization. Proper utilization of this land is possible only under ensured irrigation.

3.2 Groundwater Level

The correlation diagram between precipitation and groundwater level (figure 2) shows that after every monsoon period groundwater level in the study area uplifted and during the dry season it approached to the downward. From the time series analysis it was observed that the rainfall had an increasing trend thus the groundwater level increased over the period.

3.3 Groundwater Level at Porsha

From the time series plot (Figure 3) of groundwater level of Porsha upazilla of a selected well; it can be said that the water level is almost same over the period. There was no increasing or decreasing trend. Smooth line in this diagram indicate that there was a decreasing trend of groundwater level in the earlier years but it was increased after some years. Now, it is same as the starting time. Though the groundwater level at Porsha remained constant, the difference between water level of dry season and wet season was remarkable.

3.4 Groundwater Level at Shapahar

From the time series plot (Figure 4) of groundwater level of Shapahar upazilla of a selected well it can be said that the water level was increasing over the period. Smooth line in this diagram indicates that there was an increasing trend of groundwater level with the advancement of time. The difference between water level of dry season and wet season was diminutive.

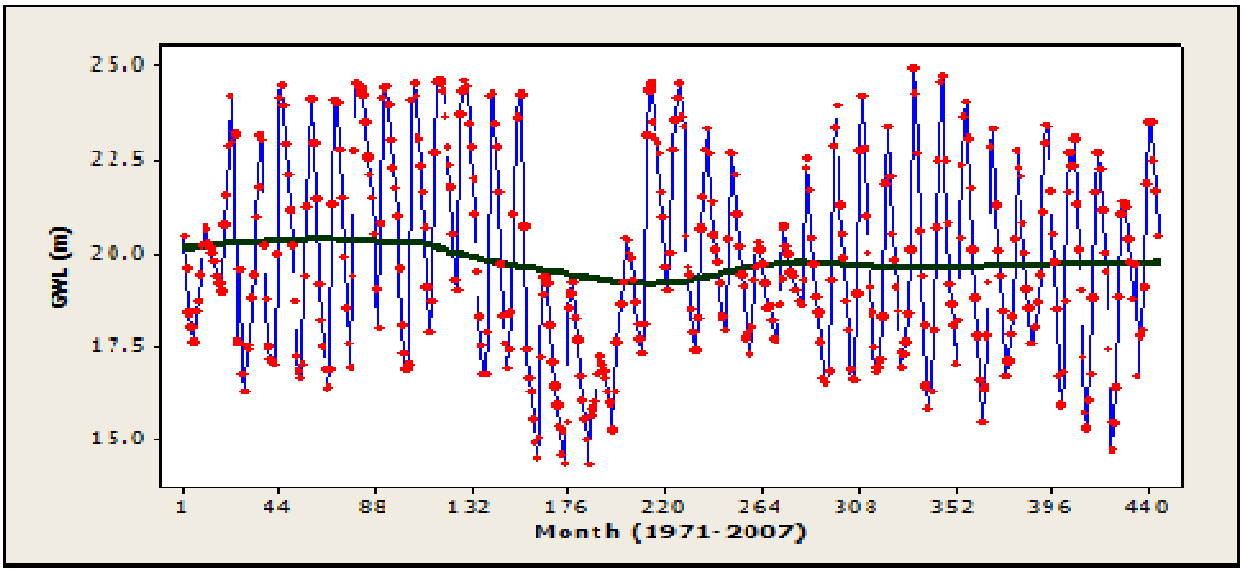

Figure 3. Time Series Plot of Groundwater Level of Porsha Upazilla.

3.5 Importance of IWRM in Context of Present Situation

It is said earlier that IWRM is globally accepted as a framework of water resources management for sustainable development. Agricultural development in the drought prone area can only ensure the development of socioeconomic status of the people around this area. According to Selvaraju et al (2006) this region's economy mostly depends on food production. After introduction of *Boro* (local name of rice cultivation) cultivation this region experienced double food cultivation from last two decades but excessive groundwater extraction also causes the reduction of groundwater level in the Barind Tract. The available surface water for irrigation purpose in the Barind Tract is very low in comparison with the demand. In many cases poor and marginal farmers cannot use the existing surface water for the agriculture purpose because of the commercial use of these water bodies (BSS, 2011). Rainwater is the principal source for agricultural purpose as well as of groundwater replenishment in the Barind Tract. This situation leads the agricultural practices of this area to deal with climatic factors. According to Selvaraju et al (2006), there are 300 fish species in this region and almost 25 percent families are engaged with seasonal fishing as their livelihood. This situation is becoming vulnerable with increasing drought condition and it will be more along with future climate variability.

Due to lack of adequate water, the people's livelihoods are changing and according to CARE (2005), there have been dramatic shifts in rural livelihood strategies in recent years. Salient changes include the transition away from agriculture into off-farm activities. Unavailability of water is also causing unemployment problem in this area. People are migrating seasonally or permanently to other places in the drought time to collect food (Rouf et al, 2010 and Selvaraju et al, 2006).

From the above discussion it can be said that water is the main factor to develop the socio-economic condition of the people living around this area. As government doesn't give any special emphasis to improve the drought condition (Rouf et al, 2010) thus IWRM approach can be an important mechanism for sustainable development in this region.

3.6 IWRM in Developing Countries

Though there are different opinions about the best way to manage water resources but IWRM have been widely accepted and adopted to achieve sustainable solution. Successful implementation of IWRM not only helps to achieve human health, economic and environmental benefits but also the millennium development goals (MDGs) in developing countries (Funke et al, 2007). However, IWRM has promising prospective but it is difficult to implement effectively. In some cases the success of this implementation is very limited (Turton et al., 2007; Biswas, 2004). To describe the applicability of IWRM in developing countries Turton et al. (2007) says that to realize the maximum output of IWRM a country should have at least more than 25 years aged of democratic systems of government. Therefore it can be said that Bangladesh can get maximum output from IWRM approach because it has more than 25 years aged democratic government.

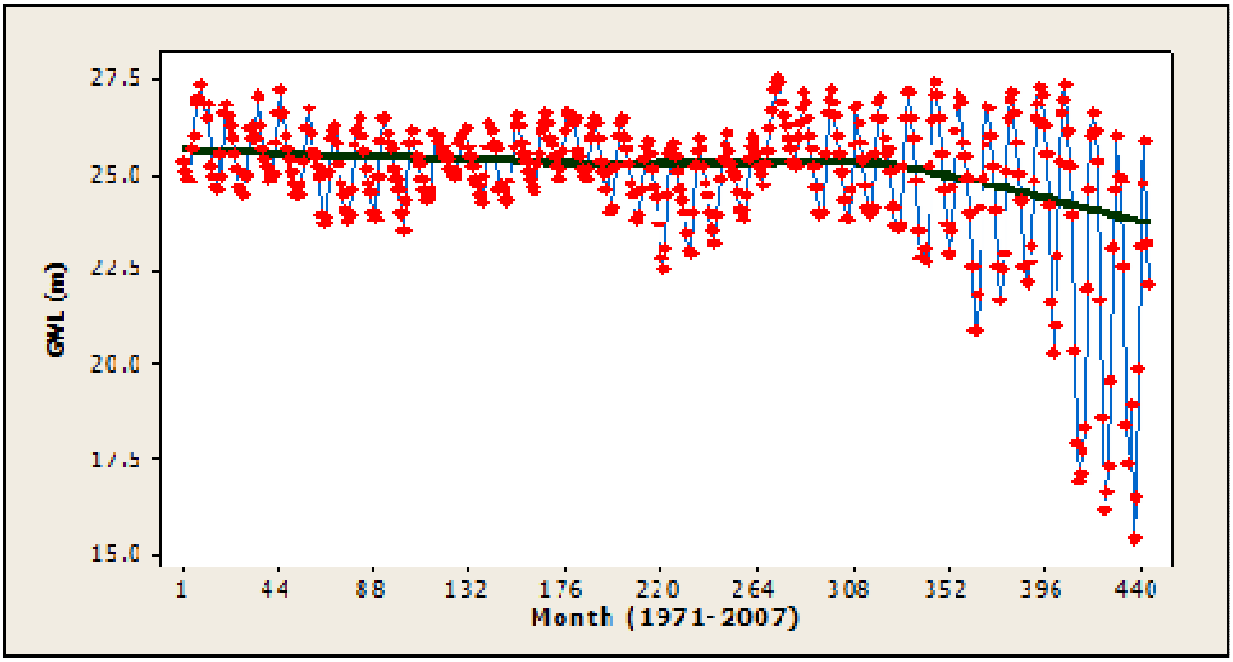

Figure 4. Time Series Plot of Groundwater Level of Shapahar Upazilla.

3.7 IWRM Strategies and Vision of Bangladesh

Bangladesh does not have any national IWRM plan. Water Resources Planning Organisation (WARPO) already developed a regional technical assistance supporting IWRM with the help from Asian Development Bank (ADB). This section will visualize the three pillars of IWRM and the efforts of Bangladesh to make an IWRM plan for addressing the issue of water resources management particularly in drought prone areas of Bangladesh.

Pillar 1: Enabling Environment (good governance)- Governance is defined by Turton et al. (2007) as a process to make a decision which have officials responsibility to overcome the conflict between different users; to make sure the impartiality and sustainability. IWRM is the product of good governance and good governance also enable to form an institutional framework which gives support to IWRM (Funke et al, 2007). Giving importance to good governance The Global Water Partnership places it as one of three pillars of IWRM. Good governance is responsible to create policies and legislation (enabling environment) that make a path to involve stakeholders to play their respective roles in the development and management of water resources. As there is no universal blueprint for IWRM and the achievement of IWRM is totally depends on the characteristics of certain countries thus good governance is essential to realize the maximum output of this approach (GWP, 2000).

Successful implementation of IWRM depends on the appropriate institutional and legal framework and that could come from good governance. Unfortunately, a developing country does not have adequate economic, technical and human resources to make it possible (Funke et al, 2007). According to National Water Management Plan, Government of Bangladesh is trying to create a favourable climate to attract private sector in the water management issues and that is not implementing due to lack of good governance (WARPO, 2001). However, announcement of National Water Policy was the bold step towards the good governance (MoWR, 1999). For strategic and sustainable approach to water resources management Bangladesh has prepared a Technical Assistance (TA) for effective and efficient IWRM plans. To develop an institutional framework Bangladesh Water Act (draft) and Water Resources Planning Act (reviewed) serving as the enabling environment (ADB and WARPO, 2009). Another important issue that there is no policy framework regarding drought problem in the TA report which can assist to develop IWRM to water resource management in the drought prone area. In the case of legislative framework there also do not have any act that can promote the drought issue in national IWRM plan. Under the BWDB Act (2000) it is said that Bangladesh Water Development Board (BWDB) will perform structural functions for drought prevention along with other water issues (ADB and WARPO, 2009).

Pillar 2: Institutional Framework- There is no blueprint for IWRM and it can vary for different cases. For this reason the roles and functions of organization at different levels are very important. Imperfect demarcation of responsibilities among different institutions and organizations causes the difficulty for successful implementation of IWRM. Moreover institutional development not only refers to create a formal constitution but also involvement and consideration of all intuitions at the time of policy development for water resources management (GWP, 2000).

There are too many government organizations are working in the water sector. According to the process development for preparing and implementing integrated water resources management plans of Bangladesh there are 35 central government organizations affiliated with 13 different ministries relevant to the water sector (ADB and WARPO, 2009). However, there is not any particular government organization working on drought. Barind Multipurpose Development Authority (BMDA) is working on the investigation for possible groundwater sources in the drought prone area and it was considered to involve in the institutional framework for IWRM plan in Bangladesh. Having too many water related government organizations, Bangladesh still has one big problem and that is its most centralized arrangements of public sector in the world. In the IWRM roadmap there is a list of government organizations from national to local level but the most decisions are taking from headquarters because significant percent of the employees are posted in there (ADB and WARPO, 2009).

Pillar 3: Management Instrument Related- The management instruments for IWRM are referred as the "tool box" that can enable and help to take alternative action to decision makers. Based on the problem in question, different quantitative and qualitative methods combined with several disciplines such as economics, hydrology, environmental sciences, sociology and many others can be used for water resources management (GWP, 2000).

Unavailable information about the water resources is not suitable for management purposes (GWP). Though there are large quantities of data in Bangladesh but most of them are scattered proves the lack of adequate technologies (ADB and WARPO, 2009). Bangladesh still does not have any particular database on drought like other natural hazards. In National Water Resources Database (NWRD) there are drought maps and data on water sources and availability in the north western (drought prone) area of Bangladesh. To develop national IWRM plan there still need some assessment of water demand of specific sectors such as drought (ADB and WARPO, 2009).

4. Conclusion

IWRM has been recognized as one of the best tools to explore adaptation measures to climate change. A successful integrated water resource management strategy considers all the functional entities regarding water resources in a particular approach. In order to formulate sustainable IWRM strategies to overcome climate change induced drought; Bangladesh has to contemplate current and future climate change scenarios in its IWRM framework. Lack of climate change information and the assessment capacity will hinder its plan to establish IWRM framework for drought management effectively.

A successful implementation of IWRM framework has several steps (Jønch-Clausen, 2005) and Bangladesh should follow these. First of all the country have to establish its status and have to define its overall goals. Secondly, the country's political will commit to reform the existing management process to engage boarder population with knowledge sharing for establishing the new framework. After then the country will analyse the gaps in implementing the IWRM framework in its existing policy, institution and capabilities. After analysing the gaps the country will prepare strategy and action to map the road towards completion of the framework for water resources management. In the next step the duty is to build commitment to actions. The new action plan have to be adopted by highest political and stakeholders for implementation. The next challenging stage is the implementation of framework. Implementation of the framework poses the enabling environment, the institutional roles and the management instruments. The final step is the monitoring of progress and evaluation of the process inputs and outcomes to improve and successful implementation of the framework.

Drought is a prominent natural hazard in the north-western region of Bangladesh occurring almost every year. Because of severe drought this country is facing severe economic loss and the socio-economic status and living standard of the local inhabitants is decreasing. Instead of having almost same devastation capacity this issue yet overlooked by the government. In the context of IWRM strategies Bangladesh yet need to fulfil some specific criteria

for establishing the national IWRM plan for water resources management in the drought prone areas. Without any action plan like other natural hazards and any relevant governmental institution the achievement of drought management is still questionable.

Competing Interests

The authors declared that they have no conflict of interest about the contents of this article

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