FUTURE PROJECTION OF GROUNDWATER LEVEL AND IRRIGATION COST IN NORTHWEST BANGLADESH

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1. INTRODUCTION

The impact of climate change is one of the principal issues in the world today, which has caused concern at all levels of government and research groups (Wang et al. 2014). Water plays a major role in economic development and food security in the world. However, ever-increasing water demand in recent decades, due to population increasing, economic development, climate change, has caused water scarcity and has restricted economic development in many countries across the world (Wang et al 2013). It is anticipated that global warming induced by climate change will aggravate the situation and more people will face water and food shortage. Groundwater is the principal source of water supply in many countries, especially irrigated agriculture based countries. About 38% of irrigated lands in the world are equipped for irrigation with groundwater. (Siebert, et al., 2010). Contribution of groundwater to irrigation is more in densely populated Asian countries, which is also increasing with time. For example, the contribution of groundwater to total irrigation has increased from 4% in 1971 to 85% at present in Bangladesh (Shahid and Hazarika, 2010).

2. CLIMATE CHANGE IMPACT ON GROUNDWATER LEVEL

Climate change impact on groundwater is still not very clear in tropical region (Alley, 2001). However, there is consensus on quantitative and qualitative changes of groundwater due to climate change (Crosbie et al., 2010; Liu, 2011). Rising temperature and changing precipitation pattern can affect the groundwater resources in a number ways. A number of researchers in different parts of the world showed that changing climate will affect groundwater recharge rates (Faye et al., 2009). Groundwater resources will be less recharged from rivers and may in fact loose. Climate change will also affect the soil moisture level and may cause an impact on groundwater level. Groundwater plays a pivotal role for agriculture and food security in Bangladesh. Therefore, it is very urgent to understand the impacts of climate change on groundwater recharge in Bangladesh. Several studies have published that climate change impacts on groundwater in different parts of the world in the recent years (Brouyere et al., 2004).

3. STUDY AREA

The study area, located in northwest Bangladesh is a part of the Ganges River basin (Figure 1). Topography of the area varies from 11 to 23 m above sea level. The upper aquifers are unconfined or semi-confined in nature. The maximum depth to groundwater table from land surface varies from 7 to 30 m. Climate in the region is controlled southwest monsoon which lasts from June to September. On the other hand, November to March is dry season. Average rainfall vary between 1400 to 1650 mm, among which almost 83% rainfall occur in rainy season. Average temperature varies in the range of 25ºC to 35ºC in dry season and 9ºC to 15ºC in wet monsoon.

4. METHODOLOGY AND DATA

Base on field survey data by BRAC research Centre, Bangladesh and secondary data of daily temperature and rainfall, and bi-monthly groundwater data collected from various sources, the present study explores the impacts of climate change on groundwater level and consequent change in irrigation cost under current agricultural practice. A support vector machine (SVM) model was developed to simulated groundwater level from rainfall, evapotranspiration, groundwater abstraction, and irrigation return flow data. Irrigation return flow from paddy field was estimated from soil properties. The Penman-Monteith method was applied to calculate crop evapotranspiration (ET_c) and using to estimate rice water demand. We compared the difference between historical and projected groundwater level using a set of eight global circulation models (GCMs) selected from Coupled Model Intercomparison Project phase 5 namely, BCCCSM1-1,CanESM2, MIROC5, MIROC-ESM, MIROC-ESM,NorESM1-M, MPI-ESM-LR, and MPI-ESM-MR.

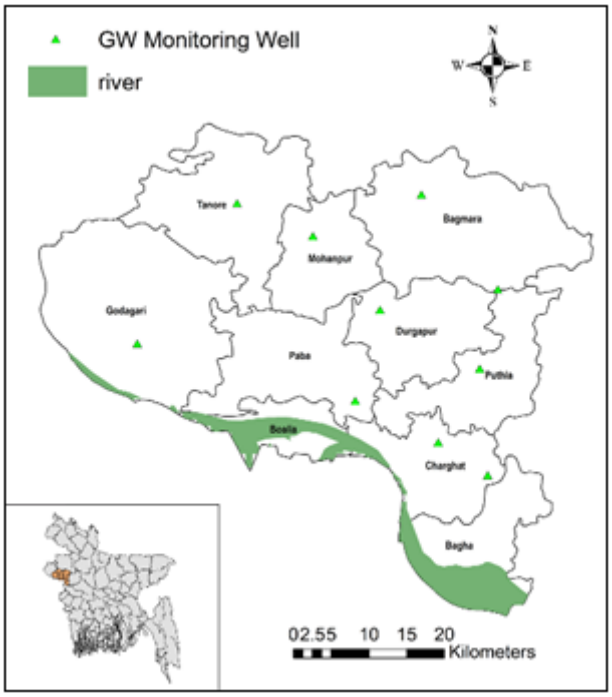

Fig.1 Location of study area and groundwater sampling points

Downscaled global circulation model outputs under representative concentration Pathways (RCP) 2.5 (soft

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scenario) scenario were used in a SVM model to assess the possible changes in groundwater level due to climate change. A multiple-linear regression (MLR) based model was developed to relate irrigation cost with groundwater level.

5. RESULTS AND DISCUSSION

The SVM and MLR models were calibrated and validated with historical data and then used for simulation of groundwater level and irrigation cost under climate change scenario. The downscaled GCMs estimated that both the maximum and minimum temperatures in the study area will increase in the range of 0.8º to 4.2°C with a mean of approximately 2.2ºC in the end of this century during irrigation period. However, there will be no significant change in rainfall in the area. The projection of groundwater level under climate change scenario during different epochs of the present century was compared with that of base years. The obtained results are presented in Figure 2.

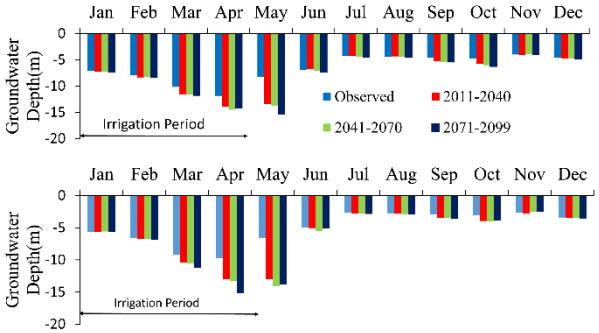

Fig.2 Changes in groundwater level during irrigation period (Jan to April) estimated using ensemble of GCMs under RCP2.5 scenarios.

Results reveal that groundwater level in the study area will decline by 0.52 to 1.79 meters from the present level during irrigation period (January to April). Average of groundwater level drop at different groundwater monitoring station simulated using eight GCMs outputs under RCP2.5 scenario was estimated as 1.09 m. The results indicate that groundwater level in the region will decline in the season when groundwater is required for irrigation. Lack of sufficient rainfall, temperature increasing, and heavy groundwater extraction for the irrigation causes the groundwater scarcity in many part of the study area which normally last until beginning of monsoon. The study indicates that groundwater level drop due to climate change will make the groundwater less accessible for irrigation. Woldeamlak et al.,(2007) modeled the effect of climate change on the groundwater systems in the Grote-Nete catchment, Belgium and reported that average groundwater levels drop by 50 cm.
The average value of groundwater level drop during irrigation period was used in MLR model to estimate the impact of climate change induced groundwater level drop on irrigation cost (Figure 3). The results show that a decrease of groundwater level by 1.09 meter will cause an increase in irrigation cost by 0.295×10^3 BDT/ha.

6. CONCLUSIONS

A study has been carried out to assess the impact of climate change on groundwater level and consequent changes in irrigation cost in northwest Bangladesh. Climate change will affect groundwater level by different direct and indirect pathways. In the present study, only the direct impacts of rising temperature and changing precipitation pattern on groundwater level has been assessed. It is expected that the study in general will help various authorities, especially in terms of those intervention aimed at water supply augmentation in Bangladesh.

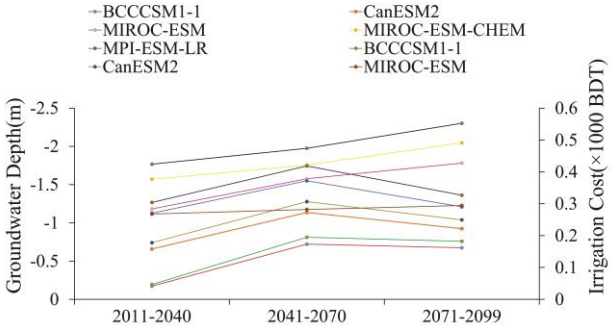

Fig.3 Changing in irrigation cost due to climate change impacts on groundwater level

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