Sustainability in groundwater based irrigation in Northwest Bangladesh

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1. INTRODUCTION

Groundwater is the major sources of irrigation in many countries across the world. About 38% of irrigated land in the world are equipped for groundwater base irrigation (Sibert et al.,2010). In some countries, particularly those are located in the arid region, irrigated farming is mostly based on groundwater (Zektser and lorne,2004). About 67% of the total irrigation land in Algeria is irrigated by groundwater,58% in Iran and 45% in the USA (Salih 2006, Zektser and Everett 2000). Groundwater use in irrigation and food production is still increasing both in absolute terms and in the percentage of total irrigation, especially in densely populated countries. In the Indian subcontinent, more than 85% of the withdraw groundwater is used for irrigation season (Mukherjee et al., 2014). Groundwater-based irrigated agricultural has grown more than 500% in India over the past three decades (Shah 2008). The total number of mechanized wells has increased from barely a few thousand to million in last few decades in Pakistan (Shah et al., 2003). The contribution of groundwater to irrigation has increased from 4% in 1971 to 85 % at present in Bangladesh (Shahid et al., 2014).It has been projected that by 2050 the world's population will reach more than 9.6 billion (United Nations 2013). Food production will have to increase by 70% to feed the growing population. These will cause a vast expansion of irrigated agriculture globally (FAO 2009). Despite huge significance, groundwater resources are heading for a crisis in many countries and need urgent understanding and attention. The rapid expansion of the groundwater based irrigated agricultural and inappropriate irrigation practices have caused lowering of the groundwater table, decrease in well yield, increase of pumping cost and consequently, increase of crop production cost. The present study to assess the impacts of mitigation measures to achieve sustainability in groundwater based irrigation.

2. STUDY AREA

The Study area located in northwest Bangladesh is a flat and low-lying topography with high population density. The study area (**Fig. 1**) extends from lat: 23.87˚ N to 24.78˚N; lon: 88.30˚ E to 88.89˚E), is part of the Ganges River basin. The mean annual rainfall in the region is 1500 mm of which about 75% occurs during the monsoon season (June to September). The maximum depth of groundwater level varies 2 to 18 m from the land surface in the study area. The major crops of High yield Boro rice cultivated during the dry season (January to May) contribute effectively to ensure food security of Bangladesh. Groundwater is the major source for irrigation in dry season rice. However, due to anthropogenic activities groundwater level is decreasing in this area. Most of Shallow tube well (STW) in the study area go blew the suction lift capacity in the irrigation period (Bangladesh Agricultural Development Corporation, 2005).

3. METHODOLOGY AND DATA

The monthly data of groundwater level recorded at ten station wells located in the study area in **Fig 1** for a period 1986 to 2009 were collected from Bangladesh water development Board (BWDB). The daily time series data for rainfall and temperature record (1986 to 2009) at Rajshahi meteorological station located in Rajshahi district (within the study area). A data-driven model has been developed to achieve sustainability groundwater use in groundwater-based irrigation. A support vector machine (SVM) model was developed to simulate groundwater level from rainfall, evapotranspiration, groundwater abstraction and irrigation return follow. Irrigation return follow from paddy field was an estimated from soil properties. The Actual crop evapotranspiration calculated by multiplying crop coefficient with reference evapotranspiration using modified Penman-Monteith method (Doorenbos and Pruitt,1977) and crop coefficient values in different growing stages of rice provided by Food and Agricultural Organization(FAO). Tow mitigation measures namely, (i) reduction of excess irrigation water use and (ii) shifting of harvesting period.

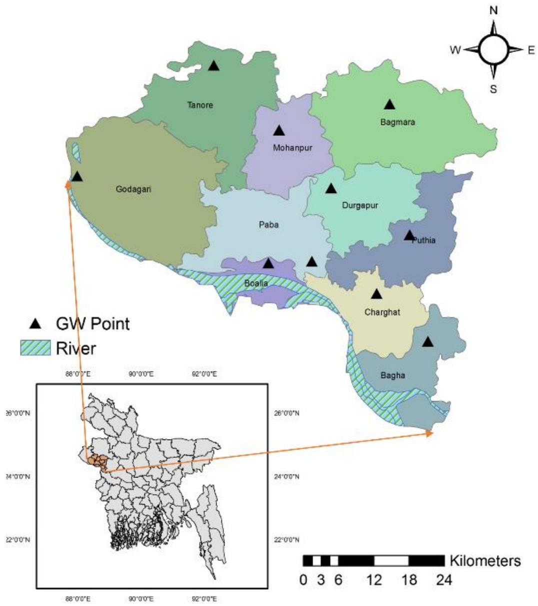

Fig.1 Location of study area and groundwater sampling points

4. RESULTS AND DISCUSSION

4.1 SVM model calibration and validation

The SVM model was calibrated and validated with historical data and then used for simulation of groundwater level at the representative location in the study area. The figure shows the relationship between the observed and simulated groundwater match very well in the whole period. The root mean square error (RMSE), correlation coefficient (R^2) and nash-sutcliff efficiency (NSE) were used to measure the performance of the model and during calibration and validation RMSE values were found very

Keywords: Groundwater Level, Adaptation, Irrigation cost, Northwest Bangladesh.
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low, and R^2 & NSE values are found greater than 0.5 in all the cases.

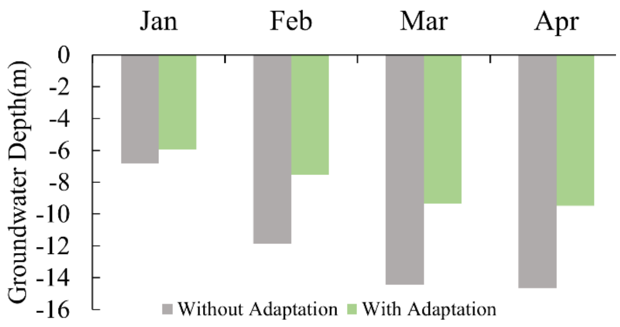

Fig.2 Changes in groundwater level during irrigation period by considering adaptation measure.

4.2 Sensitivity of SVM model

Simulated groundwater model was used to assess the sensitivity of groundwater level to rainfall and evapotranspiration. For this purpose, rainfall and evapotranspiration values in the model were varied separately, keeping all other parameter constant. It was observed that 1% increase of evapotranspiration due to the increase in temperature would cause a decrease in groundwater level 1.02% during irrigation period (January to April) and 1% increase of rainfall will cause an increase of groundwater level by 0.05%.

4.3 Estimation of maximum abstraction of sustaining groundwater level

Sustainable use requires that sustainable use of groundwater use otherwise groundwater level will be dropped and may be problems with shallow tube well running dry in the later part of the dry season when the groundwater is at its greatest depth (Shahid and Hazarika, 2010). Groundwater withdraws input the SVM model was adjusted to identify how different measure can keep the groundwater level always 9.6 m. In the present study, two mitigation measures namely, (i) reduction of excess irrigation water use and (ii) shifting of harvesting period. Shifting of harvesting period in the study area can be done maximum 30 days as monsoon crop schedule starts in early June. On the other hand, farmer extract more water compared to the required for irrigation. A comparison between require water for irrigation and groundwater withdraw for irrigation. It was observed that farmer in the study area extracts 30% more groundwater compared to that required for irrigation. Therefore, it is possible to 30% reduce the rate for excess irrigation water use by growing awareness among the farmers. SVM model was used to simulate groundwater level by these two mitigations. The obtained results are given in **Fig 2**. The result revealed that groundwater level will never go below suction left capacity of shallow tube-well 9.6 m by reduction of groundwater abstraction by 30% and shifting groundwater irrigation period by 30 days by crop rescheduling harvesting date.

5. CONCLUSIONS

A study has been carried out to assess the impacts of two adaptation measure, namely crop reschedules and water conservation that can be adopted to reduce groundwater level declination were identified based on local knowledge. The study process reduction of groundwater extraction by reduction overuse of irrigation through development of awareness among the farmers, changing cropping pattern, increasing irrigation efficiency and development of surface water resources. It is expected that the study will help in reverting the gradual declination of groundwater level in northwest Bangladesh which in turn will help to achieve food security and improve farmer’s livelihood in the region.

ACKNOWLEDGEMENTS

This research was supported by the Environment Research and Technology Development Fund(S-14) of the Ministry of the Environment Japan.

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