Managing salt water intrusion impacts in Bangladesh

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ABSTRACT

Bangladesh, being located on the Northern coast of the Bay of Bengal in South Asia, is majorly characterized by the delta of the Ganges and the Brahmaputra. Tropical monsoons, floods and cyclones occur frequently in this low-lying deltaic area. The combination of rapidly increasing anthropogenic activity and climate change increases the pressure on its coastal groundwater system and increases the magnitude of salt water intrusion. Within the BRAC WASH II (Water Sanitation and Hygiene Services) programme, the SWIBANGLA project (short name for this project) was launched. SWIBANGLA aims to update current Water Safety Plans to manage salt water intrusion impacts in Bangladesh. Part of this project is to create a 3D numerical variable-density groundwater flow and coupled solute transport model of the coastal groundwater system in Bangladesh. This model was built using SEAWAT in combination with the iMOD interface. The results of the model will be used to list key components for guidelines regarding the management of saline groundwater in the Water Safety Plans.

INTRODUCTION

In Bangladesh, saltwater intrusion is threatening drinking water resources on a large scale and is therefore confronting the population with a serious health issue (figure 1). This process has not been studied intensively in this country and has not been well recognized as a health threat yet. The guidelines used in Bangladesh to deal with drink water and sanitation technologies are incorporated in so-called Water Safety Plans (WHO, 2005, 2006, 2009, 2010). These plans mostly focus on bacterial contaminants and arsenic, and they do not take into account groundwater contamination due to salt water intrusion issues. The SWIBANGLA project aims to gather the knowledge on the groundwater system and its dynamics in order to make suggestions on the improvements of the Water Safety Plans.

Achieving the proposed project goals is a challenge that demands an integral approach. Combining technical knowledge and participative processes that increase the knowledge and awareness in the area set the framework of the project. Therefore, we developed an approach linking fact finding missions to Bangladesh, data collection, model development, monitoring workshops and participative groundwater management workshops targeting the main stakeholders.

We started with a fact finding mission to make an inventory of the main stakeholders, the available knowledge and data, and the stakeholders' main concerns and needs regarding the matter of salt water intrusion. This mission provided the project team with a basis of information and contacts that were used to analyze the groundwater system and define a conceptual model. This model was transformed into a 3D numerical variable-density groundwater flow and coupled solute transport model, used to increase the understanding of

the system, to support water resources management and to simultaneously support future research projects.

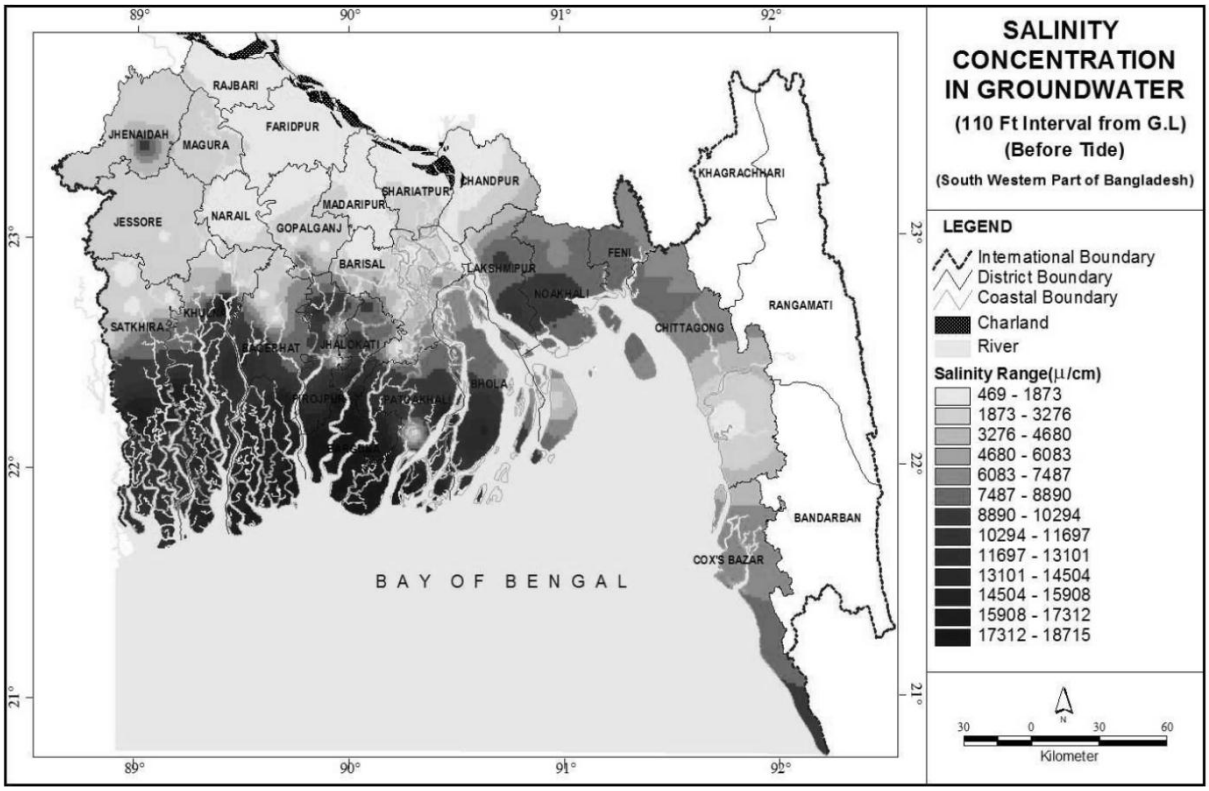

Figure 1: EC map at 35 meters depth established by the Bangladesh Agricultural Development Corporation (BADC, 2011) based on 100 observation wells with salinity measurements at a 10ft interval.

METHODS

The model was built using an adapted version of SEAWAT which supports iMOD (www.imod.nu) functionality. iMOD's user interface and modelling philosophy both significantly simplifie the model building process as well as dramatically enhance the model's transparency and accessibility in terms of input and output, for modellers as well as for stakeholders . The integration of SEAWAT with iMOD was partly developed within this project to facilitate and stimulate the use of the model by Bangladeshi authorities in the future for groundwater resources management. The 3D model is currently under development and is being built in collaboration with the project partners in Bangladesh (BRAC, DPHE and Jahangirnagar University Dhaka).

The model study focuses on the area south of the Ganges River and borders the Indian border in the West and the Bay of Bengal in the South, see Figure 2.

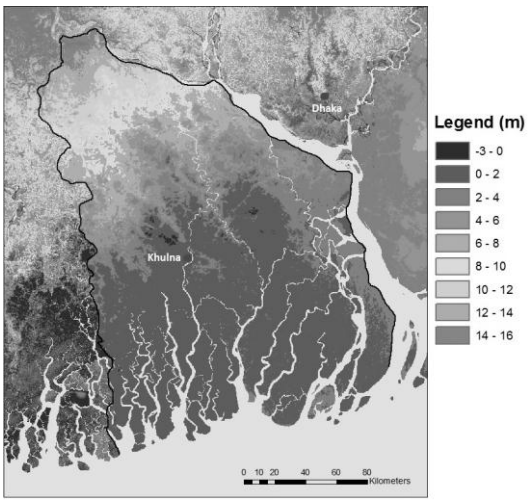

Figure 2: Illustration of total model domain and the area of interest (within black border) on a map showing the surface elevation.

The depth range of the model runs from 15m above sea level to 3000m below sea level, which is divided over 40 model layers. The horizontal model resolution is set at 1000m. The bottom of the model represents the low permeability Boka Bil formation, the first distinctive hydrogeological basis which is found at 3000m. Other boundaries are the general head boundaries at the northern and southern border of the model domain. The model's east and west borders are no-flow boundaries. The sequence of aquifers and aquitards for the model has been simplified according to the adopted profiles in previous studies (Michael, 2009). The reason behind this decision is the complex heterogeneity of the delta, which would require a complete study, not achievable within this project. The model incorporates seasonality by applying three stress periods for the surface system (rivers, precipitation and evapotranspiration), which simulates the three distinct seasons in Bangladesh: 1) a cold dry winter from November to February, 2) a humid hot summer from March to May and 3) a cool rainy monsoon season from June to October. Two stress periods are applied on part of the groundwater abstractions to simulate the differences in irrigation magnitude between the dry and the wet season.

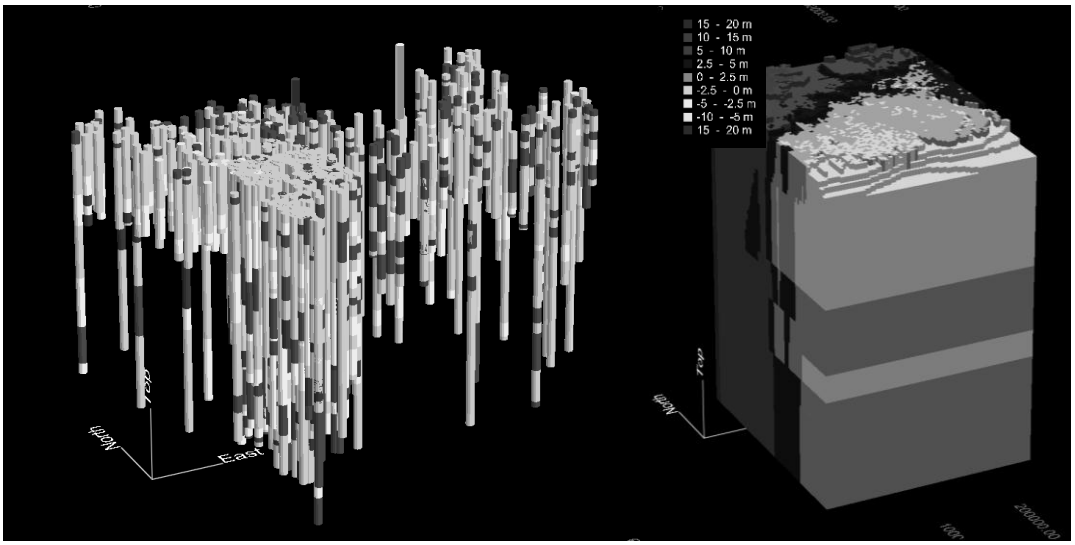

Figure 3: 3D images of the input data for the model visualized and managed with iMOD-SEAWAT. a: 3D visualization of the collected borehole dataset. b: Point water heads in a subdomain of the modeled area.

RESULTS

The current state of the model is that of fine-tuning the water balances and the fresh-salt distribution. This will be followed by performing several impact studies, for example a rising sea level scenario. Mitigation techniques will be implemented in the model and their effects and efficiency will be assessed. The model will give a better understanding in the water fluxes and solute transport of this central Bangladesh coastal groundwater system and will provide a tool to monitor the system and identify potential risks, now and in the future.

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