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Assessment of fresh water security in coastal Bangladesh: An insight from salinity, community perception and adaptation

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ABSTRACT

Safe drinking water scarcity is an acute problem in the coastal regions of Bangladesh which is mainly caused by salinity intrusion. In this context, drinking water sources are severely affected, including adverse effects on agriculture, health, fisheries and the ecosystem. This research investigates i) selected water quality parameters ii) local people's perception on drinking water scarcity iii) how local people's cope with safe drinking water scarcity. This research was conducted using local water samples, questionnaire survey of 200 households and 4 focus group discussions (FDGs) in Shyamnagar and Tala sub-district of Satkhira district. The study of the water quality parameters exposed the extreme conditions of the drinking water sources in the area. The average values of total dissolved solids (TDS), electrical conductivity (EC) and Chloride concentration (Cl^-) were found respectively 4044.12 mg/L, 7186.7 μS/cm, and 3143.6 mg/L in Shyamnagar and 2313.60 mg/L, 4390.3 μS/cm, and 1402.1 mg/L in Tala. The result of community perception reveals that local people are aware of the safe water scarcity and nearly all of them perceive that salinity is the main reason behind it. Even though there are a number of socioeconomic factors, communities have their own adaptation technologies to cope with the problem. The study concludes with the development of a community based model defining the key responsibilities of the stakeholders, including local and central government, NGOs and community people to work in a well-coordinated manner which will be effective for reducing the scarcity of the safe drinking water.

1. Introduction

Crisis of fresh water supply is persistent across the world and is on the rise with the increasing rate of population (Dolatyar and Gray, 2000). About 2/3 of the global population lives under conditions of extreme safe drinking water scarcity for at least 1 month of the year (Mekonnen and Hoekstra, 2016). Safe drinking water is important for all life on earth. Safe water can be helpful for improving the environment, health condition, economy, and food production (Jain, 2012). Millions of people in the developing countries are suffering from diarrhea, cholera, typhoid, and parasites because of drinking unsafe water (Khan et al., 2011).

It is estimated that the area within 200 km of a coastline is home to half of the world's population. In 2003 the population density near the coastline was twice as that of the global average population density (Root, 2008). Salinity intrusion in the groundwater aquifers and freshwater wetlands has been an ever increasing phenomenon and is augmented by the sea level rise caused by the global climate change (Khanom, 2016).

Around 13 percent of the total world urban population lives in coastal zones and of these, more than 75 percent lives in Asia (ADB, 2013). About half of the land area of Bangladesh lies below 10 m above sea level. It further suggests that the South Asian countries are at higher risks with the presence of intricate river networks which span through different geopolitical areas, thus their flows are becoming more human-administered rather than natural. Poverty levels of the countries of this region are also a matter of concern. The dependency of the people of these countries on agriculture makes the availability of fresh water for irrigation purposes a prerequisite. The search for fresh water will eventually lead people to

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migrate to new places and add to the number of "climate refugees" (ADB, 2013).

In Bangladesh, groundwater is the principal and safer source for collecting drinking water compared to other water sources. The rural population is heavily dependent on tube well for drinking water. In 2010, 73% of the rural population were using tube well for drinking water purposes. The number of people who have access to drinking water have increased significantly over the years, yet one fourth of the population is still awaiting access to safe drinking water (WHO, 2008). According to the Coastal Zone Policy (2005) and Haque (2006), 19 districts of the country are being affected directly or indirectly by the influence of tidal waters, salinity intrusion and cyclones/storm surges.

Bangladesh has a coastline of 710 km throughout the length of the Bay of Bengal (MoWR, 2005). The coastal regions of Bangladesh are prone to natural disasters (Rahman et al., 2010). The combination of natural and man-made hazards, like land erosion, high arsenic content in water, water logging, water and soil salinity, pollution, risks from climate change, etc., have affected the lives and livelihood of the coastal peoples (Hossain et al., 2016). Salinization in ground water is depriving a number of populations in coastal areas from getting safe drinking water (Hoque, 2009).

Salinity intrusion poses significant threat to fresh groundwater bodies and also to the natural fresh water wetlands (Talukder et al., 2015). According to the World Bank (2000) anticipation, the changing climate will cause widespread submergence in the low lying areas augmented with increased rate of salinity intrusion. Climate change induced global warming is the main reason for the rising sea water level (Oude Essink, 1996; IPCC, 2013). On the other hand, fresh water flow from upstream has gradually decreased, especially in the dry season. These two natural phenomena cause incremental salinity intrusion in the coastal zone of Bangladesh. It is predicted that the area of fresh water zone will be reduced from 45 percent to 36 percent and moderate saline zone will be reduced from 50 percent to 47 percent because of the sea level rise. But the area of the salt water zone will increase from 5 percent to 17 percent (Rahman and Rahman, 2015). According to a study of Participatory Research and Development Initiatives (PRDI), due to increasing salinity 10% more land relative to 1990 will be saline-affected and salinity intensity will be increased by 10%. The Soil Resources Development Institute (SRDI, 2010) suggests that the rate of increase of salinity intrusion is about 0.74% per year.

There are various causes of salinity intrusion in these areas which are part of the southwestern coastal belt of Bangladesh. The principal causes can be cited as geographical location, sedimentation, sea level rise, cyclone, storm surge and tidal surge and other human causes like shrimp farming (Clarke et al., 2015). Various rivers like Kabodak, Shibsha and Kholpetua crisscross these areas which experience low and high tides. Discharge in these rivers fluctuates seasonally and when the flow is low during the dry season saline water intrudes from the sea at the time of high tides into the estuarine of these rivers (Rahman and Rahman, 2015). Thus the river waters at most of the places of the mentioned areas have become saline and unsuitable for drinking water purposes. Storm surges and tidal flooding also occur frequently, which helps in salinity intrusion. As the natural wetlands are more or less affected by salinity the native people are looking into options like digging artificial ponds to retain fresh water or rain water harvesting. The interpretation of various water sample tests and geochemical analysis indicates that groundwater sources along the south-western Bangladesh are at risk of salinity intrusion (Subramainan, 2015).

Salinity intrusion in the coastal regions of Bangladesh is also increasing because of decreasing upstream water flow in the Ganges River. This reduction of water flow is caused by the construction of Farakka Barrage in the upstream of the Ganges River. Reduction of water flow increased the ground water and river water salinity in the southwest regions of Bangladesh. Salinity in these areas was found in greater extent during the post Farakka period (Gain et al., 2007).

Islam et al. (2013) studied on the perceptions of the communities exposed to severe water scarcity in the coastal regions. The perceptions indicate that the local people might not have the knowledge to understand the changing phenomenon regarding water security, but they do have the experience to cope against such adversities. They have their own adaptation measures like rainwater harvesting and conservation of pond water. Also Parvin et al. (2008) studied about the vulnerability of Bangladesh to natural hazards such as floods, cyclones, river erosion, water scarcity, drought etc.

Many researchers have conducted different studies about the coastal regions of Bangladesh. However, only a few have focused on severe water stressed regions. Moreover, there is hardly any research that focused particularly "Shyamnagar" and "Tala" which are the hardest climate hit water stressed regions of Bangladesh (Abedin et al., 2014). This study provides a brief overview of safe drinking water scarcity caused by salinity at the villages of the South-Western coast of Bangladesh. It also examines the current water quality conditions, community perceptions and adaptation measures to safe drinking water scarcity, the local people's expectations to overcome the water crisis. This paper also suggests a community based adaptability action plan at the local level to combat drinking water scarcity.

2. Materials and methods

This study was carried out in four villages spread over two Upazila (Sub-district) of Satkhira district, in the southwest coastal zone of Bangladesh (Fig. 1). Satkhira district has a population of about 1.99 million people (Islam et al., 2015). The four villages of interest are namely Gabura, Vamia, Dalua and Vabhanipur. Gabura and Vamia are located in Shyamnagar Upazila and Dalua and Vabhanipur in Tala. Salinity intrusion and intrusion of other trace elements have been imposing great threat to this area's drinking water sources (Abedin et al., 2014). Of these four villages, two (Gabura and Vamia) have been classified as extreme drinking water scarcity areas (EDWSA) and two (Dalua and Vabhanipur) as high drinking water scarcity areas (HDWSA). Classification of severity of drinking water scarcity villages is not based on quantitative benchmark rather based on the existing local conditions and community perceptions on drinking water scarcity (Abedin et al., 2014).

For example, Dalua and Vabhanipur villages of Tala Upazila appear to have lower safe drinking water scarcity compared to Gabura and Vamia villages of Shyamnagar because of the presence of water more or less satisfying national water quality standards; rainwater harvesting systems; pond sand filters (PSF); interactive coordination and participation of several stakeholders such as governmental, non-governmental organizations and community bodies. On the contrary, Gabura and Vamia villages of Shyamnagar Upazila appear to have severe safe drinking water scarcity because of inadequate safe water sources, insufficient infrastructure like PSF, unattended salinity problems and least the practice of adaptation measures such as rainwater harvesting at the root level (Abedin and Shaw, 2013).

The climate study of Satkhira district has shown fluctuation in temperature and rainfall patterns over several decades (Ahmed, 2008; Miah, 2010). The average temperature of Satkhira is about 30.6 °C. The average maximum temperature is 33 °C during March to May while the average minimum temperature is about 18.9 °C in