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IMPACT OF GROUNDWATER DROUGHT ON DOMESTIC WATER USE IN BARIND TRACT, BANGLADESH

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***SUMMARY*_____**

The prevailing extreme climatic condition in the northwest part of Bangladesh, also known as the Barind tract has severely intensified the drought condition of the region which has developed a greater shortage of domestic water in the region. This paper intends to explore the nature of the domestic water crisis of the Barind tract, the adaptation strategy of people to manage the domestic water crisis, and the relationship between climate-induced droughts with the domestic water crisis. For conducting the study, three villages from Porsha Upazila of Noagoan district of Barind tract have been selected. In the study area, Questionnaire survey, Focus Group Discussion (FGD), and Participatory Rural Appraisal (PRA) surveys were performed to gather the primary data. Secondary information was collected from the Barind Multipurpose Development Authority (BMDA). All the collected data were analyzed using SPSS, Excel, and GIS software. The results of the research present a portfolio of the domestic water crisis of Porsha Upazila that demonstrates the history of domestic water sources, availability scenario of domestic water, consumption pattern, and collection techniques. The adaptation strategy to the domestic water crisis followed by the people is also revealed in this research. Most importantly the relationship between the domestic water crisis and the climate-induced drought of Porsha Upazila has been explored in this research.

Key Words: Climate Change, Domestic Water Crisis, Drought, Ground Water Depletion, Focus Group Discussion, Participatory Rural Appraisal.

1. INTRODUCTION

The occurrence of natural disasters every year in different parts of Bangladesh has become a recurrent phenomenon. Cyclone in the south, the landslide in the south-east, flood in the north-east, and drought in the north-west takes place every

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year at different intensities. Among all these disasters, drought has received the least attention in the disaster literature of Bangladesh (Habiba et al., 2011; Ahmed et al., 2014; Rahman et al., 2016).

Drought is slowly evolving and complex disasters that is often poorly understood in the context of their regional climatic, hydrological, and human environment. Drought prevails in the north-western part of the country mainly due to high variability in rainfall (Shahid and Behrawan, 2008 in Adhikary et al., 2013). The north-western part of Bangladesh lies within Barind tract which is comprised of 7,770 sq km land covering greater Dinajpur, Rangpur, Pabna, Rajshahi, Bogra, Joypurhat, and Naogaon districts of Rajshahi division (Banglapedia, 2014). The annual rainfall of this region is less than the country's average rainfall record (Mohsenipour et al., 2018). The economy of the region mostly depends on agriculture, livestock rearing, and fishing. Nearly 82% of local inhabitants of the study area are involved with these occupations where agriculture takes up the highest percentage (Selvaraju et al., 2006). Throughout the past, peoples of the Barind tract use rainwater and other surface water sources for irrigation as well as for drinking and domestic uses. Rainfall intensity and frequency were sufficient enough to meet the demand for irrigation water. In the last 2-3 decades, the situation has been altered entirely as the rainfall frequency becomes irregular and insufficient too. During summer, due to the high rate of evapotranspiration; ponds, rivers, and other surface water sources of this region become dry and it causes a crisis of drinking and domestic water (Habiba et al., 2011). Thus people have bound to use groundwater for irrigation and other uses. Over extraction of groundwater has led to depleting groundwater levels sharply. The situation is deteriorating in every passing day as Adhikary (2013) stated that increasing day time temperature and low rainfall has obliged the groundwater level to deplete by 7m in a decade.

For domestic uses, people are accustomed to using pond water which diminishes in summer and the suffering goes beyond the endurable limit. People need to travel furthest places on foot to collect potable water from STWs and ponds. Although the situation is extremely difficult to survive, the local people do not migrate from their origin. Within this backdrop; this research aims to highlight how the indigenous people tackle, survive, and adapt to these drought events by portraying the field examples from three communities of the Barind tract of Bangladesh. The specific objectives of this research are:

- To investigate the nature, scale, and characteristic outlook of Domestic Water

(DoW) crisis within the study area;

- To find out the coping strategy of people to combat with DoW crisis.

2. MATERIALS AND METHODS

At the beginning of the research, a desk study covering the existing pieces of literature, statistical records, newspaper articles were reviewed. Based on the input from the literature review; research gaps and themes were identified. A reconnaissance survey was carried out in some other sub-districts of Noagoan district to search drought-prone area suitable for conducting a case study. According to the feedback from reconnaissance, survey water scarcity in the Porsha sub-district is found to be the most severe. Thus Porsha sub-district of Noagaon district was selected as the case study area. The case study comprised of the household questionnaire survey, Participatory Rural Appraisal (PRA) survey, and Focus Group Discussion (FGD). A structured questionnaire was prepared to explore the history of domestic water sources, availability of DoW, storage of DoW, collection time, collection distance and adaptation technique during DoW crisis, and opinion to solve the problem. Questionnaire surveys were carried on 50 households. In addition to the questionnaire survey, PRA tools such as social and resource mapping, seasonal diagrams, and daily activity schedules were used to collect data on the nature and impact of domestic water scarcity in the region. For conducting the PRA survey, three FGD within three different communities were chosen. Each focus group consisted of 8 to 10 members. Gender equivalence was tried to maintain in each focus group. Data collected by questionnaire survey were analyzed by using SPSS and Excel software. Maps were produced during the PRA survey and digitalized later using AutoCad. Based on the analyzed data, the interpretations were made which contributed to generate the findings of the research.

2.1. Study area

This study was conducted in a marginalized community which is located in the Porsha sub-district of Naogaon District in Bangladesh. Naogaon district is located at 240 km North-West from Dhaka, the capital city of Bangladesh (BBS, 2011). Porsha Upazila is located at the North-West corner of Naogaon District covering an area of 252.8 km^2 with a population of 121 809 (Selvaraju et al., 2006) (Fig. 1). The study area is located between 88° 24'E and 88°39'E longitude and 24°54'N and 25°05'N Latitude (BBS 2011). Porsha Upazila of Noagoan district is the most drought-prone area of Noagoan district based on combined drought vulnerability ranking and drought severity ranking (Dutil et al., 2015). Three villages of Porsha Upazila namely Khatirpur, Bondhu para, and Natun para

have been chosen to conduct the study. According to BBS (2011), in the study area, about 175 households are having 676 inhabitants out of which 48% are male and 52% are female. Overall household size is about 5 which has increased over the past 3-4 decades. The education rate in the study area is about 56.6% and the rests of the people are illiterate (BBS, 2011). Most of the people in this area belong to tribal owing to the Santal community. The majority of these tribal people are landless poor. The main occupations of the respondents are agricultural day labor, wage labor, livestock rearing, and driving pushcarts. More than 80 percent of the ethnic population serves as an agricultural daily labor. Female are engaged mostly in household works; the majority of them help in agricultural works (BBS, 2011).

Fig. 1. Naogaon District of Bangladesh.
(Source: Wikimedia, 2010).

The topography of the area is mainly undulated ranging from 40 m in the northeast to a minimum of 22 m in the west above the mean sea level (Reza and Mazumdar, 2005). Due to high land elevation, the groundwater level remains at a very low altitude causing it more difficult for groundwater extraction in this area (Fig. 2). It is known that the shape of an aquifer is bowl-shaped and at the edge of the aquifer water availability is least. This region lies at the edge of the bowl-shaped aquifer which implies the water crisis and drought condition of the region. This is also one of the reasons for acute groundwater drought in this area (Uddin et al., 2017).

Climatically, the study area belongs to a dry humid zone with annual average rainfall vary between 500 mm to 2100 mm (Uddin et al., 2017). The seasonal distribution of rainfall shows that almost 92.7% of rainfall occurs from May to October. Less than 6% rainfall occurs during the irrigation period of Boro rice (January to April). The rainfall also varies widely from year to year (Shahid, 2008). Hydrograph analysis of the study area indicates a significant direct relationship between rainfall and groundwater level fluctuation (Reza and Mazumder, 2005). Such low rainfall intensity, undulated ground, and hard topsoil conditions allow the water level to vary from place to place which results in groundwater drought. The

temperature of the study region ranges from 25°C to 40°C in the summer and 8°C to 25°C in the winter (Shahid, 2010).

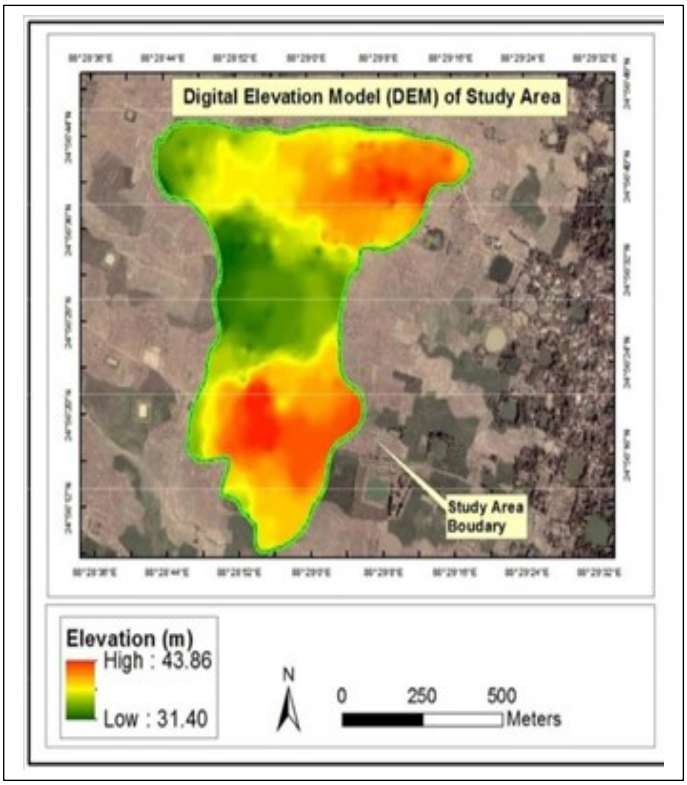

Fig. 2: Topography of the Study Area.

A gradual increase in daytime temperature and the extreme environment was observed by both the meteorological department and the local dwellers of the study area. The statistical record confirms that there is a declining trend of annual fluctuation of groundwater table in the northwest region of Bangladesh over the last 30 years (1981-2011), which implies that groundwater use is not sustainable in the study area (Masud et al., 2014). Evidence suggests that due to low rainfall in the short monsoon period and less available soil moisture, recharging of groundwater gradually stops in the dry period (Jahan et al., 2010). It was revealed through the questionnaire survey with the local farmers that about 73% of them are well-known with the phenomenon of lowering groundwater depth in agricultural fields. This is mainly due to extracting an increased amount of groundwater than recharging aquifer (IWM, 2006; Mamunul et al., 2012). The BADC study (2002) also found that during 1980- 2000, groundwater irrigation coverage rose from 6% to 75% in Bangladesh.

Shahid and Hazarika (2009) have proved that the available potential of the aquifer that could be extracted by STWs for sustainable use of groundwater in irrigation had almost been exploited by 1996. Since then, the use of both STWs and Deep Tube Wells (DTW) has expanded which suggests that groundwater resources have already been over-exploited which may adversely impact the environment. At present, groundwater is almost unavailable in shallow depth in some selected areas (Shahid and Hazarika, 2009). Ahmeduzzaman, Kar, and Asad (2012) have shown the over-extraction of groundwater for irrigation as the prime cause behind the rapid depletion of the groundwater table in the Barind region. Uddin et al. (2017) presented in their study that Porsha Upazila has the highest rate of groundwater table depletion (2.8 ft/ year) with a total depletion of 48 ft in the last 17 years (Table 1).

Table 1. Depletion of groundwater from 1995 to 2012 (Uddin et al., 2017)**.**

Upazila	Total depletion last 17 years (ft)	Rate of depletion ft/year
Porsha	**48**	**2.8**
Shapahar	26	1.6
Raninagar	11	0.6
Mohadevpur	3	0.2
Atrai	5	0.3
Dhamorhat	7	0.4
Patnitola	15	0.9
Naogaon Sadar	8	0.5
Manda	21	1.3
Badalgachi	8	0.5

2.2. Domestic water use

Since the history of habitat in the study area, till to date; people have been accustomed to using surface water for various domestic water uses. Among them, pond water remains the most common form of DoW source. Rainwater has also been used as the source of DoW in the study area. Household activities where water is used can broadly be classified as (1) cooking (2) dishwashing (3) bathing (4) cleaning and (5) livestock management. Apart from pond water, people of the study area use rainwater also for various household purposes. Comparing the present and past DoW use scenario, it is assumed that present water use sectors for domestic purposes increased over the past. For example, presently, people are trying to cultivate some essential food items (i.e. ginger, turmeric- which require a few amounts of water) that consume pond water. It was not practiced in the past. The ponds of the area are drying at a constant rate. People of the region are constantly struggling to manage the domestic water as water scarcity has reached the peak.

3. RESULTS AND DISCUSSIONS

This study has attempted to prepare a DoW crisis portfolio of the Porsha sub-district based on the three indicators. These indicators are (1) vailability and sources of DoW, (2) Consumption and use of DoW (3) Coping strategy during the DoW crisis period. The following analysis aims at presenting the relevant information of the study area.

3.1. Availability and sources of DoW

People of the study area depend entirely on pond water to meet the domestic water needs. A resource map of the study area has been produced with the help of a focus group which shows the locations of the ponds within the communities (Fig. 3).

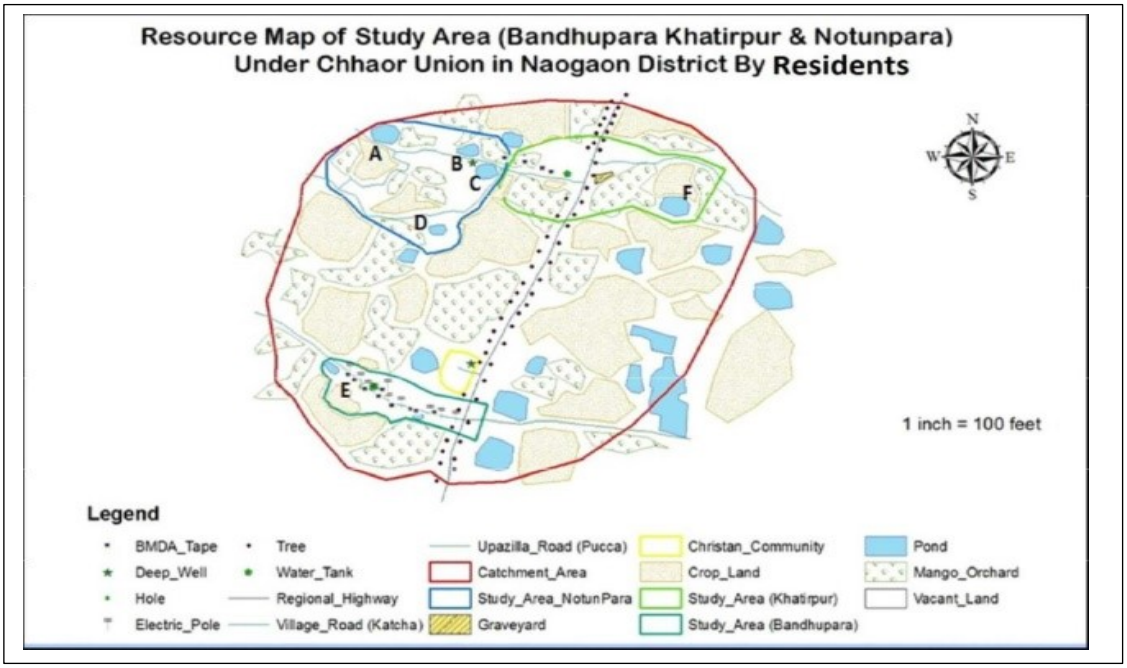

Fig. 3: Resource map showing the location of ponds in the study area (Ahmed et al., 2018).

The resource map of the study area shows that in Khatirpur and Bandhupara community has only one pond inside of the community whereas the Notunpara community has four ponds inside the community boundary. Therefore the people from Bandhupara and Khatirpur community need to spend a much higher amount of time collecting DoW comparing to the people of the Notunpara community.According to respondents, DoW is easily accessible at rainy season. During the rainy season, the depth of water in the ponds remains 10-12 feet. This depth of pond water is suitable for all DoW use purposes. But during summer, the depth of pond water becomes 3-4 feet only (Table 2). In summer, only one pond from Notunpara remains active and the rest of the ponds from Notunpara as well as Bandhupara and Khatirpur communities dry up and become beyond usable. At this time people from these three communities depend solely on the only active pond of the Notunpara community (Table 3). Water collection time in summer increases in all three communities as the water level of the ponds falls sharply and the bed of ponds open at the end. Due to this reality, people have no other choice but to suffer this water crisis and travel farthest ponds to meet their DoW use demand (Table 2). The incidence of drying ponds and wetlands are physically observed by the locals, as they could measure the water level which was about to their chest level during monsoon.The water level in some ponds is so low that even fish culture becomes impossible. At this shallow depth, water becomes polluted and becomes difficult to use. Due to the hot and temperate climate, evaporation takes place at a faster rate and it causes rapid vanishing of surface

water. During the last 10 to 15 years, people of the locality observed the incidence of drying of ponds and opening the beds of ponds and wetlands. This physical observation of drying up ponds and wetlands indicates a foreseeable drought situation and the initiation of the desertification process.

Table 2. Impact of Drought on Availability of DoW. *(Source: Field Survey, 2017)*

Parameter	Monsoon	Summer	Remarks
Water depth of ponds	10-12 feet	3-4 feet	In summer, water depth decreases and water becomes unsuitable for domestic water use activities.
Fish culture	Yes	No	The depth of pond water in summer is unsuitable for fish culture.
DoW Collection Time	5-10 minutes	15-30 minutes	In summer, DoW collection time increases.
DoW Collection Distance	100 -200 meter	400-500 meter	In summer, DoW collection distance increases. It imposes mental and physical stress on women and children as they need to carry as many as pots possible to reduce the travel frequencies.
Mode	walking	walking	Women and children have to walk a long distance in the hot climatic condition during summer which imposes a huge physical and mental stress

Table 3. Domestic water demand during summer & monsoon. *(Source: Field Survey, 2017)*

Total number of ponds (Fig. 3)	**Notunpara**			**Bandhupara**	**Khatirpur**	
	Pond A, B, C, D (Fig. 3)			**Pond E (Fig. 3)**	**Pond F (Fig. 3)**	
	(04)			**(01)**	**(01)**	
Functional Period	Summer and monsoon			Monsoon		
Number active ponds	Only 'A' pond is active in Summer			No ponds are active in summer		
User in Summer (No of HH)	Pond A	Pond B	Pond C	Pond D	Pond E	Pond F
	100	0	0	0	0	0
User in Monsoon (No of HH)	30	20	15	15	10	10
Remarks	During summer, huge pressure of DoW demand is created on the single active pond 'A' of Notunpara, and a domestic water crisis is created. This indicates a drought trend in the study areas.					

3.2. Consumption and use of domestic water

The consumption of DoW varies from season to season. In general, In general, the demand for DoW for cooking, cleaning, and washing does not have a significant difference between summer and other seasons. For other purposes i.e for livestock management, the difference in DoW demand is noticeable. For example, other than the summer, cattle bathing is a regular household activity that is practiced twice a week. But during summer people limit this activity to once a week to minimize the traveling during the hot climatic condition of summer season. DoW consumption varies from a minimum of 2 pitchers per day to 9 pitchers per day. Among the 58 respondents of the household survey, it is found that the mean amount of DoW

use is 4 pitchers per day (Table 4).

Table 4. DoW Consumption Scenario (Pitcher per day; 1 pitcher =10 liters). *(Source: Field Survey, 2017)*

Mean	4
Median	4
Mode	3
Maximum	2
Minimum	9

People collect water from nearby ponds and carry water to their homes using pitchers. People also go to the pond for bathing; dishwashing, and washing clothes (Fig. 4 and 5). Usually, they do these activities at late noon. Reviewing the history of the locality, it is evident that there is a sharp increase of DoW use or consumption rate due to: (1) demographical change (2) diversity of water uses pattern (3) increase in individual consumption pattern. These contribute to increasing the water demand without increasing the water source. Eventually, this acute water shortage tends to a drought scenario in the locality. DoW collection time has increased manifolds as the ponds near the communities have dried up.

Fig. 4. Washing and Collecting DoW.
(Source: Field Survey, 2017)

Fig. 5. Bathing in Pond Water.
(Source: Field Survey, 2017)

During the monsoon, 53% of the people of the community spend 5 to 10 minutes collecting water. About 8% of people were found who spend more than 20 minutes collecting DoW (Fig. 6). This variation in collection time depends on the distance of the ponds. The resource map of the study area (Fig. 3) shows the location of ponds in the communities. The DoW collection distance varies with the location of ponds.

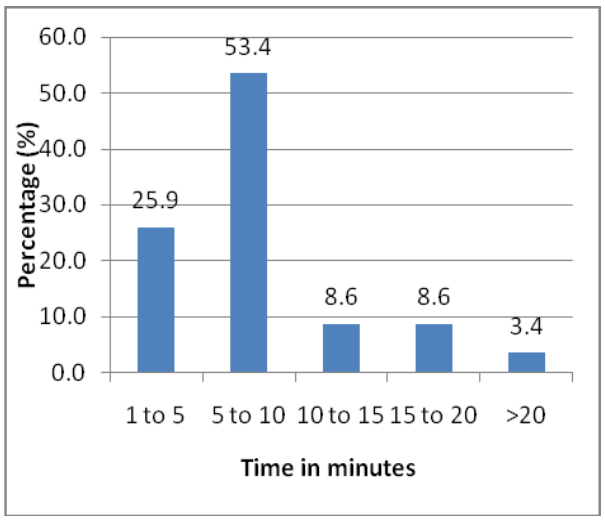

Fig. 6. DoW collection time. (Nonwater availability period). *(Source: Field survey, 2017)*

It has been already discussed above that during summer only one pond remains active and it contributes to the increase of DoW collection distance. Furthermore, 55.2% of people perceive that the ponds of the study areas have been drying

up since 2002-2007. Rest thinks that the drying of ponds has started since a decade ago (Fig. 7). Their perception regarding the period of the initiation of drying of ponds resembles the drought scenario of the region.

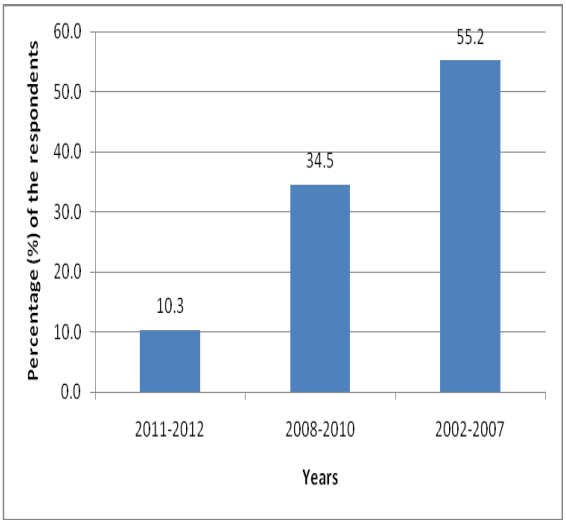

Figure 7. People's perception of the drying up the ponds (in years). (Source*: Field survey, 2017)*

3.3. Coping strategy during the DoW crisis period

People of the study area use pitchers, plastic mugs, balti for storing water. Previously, before 1980, they used pitcher made of mud for storing water. Now they are using the same kind of pitcher, but along with this, they use available plastic balti, mug for storing water (Fig. 8). During the acute shortage of DoW, people collect water from distant water sources as the water is not available in nearby places and they try to keep their water consumption rate minimum to cope with the situation. To tackle the crisis, people store water in pitcher and pots which serves their daily demands.

Fig. 8. Conventional DoW Storage System. (Source: *Field Survey, 2017)*

People collect water twice a day. Two common forms of crisis management were observed: (1) reducing the consumption rate (2) increasing the endurance level. People said that they cannot even offer a single glass of water to their guests during the water crisis period. Table 5 presents the overall storage option and drought indicator of the study area.

Table 5. Domestic water storage options and drought indicators. *(Source: Field Survey, 2017)*

Indicator	Monsoon	Summer	Remarks
Travel Frequencies	2	3	Increase in travel frequencies
Storage facilities	Decreases	Increases	Slightly increases in summer to reduce travel frequencies.
Water consumption	Increases	Decrease	Slightly decreases to reduce the travel frequencies
DoW use	Increases	Decreases	Decreases due to lack of DoW sources
Travel distance	Decreases	Increases	Only one pond remain active

3.4. Relationship between the climate changes with DoW crisis

From the analysis of the DoW availability; consumption; collection pattern; and storage system it has been realized that DoW use depends on pond water. The crisis starts in summer as the water level of ponds lowered due to low recharge, high evaporation rate, and depletion of groundwater level. All these factors are natural phenomena and it can be said that the DoW crisis is mainly driven by natural or climatic change induced factors. Along with the natural causes, the increasing demand for DoW is also responsible for causing the DoW crisis in the region as the numbers of sources are limited. The overall analysis proves that the DoW crisis in the study area is a strong indicator of climatic change-induced drought in the region.

4. Conclusion

The study was conducted on three communities from the Northwest part of Bangladesh named Khatirpur, Notunpara, and Bandhupara to understand the impact of groundwater drought on the domestic water use sector. This research aimed at investigating the nature, scale, and characteristics of the domestic water crisis of the study area as well as exploring the indigenous coping strategies that the local people are following to combat the DoW crisis. The findings of the study suggest that the livelihood of the people of this region depends solely on agriculture. The irrigation system of the region depends on surface water and rainwater since the past. But since 1980, the rainfall intensity of the region started to decrease and temperature increased significantly which eventually compelled people to depend on groundwater instead of rainwater for irrigation. Later people started using STW and DTW for groundwater extraction. Geographically, Porsha Upazila is located at the edge of the bowl-shaped aquifer of the region. The topsoil of the area is hard in characteristics that impede the natural infiltration process. These natural disadvantages along with low rainfall intensity and increased temperature have created a cumulative impact on the depletion of the groundwater table. Therefore both natural and manmade reasons are responsible for the occurrence of drought in the Porsha Upazila. At present, the agriculture, as well as food production of the region, are under threat. In addition to the problem of irrigation water, people are suffering from terrible drinking and domestic water crisis. For domestic activities i.e. cooking, dishwashing, cleaning, bathing, cattle bathing, and feeding, people depend on pond water. With the diminishing trend of rainfall, rise of temperature, and faster Evapotranspiration; ponds

are gradually drying. During monsoon, the water depth of the pond remains suitable for domestic uses but during summer the water level of the pond decreases, and the river beds open up. The water collection time and frequency increases in summer. With the increase in the number of households in these communities and other sectors that require water, the total demand for domestic water has increased than in the past. Research findings suggest that, with the pace of the increase of domestic water uses, the sources for domestic water have not increased. It is evident from the research findings that the natural phenomenon contributed to the present DoW crisis. Besides, demographic changes and over-extraction of groundwater simultaneously contributed to the crisis as a man-made cause. The respondent's feedback, field observation, and expert opinion claim the incidence as a climate-induced drought. If such a situation continues, there will be no pond available for serving domestic uses soon. An investigation should be made on exploring the potentials of artificial recharge of the groundwater in the study area. Besides, indigenous concepts of water preservation such as digging ponds and canals should also be explored to develop an effective solution to the domestic water crisis in the region.

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