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Abstract

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Keywords	Barind Tract; disasters; disaster risk; participatory rural appraisal; Santal
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All data are provided in this manuscript through the tables and figures. Further details of interviewees and participants cannot be provided due to confidentiality.

<u>Indigenous people's responses to drought in northwest Bangladesh</u>

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1. Introduction

Bangladesh is highly disaster-prone due to long-standing vulnerabilities to a multitude environmental hazards which continually affect the country (e.g. Ahmed, 2015ab). One of Bangladesh’s major hazards is drought (Paul, 1998; Shahid, 2008), manifesting in all forms defined in the literature (Wilhite and Glantz, 1985) including rainfall deficit, groundwater abstraction, local demand exceeding supply, and climate variability including climate change (Habiba, 2012; Habiba et al., 2014; Selvaraju et al., 2006; Shahid and Kumar, 2010). Droughts in Bangladesh over the last few decades have substantially impacted water availability, food, health, livelihoods, and migration (Habiba et al., 2014; Islam et al., 2017; Paul, 1998; Shahid and Behrawan, 2008).

Despite recognising Bangladesh’s drought hazards and vulnerabilities, existing literature pays limited attention to community-level views of and actions for responding to drought. Plenty is published on drought and drought impacts in Bangladesh (e.g. Dey et al., 2011; Karim et al., 1990; Paul, 1998; Shahid and Kumar, 2010), including the most drought-prone area of the country in the northwest. Limited work (e.g. Islam et al., 2017) examines what people in these communities think about and do regarding droughts, apart from non-indigenous and farmers’ perspectives (Alam, 2015; Habiba et al. 2012, 2014; Mardy et al., 2018).

Based on indigenous peoples’ wishes, no formal definition has been adopted in international law of “indigenous”, instead focusing on groups who self-define as indigenous with characteristics highlighting having settled a location first and now being a minority with distinctive characteristics (Asia Pacific Forum of National Human Rights Institutions and the Office of the United Nations High Commissioner for Human Rights, 2013; ILO, 1989). With this approach, over 54 indigenous peoples groups live in Bangladesh comprising 1.6-5.0 million people, a small minority of the country’s total population (IWGIA, 2018) who have typically been excluded from disaster-related work.

This paper aims to contribute to filling in this gap by examining how the Santal, an indigenous group in Bangladesh's northwest, respond to drought through local strategies. The Santal are labelled as one of the oldest indigenous groups in Bangladesh, comprising less than 0.1% of the country's population, and assumed to have been originally nomadic, but their history continues to be debated in the literature especially with regards to their past migration patterns and changes to identity (Khan, 2017; Knight, 2014; Sarker et al., 2016). Bangladesh's northwest has never before been studied regarding detailed indigenous drought response strategies, so the drought literature for Bangladesh provides a useful framework of three main categories of responses based on impacts seen (Ahmad et al., 2014; Alam, 2015; Selvaraju et al., 2006; Shah et al., 2006) which are food, water, and migration. These three categories are linked by health and livelihoods. Food, with nutrition impacting health, is produced through local livelihoods such as cultivation (e.g. rice crops) and livestock farming of mainly domesticated animals (e.g. cows, goats). Water is essential for these food-related livelihoods while water-borne disease is a major health concern in the region. Migration provides alternative livelihoods but also impacts health due to poor living conditions experienced during migration to megacities like Dhaka or other urbanised locations within the country. These drought impacts in Bangladesh from the literature (water, food, and migration then linking with health and livelihoods) will be examined here in terms of Santal responses.

2. Drought in the Barind Tract

The Barind Tract, an agrarian upland in northwest Bangladesh, covers most of Dinajpur, Rangpur, Pabna, Rajshahi, Bogra, and Joypurhat districts of Rajshahi and Rangpur divisions (Figure 1). Much of the Barind Tract is over 20 metres above sea level, placing it higher than most of the rest of the country (Khan, 1991). Rainfall in Bangladesh ranges from as high as 5,000 mm/year in the northeast to under 1,500 mm/year in the west, with a discernible west-to-east trend (Figure 1). The Barind Tract region is located in the low-rainfall area of the northwestern part of the country, considered to be drought-prone.

Figure 1: Rainfall in Bangladesh including the Barind Tract (produced by the authors).

Droughts in this region are (i) meteorological (Mondol et al., 2017) resulting from variable rainfall and higher temperatures in the dry season leading to high evapotranspiration losses and (ii) hydrological (Paul, 1998; Habiba, 2012) resulting from sustained depletion of groundwater (Figure 2) due to intensive dry-season irrigation for high-yielding 'Boro' rice cultivation to meet increasing demand for food and water supplies (Shamsudduha et al., 2009, 2012).

Figure 2: Groundwater levels in Naogaon, northwestern Bangladesh compared to the rest of the country (produced by the authors from Bangladesh Water Development Board data).

One of the main characteristics of meteorological droughts in the Barind Tract is the short duration of monsoon rainfall. Every year, this area experiences a dry season of up to seven months starting in November. The usual rainy season for the Barind Tract lasts from late April or early May to October, but due to long spells of dry weather, the seasonal rainfall is often insufficient for increasing soil moisture or for fully replenishing shallow groundwater, especially as the air temperature often exceeds 40ºC leading to increased evapotranspiration losses (Shamsudduha et al., 2009; Hassan, 2012).

The national water policy of Bangladesh's government encouraged groundwater development for irrigation both in the public and the private sectors. A government poverty alleviation programme introduced a special groundwater-based irrigation project in the Barind Tract called the "Barind Integrated Area Development Project" under the Bangladesh Agricultural Development Corporation (BADC). In 1990, the project was successfully completed and, following a review by the Ministry of Agriculture of Bangladesh, a separate authority was formed in 1992 named the "Barind Multipurpose Development Authority" (BMDA). Numerous groundwater-fed irrigation projects were conducted in the Barind Tract under the supervision of and with consultation by BMDA that accelerated groundwater use, leading to a Green Revolution in the 1990s (Sala and Bocchi, 2014).

Although around 5,320 km^2 of the Barind Tract's 7,730 km^2 is cultivable, in recent decades, water has apparently become scarcer, leading to increased (or increased reports of) food scarcity, malnutrition, and livelihood insecurity (Alauddin and Sarker, 2014; Faisal et al., 2005; Habiba et al., 2012, 2014). Following BMDA's creation, around 6,000 deep tubewells (DTW; high capacity pumps bringing 50-60 litres per second) were installed in the area. Additionally, about 66,000 shallow tubewells (STW; 10-15 litres per second) were installed by the private sector before the year 2000 for exploiting groundwater for irrigation, while the number of shallow tubewells after 2005 increased rapidly, meaning higher use of shallow groundwater in this region (Faisal et al., 2005; Haque, et al., 2000; Asaduzzaman and Rushton, 2006). Currently, main rivers and channels of the area dry up during the dry season, making the people depend completely on groundwater, further stressing Barind Tract aquifers.

Prolonged absence of groundwater within the operating range of shallow tubewells during the dry season is common (BADC, 2002; Bari and Anwar, 2000). Shamsudduha et al. (2009) and Ahmad et al. (2014) concluded that the use of STWs for shallow groundwater for irrigation in the Barind Tract is unsustainable as the water table in many areas is now beyond the suction limit (~8 metres below ground level) of commonly used pumps. Rahman and Roehrig (2006) examined water balance for the Barind Tract with a numerical groundwater model, showing that increased irrigation means that drawdown exceeds the recharge rate.

Existing literature pays limited attention to understanding strategies used by indigenous peoples in Bangladesh for dealing with these challenges which contribute to drought. Studies typically focus on drought impacts on agriculture (Karim et al., 1990; Saleh et al., 2000), food production (Ericksen et al., 1993), land degradation (Karim and Iqbal, 2001), the economy (Ericksen et al., 1993; World Bank Bangladesh, 2000), and livelihoods (Selvaraju et al., 2006) separately. Habiba et al. (2011ab) describe an approach called socioeconomic, institutional, and physical (SIP) which helps to measure drought resilience at the institutional level, but they do not address local or indigenous knowledge for response strategies.

Without mentioning indigenous peoples or their knowledge, Ahmed and Chowdhury (2006) discuss approaches for dealing with drought in northwest Bangladesh, including pond and lake excavation, retaining rainwater in small canals, shedding, tillage and breaking top soil, deep tube well irrigation, changing crops and livestock, and changing livelihoods such as increasing poultry rearing. Alauddin and Sarker (2014) similarly showed that improved crop culture practices and efficient surface-water irrigation infrastructure, rather than more dependency on groundwater, are important for dealing with drought.

Also in northwest Bangladesh, Alam (2015) and Habiba et al. (2012) investigated non-indigenous farmers' experiences of and responses to drought. From Alam (2015), those with more farming experience, better education, more secure land tenure and rights, better access to utilities, and more climate awareness are more likely to be able to deal with drought. According to Habiba et al. (2012), farmers perceive a changed climate in recent years and also drought as the most prevalent hazard for them, which emerges from groundwater depletion, variation of rainfall and temperature, lack of canal and river dredging (which reduces water body surface area as siltation occurs), a higher population, and deforestation.

Using such work as a baseline, a major gap emerges in understanding indigenous experiences of and responses to drought, a gap which this paper aims to fill.

3. Methods

In this research, a mixed methods strategy was applied by collecting primary community-level data incorporating both quantitative (household questionnaire survey) and qualitative (focus group discussions) research methods (Roelen and Camfield, 2015). The reason is that it is not always possible to capture the overall scenario of a community by applying merely a single social science research strategy (e.g. Ahmed, 2015ab). For example, through questionnaire surveying, it is possible to quantify some demographic and economic information of a household such as sex, age, education level, main livelihoods, and monthly income and expenses; however, it is not possible to identify the surrounding natural resources, land use, and infrastructure, nor is it possible to record the historical evolution and coping mechanisms of a community. For such information, focus group discussions (FGD) implementing participatory rural appraisal (PRA) tools like social and resource maps, transect maps, and timeline diagrams are more relevant (Chambers, 1994, 2002; Kumar, 2002). PRA is generally described as a growing body of methods to enable local people to share, enhance, and analyse their knowledge of life and conditions to plan, act, monitor, and evaluate.

In Bangladesh, PRA tools are being used frequently to facilitate disaster-related research and action in communities. For instance, Ahmed (2015ab) applied similar techniques proposed here for addressing landslide vulnerabilities. For the Santal, PRA approaches have been applied for ethnographic study by Akan et al. (2015) and for understanding the role of women in the community by Islam (2010). Islam et al. (2017) used PRA work to explore using traditional and local knowledge to identify and deal with droughts in northwest Bangladesh.

Here, three sets of research processes were run. First, a household survey was completed, with details provided in Section 4. A semi-structured, partly open-ended questionnaire was completed yielding quantitative and qualitative data, highlighting issues and challenges related to Santal drought responses; policy level challenges to improving drought response; and how to apply known good practices and limitations of doing so. The questionnaire was piloted and tested in the field in January 2017 before conducting the final fieldwork in March 2017, from which the data here are reported. Five enumerators conducted the survey supervised by the project team leader. To ensure the consistency, reliability, and validity of the results, all the field surveyors were trained and given background information prior to visits to the study area.

Second, a series of PRA tools (Table 1) was applied through FGDs to prepare the participatory maps and diagrams. The average number of participants in each focus group was 8-10 and they included both male and female participants. Two project team members and one field assistant from the project team helped in conducting the FGDs. Each FGD was arranged for a previously agreed time and suitable location within each community. The participants were provided with all materials. In some cases, the participants were divided into men-only and women-only groups, in order to understand gendered experiences. The facilitators described the tools and then the participants completed their tasks. The maps and diagrams were digitized afterwards by the research team.

Table 1: PRA tools applied

Main issues	Specific tools	General tools
Profile of villagers and agricultural patterns.	Daily activity schedule.	▪ Review of secondary data. ▪ Reconnaissance survey. ▪ Semi-structured interviews. ▪ Household interviews. ▪ Focus group discussions.
	Seasonal diagram.	
	Cropping calendar.	
	Historical timeline.	
Access to and control over resources.	Transect walk.	
	Mobility map.	
	Resource map.	
	Organizational linkage diagram (Venn diagram).	
	Social map.	
Constraints, problems, and opportunities.	Pairwise ranking.	
	Strength-Weakness-Opportunity-Threats (SWOT) analysis.	
	Cause-effect diagram.	

Third, a regional workshop was held in August 2017 at Rajshahi University of Engineering and Technology (RUET) to cross-validate and triangulate the results (Chambers, 2002). Adult males and females from the surveyed villages, university teachers and students, local representatives, key informants, experts, and governmental officials took part in the workshop. An agenda was sent in advance indicating that preliminary results are to be presented formally; then a round table discussion takes place; and then aspects of further interpretation and reasoning are explored.

All fieldwork took place from January to March 2017. The surveys, interviews, and FGDs were conducted in the Bangla language (Bengali) by native speakers with a population of native speakers of the language. As the study involved human participants, it went through institutional ethics approval and risk assessment. The respondents were provided with a project information sheet or explained the material verbally, with either written or oral informed consent being given before the surveying or participation. An SPSS database was prepared from the household questionnaire survey that was used for generating and analysing statistics.

In the next two sections, the results and discussion are joined in order to report material which is directly relevant for each drought response strategy. First, the case study area is described and analysed using data from the household surveys and observations. Second, the drought response strategies are described and analysed in the three main categories from the literature (Ahmad et al., 2014; Alam, 2015; Selvaraju et al., 2006; Shah et al., 2006) of food, water, and migration linking to health and livelihoods.

4. Case study area

The case study area is in Porsha Upazila (an upazila is a sub-district) of the Naogaon District of Bangladesh. Naogaon is located in the northwest region of Bangladesh (Figure 3a), 240 km northwest from the capital Dhaka). Porsha Upazila (Figure 3b) is in the northwest corner of Naogaon District, bordered by India. In this area, the three villages (Figure 3c) of Khatirpur, Bondhupara, and Natunpara were selected because they are indigenous communities in some of the most drought-prone areas of Bangladesh. They are surrounded by agricultural land with the study area covering approximately 0.56 km^2 and located between 88°28'43" east and 88°29'18" east in longitude and 24°56'08" north and 24°56'45" north in latitude.

Figure 3: Case study area of Porsha Upazila (produced by the authors).

The Santal in this area aim to preserve their indigenous culture, identity, and lifestyle, but are experiencing major social and environmental changes compared to previous centuries (Samad, 2006; Sarker et al., 2016). Livelihoods are based mostly on agriculture, farming, and paid labour but include small-scale freshwater fishing. The people feel geographically isolated, experiencing only marginal participation in the social and economic life of the surrounding area.

According to the Bangladesh Bureau of Statistics (BBS, 2013), the entire Chhaor Union (a union is the lowest electoral unit in Bangladesh) has 175 households with 676 inhabitants, yielding an average household size of 4 people. Most households (29%) comprise 3 people. 48% of the population are male and 52% are female, of whom about 11% are widowed or divorced (the governmental survey did not consider this rate for men). In this area according to BBS (2013), about 87% of people are Muslim, 2.5% are Hindu, 9.1% are Christian, and 0.8% are Buddhist.

The field investigation yielded different numbers, partly because no extrapolation was made, as occurs for the governmental survey, and partly because this study covered three villages of Chhaor Union rather than the entire Union. The total number of households in the case study area is 100 of which 60 sample households were chosen for the survey through simple random sampling. 95% are indigenous Santal people, with 95% involved in agricultural livelihoods including as labourers and subsistence farmers, generally working land which they lease from the landlord owners. Almost all are Christians, primarily Catholic, having been Hindu before with some elements of Hinduism still present (Akan et al., 2015).

The education rate in the study area is low being only 57%, with the rest of the people not being functionally literate. 53% of males and 60% of females are listed as being literate. Out of the 34% of the population who are 14 years old or younger, 53% attend school, of whom 46% are male and 54% are female (BBS, 2013). The FGD based PRA sessions provided a different picture, indicating that most of the Santal people are not functionally literate and lack opportunities for formal education. Instead, Santal children help with their parents' agriculture (boys) or household (girls) related work, so following traditional gender roles. The importance of education was rated low.

Mud houses dominate in the study area (85%) and they are generally rectangular with lengths of 6.0-9.0 metres and widths of 3.0-4.5 metres. They often have palm tree leaves as roofing material (also corrugated iron sheets). Since palm trees can live with limited water, this material indicates an adaptation to a water-deficit area. Mud houses are traditional in this area for poor families, being usually one or two storeys high and each house typically being used by one family. The local people explained that the mud house is long-lasting and comparatively cooler during the hot months of mid-April to mid-June.

BBS (2013) suggests that 80% of households own their own houses; 3% are rented; and the remaining 17% reside on land owned by others. The field survey here indicated that 97% of the Santal people do not own agricultural land, even when they own their house. The apparent difference arises because the Santals mostly live in tiny villages where they own their houses, but the villages are surrounded by vast agricultural fields which are mostly owned by some local influential people or landlords. The landlords typically sublease their agricultural lands to the Santal. Because DTWs improved water availability, agricultural production has been augmented while permitting multiple crops each year and rearing livestock simultaneously. Food availability and livelihood options for the Santal have thus expanded, improving their conditions, but not improving land ownership or access.

About 91% of the female population are engaged in household work while, among the employed male population, 83% are involved in the agricultural sector and 17% in the service sector such as pulling rickshaws, driving vans, selling consumer items, working in schools, and working with non-governmental organisations (BBS, 2013). No industry is listed for this area, confirmed during the fieldwork. The field investigation also confirmed that the Santal livelihoods in this area are based mainly on agriculture, both crops and livestock. More than 80% of Santal men and women find livelihoods in agricultural day labour, wage labour, and livestock rearing and driving (with non-indigenous Bangladeshis owning the farms) while the females also take care of the household. Agriculture dominates income sources, with two-thirds of the population deriving more than fourth-fifths of their income from agriculture.

5. Results and discussion: Responses to drought in northwest Bangladesh

5.1. Water collection and storage

Traditionally, according to the daily activity schedule and resource maps, people in the case study area used ponds and other surface water sources for drinking water and other domestic water uses, such as cooking, dish washing, bathing, cleaning, and livestock management. The resource maps (Figures 4a,b) show the locations of the ponds in the communities. Khatirpur and Bandhupara communities have a single pond inside the community whereas Notunpara community has four ponds inside the community boundary. When drinking water came from the ponds, water-borne diseases such as cholera and dysentery were common. People would get sufficient water only from May to July when rainfall is abundant, whereas March and April tend to be dry.

Figure 4: Resource Map of Study Area (Bandhupara Khatirpur and Notunpara) Under Chhaor Union in Naogaon District: Figure 4a from women, Figure 4b from men (produced by the participants).

From 1990-2000, the water situation changed. The people recognised that the surface water sources were being depleted, with rainfall pattern changes perceived to be a factor, but increased use likely contributed too, especially since BMDA had established a large number of deep-set STWs with a suction head of around 13.5 metres. Groundwater became the principal source of water, especially for drinking, although the ponds continued to be needed for other domestic water use. Water-related diseases dropped substantially with the people now saying that they are 100%-free from them. While arsenic and salinity contamination in drinking water is a concern for Bangladesh (Abedin et al., 2014), the aquifers of the Barind Tract display amongst the lowest arsenic concentrations in the country (Smedley and Kinniburgh, 2002).

In 2008, STWs started failing, as the suction head went beyond their reach. BMDA started establishing DTWs initially with a suction head of about 17.5 metres. Around 2014, with the gradual rise in irrigation water demand, the work efficiency of the DTWs was reduced to 70%

as the groundwater table went below 24 metres. At present, DTWs are almost non-functioning as the water suction head has gone beyond 30 metres.

The timelines revealed regular "summer" water problems until 2012, first due to ponds and other surface water drying up, but then after 2000, as the groundwater level fell, leading to a lower discharge rate from the DTWs. During the rainy season, the ponds' depth of water remains 3-4 metres which is suitable for all domestic water use. During the "summer", the ponds' depth of water becomes one-third of this value, so perhaps only one metre. At this shallow depth, the pond water becomes polluted, dirty, and unusable while some of the ponds have such low levels that fish cultivation becomes impossible. Only one pond from Notunpara remains active and the rest of the ponds from Notunpara as well as those in Bandhupara and Khatirpur become non-functional. Then, everyone from these three communities depends solely on the only active pond in Notunpara meaning that most people have farther to walk to get water for domestic use and so their water collection time increases.

The local Christian Missionary installed a DTW (the one within the Christian community's boundaries in Figure 4) in 2012 which now serves the surrounding local population, so fewer people have been experiencing a water crisis in the "summer". The surveys and timelines reported that, before 2012, 100% of the population had water problems in the "summer", but after 2012, only 35% did, mainly those beyond the access to the Christian Missionary's DTW. Before 2015, however, the drinking water was free, but now each household must pay BDT 20 per month (BDT is Bangladeshi Taka; 1 BDT ≈ 0.012 USD during this research) for drinking water which the Christian Missionary charges to offset the electricity costs for the pump. Nonetheless, it was said that those who do not pay the fee tend to be permitted to use the well.

2017 brought water crises in tandem with changing understandings of seasons. Traditionally, the "summer" would be from mid-March until early June, effectively the dry season until the monsoon comes. The monsoon or rainy season would then be from June until mid-August when the intense rains would stop. These timings have been shifting and becoming less reliable. For example, the interviewees stated that they could not plant the paddy rice during the regular season in 2017 due to lack of water, but they were able to plant later in the year.

For collecting water for domestic use, the survey data reveal households rely on female members. 79% of respondents said that the drinking water for their household is collected by a female member. The rest stated that both male and female members collect the water. The mobility maps prepared by the male and female participants revealed that women walk to collect drinking water mainly two times a day, at 8 am and 2 pm.

The household survey shows a change in drinking water collection time, defined as travel time both ways plus waiting and collection time which is not usually significant. From 1960-1990, the women's average water collection time was 15 minutes. From 2012, drinking water collection time increased to 20 minutes, although in some extreme cases the collection time extended to 30 minutes. As expected, the time varies according to the distance of households from the water collection point.

The average distance for walking to collect drinking water has increased over time. From 1960-2010, the average distance for collecting water was 100-200 metres. At present, the average distance has increased to 350-500 metres. The reason behind the increasing distance for collecting drinking water is that many water points have deteriorated and become obsolete, seemingly from overuse because so many households were going to a single source. The witnessed drought problems therefore appear to be more due to consumption patterns rather than due to rainfall variation.

The situation is similar for domestic water use other than for drinking (Table 2). Collection time for water for non-drinking domestic use has increased significantly as the ponds have dried up. During the rainy season, 53% of respondents spend 5-10 minutes collecting water for non-drinking domestic use while about 8% spend more than 20 minutes. During the dry season, times and distances for collecting water for non-drinking domestic use increase as the ponds' levels decline. Over the decades, people report faster drying of the ponds and lower water levels, meaning increased times and distances for collecting water for non-drinking domestic use.

Table 2: Availability of water for domestic use

Parameter	Monsoon	Summer	Remarks
Water depth of ponds.	3-4 metres	1-1.5 metres	In the "summer", water depth decreases and water becomes unsuitable for domestic use.
Fish cultivation.	Yes	No	The depth of pond water in summer is unsuitable for fish cultivation.
Collection time for water for non-drinking domestic use.	5-10 minutes	15-30 minutes	In the "summer", non-drinking domestic water collection distance increases. It imposes mental and physical stress on women and children as they try to carry as many pots as possible to reduce the travel frequencies.
Collection distance for water for non-drinking domestic use.	100-200 metres	400-500 metres	
Mode	Walking	Walking	Women and children have to walk longer distances in hot temperatures during the "summer" which imposes physical and mental stress on them.

People reported collecting water typically twice a day. From the household survey, people use mainly clay pitchers for storing drinking water and water for other domestic uses, covering over any storage facility to prevent evaporation. Other storage containers include plastic jugs, buckets, and mugs, with mud pitchers being traditional but less frequently used now. Rainwater is collected and stored, including for drinking, but the people reported perceptions that rainfall intensity and frequency have decreased over the years, meaning that opportunities for collecting rainwater are increasingly limited.

A standard pitcher equals approximately ten litres. According to this estimate, around 64% of the households consume one pitcher (ten litres) of water per day for drinking. Current water consumption for non-drinking domestic use varies markedly in different seasons. In general, the demand for domestic water use for cooking, cleaning, and washing does not vary much, but it changes substantially for other purposes such as livestock management. For example, during the "summer", cattle are bathed once a week compared to twice a week at other times. The change during the "summer" also helps to minimise travel time during the hottest months. The respondents further report a significant increase in domestic water use over past years due to increased population, more diversity of water uses, and increased use per person.

During times of water crisis, people try to reduce their daily water consumption. They reported often using only half a pitcher per day for drinking water, so approximately five litres per household per day. They also reported travelling to more distant sources to collect water in order to try to keep their water use at the typical level. People talked about storing water for times of water shortage, but did not seem to do anything differently than the regular collection and storage in pitchers and other containers. They did comment that during these periods, they cannot even offer a single glass of water to guests during the water crisis period. Table 3 summarises collection and storage of domestic water as drought responses.

Table 3: Collection and storage of domestic water as drought responses

Indicator	Monsoon	Summer	Remarks
Collection frequency per day.	2	3	Increasing travel frequencies in the "summer" due to availability of fewer water points and sometimes lack of water supply in the targeted point.
Amount stored.	Decreases	Increases	Increased storage in the "summer" to try to reduce travel frequency and avoid uncertainties of getting water.
Drinking water consumption.	Increases	Decreases	Decreasing use to try to reduce travel frequency and to store more water.
Household water use.	Increases	Decreases	
Travel distance.	Decreases	Increases	Only one pond remains active in the "summer".

5.2. Crop and livestock selection

Though agriculture is their main source of income, 79% of respondents think that it is not beneficial to invest in agriculture to increase income. The seasonal calendar (Figure 5) and cropping map indicate that, usually, only four months of the year experience rainfall whereas the other eight months tend to remain dry. Crops are cultivated during only four months—February, March, April, and October—so for the rest of the year, people rely on the foods produced during these months.

Figure 5: Seasonal calendar (produced by the participants).

The SWOT analysis (Table 4) further indicates why the people tend to be reluctant to expand agriculture, because the weaknesses and threats create major problems, especially relying on crops and livestock more than they do already.

Table 4: SWOT analysis of the study area by the focus groups

Strengths 1. Soil is fertile. 2. Soil is suitable for mango cultivation. 3. Productivity of crops is good. 4. Date juice is sweet.	**Weaknesses** 1. Water crisis. 2. Soil is hard, so a lower infiltration rate. 3. Low rainfall.
Opportunities 1. Seasonal migration. 2. Medical and school facilities. 3. Easy to go to hat/bazaar (the market).	**Threats** 1. Groundwater levels are decreasing due to surrounding DWTs. 2. Decreasing area for rice cultivation due to increasing mango orchards.

	3. The owners of the pond do not allow water extraction from the ponds.

Prior to 1970, paddy rice was the single largest crop in the study area, with livestock of buffalo and cattle being used to plough the land. Locally identified as *Roghushail*, *Zhirashail*, and *Sonashail*, there was one cultivation each year, mainly because irrigation water demand was too high. Given the cost of irrigation, little profit was made from paddy rice production, although it provided food to eat.

Considering both water demand and economic return, around 1992, people started to cultivate lentils as an alternative crop alongside paddy rice. Legumes improve soil aggregation, structure, permeability, fertility, and infiltration rate.

Progressively, people learned from nearby areas that guava and mango farming are more beneficial, being less labour-intensive, less water-intensive, and bringing much higher economic return. So around 2000, the Santal initiated guava and mango husbandry. At the beginning, when mango trees were being planted or are small, they cultivated paddy within the mango trees. As the trees grow bigger, they switch to mango production only. The mango trees mature enough to yield an economic return within 2-3 years after being planted and mango provides over four times the economic return compared to paddy rice cultivation (Table 5). In fact, because of the soil, mangoes from the Barind Tract are known as some of the highest quality mangoes in Bangladesh (see also Islam et al., 2017). Within five years, mango farming had become so popular that it had almost replaced traditional paddy rice cultivation, although paddy rice is still continued. New varieties of Boro rice—such as Sorna-5 and GutiSorna—are used, although the water demand for paddy rice cultivation remains high. A little income is also obtained from selling date juice and its products, which have good market value. Date trees have deep roots to extract soil moisture from deep soil rather than topsoil which is dry.

Table 5: Comparative return of agricultural crops in the study area from the focus groups (In this location, 1 Bigha = 1,340 m^2)

Crop	**Water requirement (m^3/Bigha)**	**Irrigation frequency per crop**	**Irrigation cost (BDT/Bigha)**	**% of Economic return**
Paddy	1300	10	2600	71%
Wheat	900	3	1800	102%
Beans	300	1	600	180%
Guava	85	2	170	220%
Mango	55	1	110	328%

Yet entire crop substitution would not be a solution, since rice gives different nutritional values than mango for eating. The people in the focus groups also explained that mixed cropping for drylands helps to overcome the water limitations during drought. In paddies, they cultivate some drought-tolerant rice varieties invented in Bangladesh such as BRRI DHAN-56 and BRRI DHAN-57. They also diversify to short-duration crop varieties requiring minimal water such as pulses, oil seed, guava, and mango with Table 5 showing the water cost and comparative economic return of these crops in the study area.

The fieldwork revealed a significant shift in the crops being cultivated, to diversify, to aim for higher income, and to adjust to drought conditions. The newer crops require less water, can survive dry periods, and exploit residual moisture in the soil.

5.3 Migration

The focus group discussions indicated the importance of migration as a response to drought and expectations of drought. The people tend to prefer temporary or seasonal migration, typically migrating for 2-3 months each year due to the unavailability of work during the off-season. One exception is that many young adults prefer to migrate permanently to the capital city of Dhaka. The seasonal calendar (Figure 5) indicates that migration out from the area is high from September to December, especially in December when there are few agriculture-related tasks to do. People move to other areas to work at jobs such as rickshaw pulling, masonry construction, and garment making. They return in January for harvesting. Regarding April and May, the people who migrate (mostly adult males) tend to leave during the "summer" when there is a water shortage and then they return once the monsoon starts.

The household survey indicated that approximately 45% of the population migrate to nearby cities, namely Rajshahi or Naogaon, when cultivation stops. About 36% remain behind to tend to livestock, with the others involved mainly in household activities. Temporary and seasonal migration is viewed as a relatively recent activity, possibly linked to increasing drought. According to the survey, 52% of respondents believe that the scale of migration seen now started 6-10 years ago, whereas 38% stated that it is much more recent, starting just 1-5 years ago. These views could indicate a change in strategies to deal with drought, relying more on temporary migration and income diversification, whereas traditionally all strategies would be home-based.

The Government of Bangladesh (2017) recently adopted the National Plan for Disaster Management (2016-2020). This plan suggested investing intensively to deal with drought by supporting a range of measures such as drought-sensitive land use planning, food stock buffers for crises, improved use of rainwater, technologies for recharging groundwater, development of community-based warning systems, strengthening of formal institutional capacities, and promoting indigenous knowledge. This research supports this plan in providing guidelines on how indigenous knowledge might be transferred and applied for addressing drought disaster in northwest Bangladesh. It also offers alternatives, such as managed migration and more attention given to gender equity.

6. Wider applicability and conclusions

This research contributes to the literature since the Santal have never before been researched with regards to their responses to drought. The results suggest that the Santal people have developed and applied mechanisms for themselves to respond to drought, including changing crops, reducing water use, storing water, travelling farther for water, and migrating to large cities temporarily for alternative livelihoods and for reducing local water consumption. The availability of modern water supply sources installed by various NGOs and government initiatives have provided opportunities, such as reducing water-borne diseases, but have also depleted groundwater and created dependencies on external support. Thus, it has been useful to apply the framework from other drought-related research in Bangladesh covering three main categories of food, water, and migration which link directly to health and livelihoods.

This understanding of local approaches for dealing with drought hazards and vulnerabilities in Bangladesh corroborates wider literature, such as from southeastern Kenya (Fleurett, 1986) and south Peru (Moseley et al., 2017), demonstrating the challenges and opportunities which indigenous peoples face in addressing drought locally. Transferability from the Barind Tract elsewhere and vice versa could be investigated further, especially in the context of determining the applicability and generalizability of development approaches to drought (Wilhite and Glantz, 1985) and dealing with droughts of all types through well-established development mechanisms (Kinsey et al., 1998; Rossi et al., 2005).

Certainly, if water use continues to increase along with climate variability, then no guarantee exists that indigenous responses in a particular location would suffice to deal with all the negative impacts of droughts. External approaches in tandem with indigenous knowledge (e.g. Balay-As et al., 2018; Glantz, 2003; Shaw et al., 2009) might best support drought responses. To move forward with such changes and drawing on international expertise for it, the research here provides a solid baseline for collaborating with the Santal in northwestern Bangladesh.

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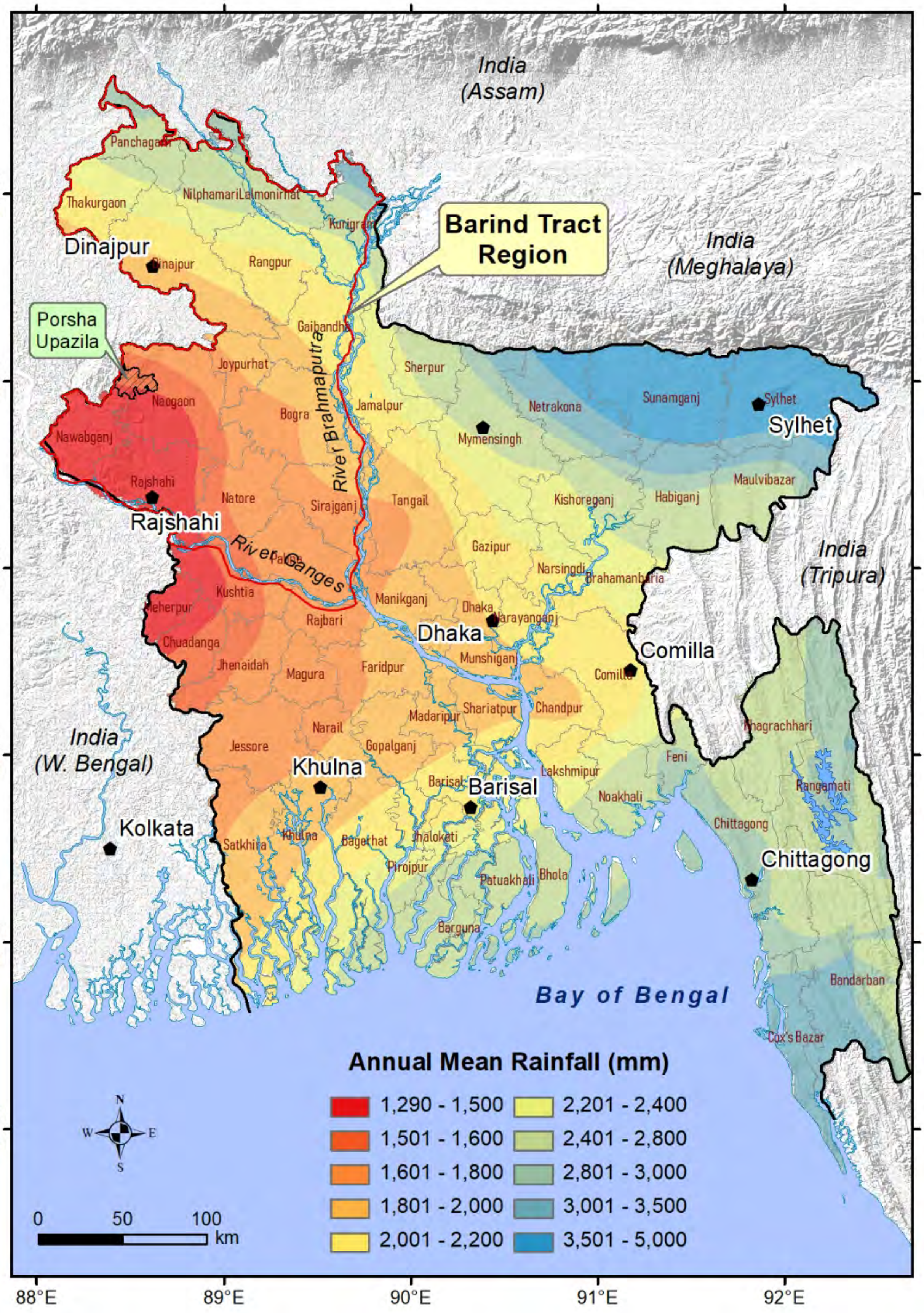
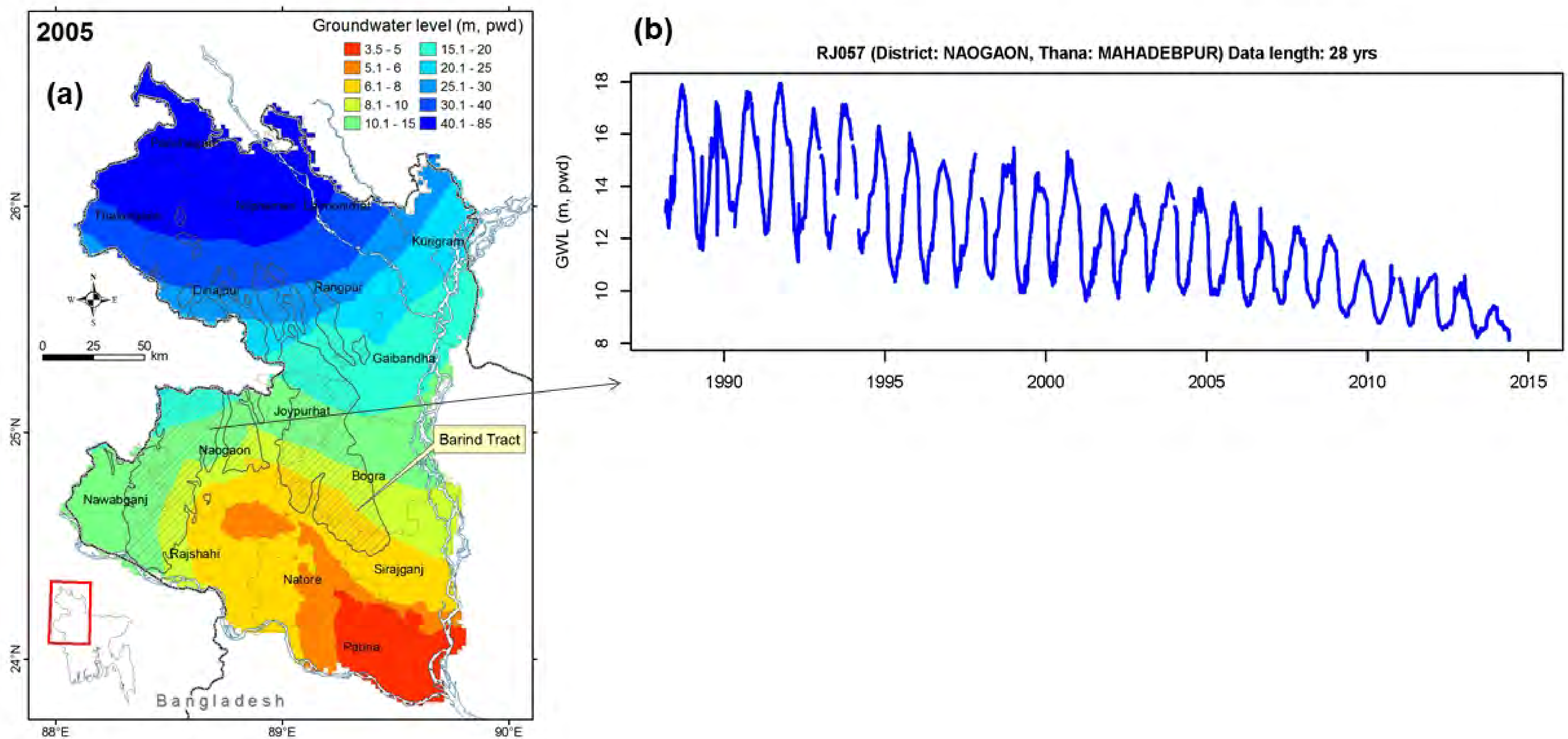
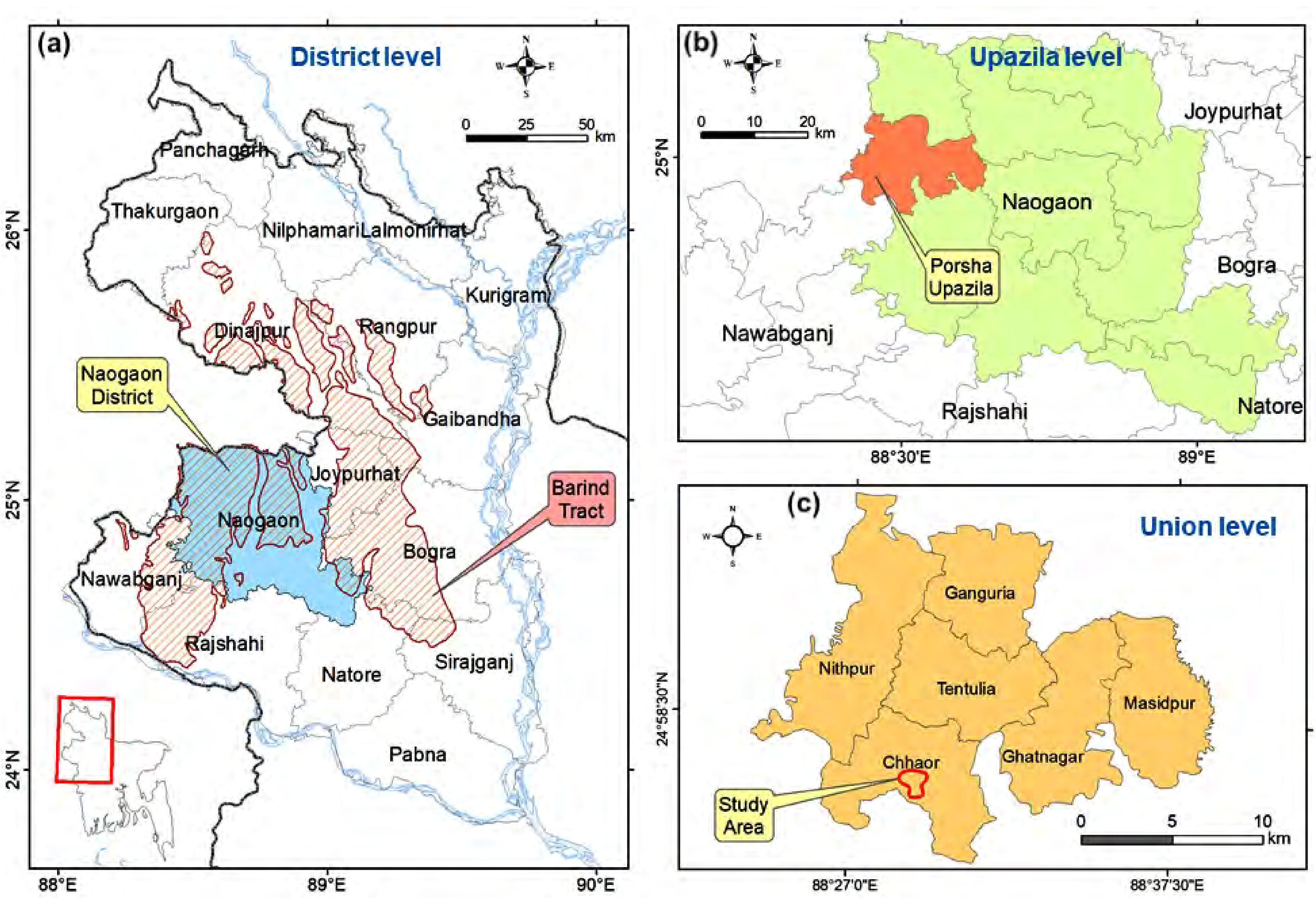
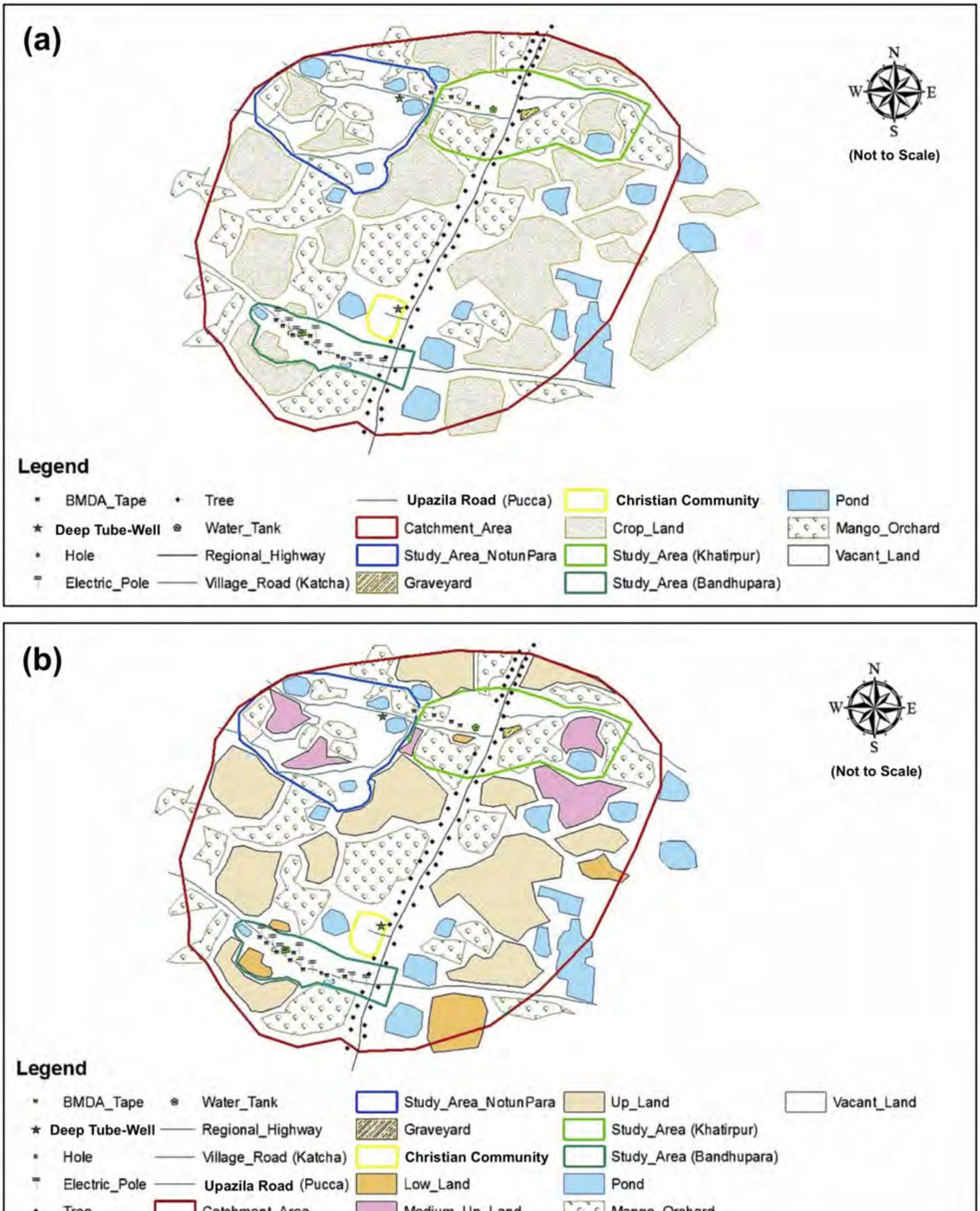


India (Assam)
India (Meghalaya)
India (Tripura)
India (W. Bengal)
Barind Tract Region
Porsha Upazila
Dinajpur
Rajshahi
Sylhet
Dhaka
Comilla
Khulna
Barisal
Kolkata
Chittagong
River Brahmaputra
River Ganges
Bay of Bengal
Annual Mean Rainfall (mm)
1,290 - 1,500
1,501 - 1,600
1,601 - 1,800
1,801 - 2,000
2,001 - 2,200
2,201 - 2,400
2,401 - 2,800
2,801 - 3,000
3,001 - 3,500
3,501 - 5,000
0 50 100 km
88°E 89°E 90°E 91°E 92°E
21°N 22°N 23°N 24°N 25°N 26°N



2005
(a)
Groundwater level (m, pwd)
3.5 - 5
5.1 - 6
6.1 - 8
8.1 - 10
10.1 - 15
15.1 - 20
20.1 - 25
25.1 - 30
30.1 - 40
40.1 - 85
Kurigram
Dinajpur
Rangpur
Gaibandha
Joypurhat
Naogaon
Bogra
Barind Tract
Nawabganj
Rajshahi
Natore
Sirajganj
Pabna
Bangladesh
0 25 50 km
26°N
25°N
24°N
88°E
89°E
90°E
(b)
RJ057 (District: NAOGAON, Thana: MAHADEBPUR) Data length: 28 yrs
GWL (m, pwd)
8
10
12
14
16
18
1990
1995
2000
2005
2010
2015


(a)
District level
0
25
50
km
Panchagarh
Thakurgaon
Nilphamari
Lalmonirhat
Kurigram
Dinajpur
Rangpur
Naogaon District
Gaibandha
Joypurhat
Naogaon
Barind Tract
Bogra
Nawabganj
Rajshahi
Natore
Sirajganj
Pabna
26°N
25°N
24°N
88°E
89°E
90°E
(b)
Upazila level
0
10
20
km
Joypurhat
Naogaon
Porsha Upazila
Bogra
Nawabganj
Rajshahi
Natore
25°N
88°30'E
89°E
(c)
Union level
Ganguria
Nithpur
Tentulia
Masidpur
Chhaor
Ghatnagar
Study Area
0
5
10
km
24°58'30"N
88°27'0"E
88°37'30"E


(a)
N
W
E
S
(Not to Scale)
Legend
BMDA_Tape
Tree
Upazila Road (Pucca)
Christian Community
Pond
Deep Tube-Well
Water_Tank
Catchment_Area
Crop_Land
Mango_Orchard
Hole
Regional_Highway
Study_Area_NotunPara
Study_Area (Khatirpur)
Vacant_Land
Electric_Pole
Village_Road (Katcha)
Graveyard
Study_Area (Bandhupara)
(b)
N
W
E
S
(Not to Scale)
Legend
BMDA_Tape
Water_Tank
Study_Area_NotunPara
Up_Land
Vacant_Land
Deep Tube-Well
Regional_Highway
Graveyard
Study_Area (Khatirpur)
Hole
Village_Road (Katcha)
Christian Community
Study_Area (Bandhupara)
Electric_Pole
Upazila Road (Pucca)
Low_Land
Pond
Tree
Catchment_Area
Medium_Up_Land
Mango_Orchard

	January	February	March	April	May	June	July	August	September	October	November	December
Rainfall and Temperature	×	×	×							×	×	×
Crops												
Migration				↓ ↓ ↓ ↑ ↑ ↑	↓ ↓ ↓ ↑ ↑ ↑				↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑ ↑ ↑ ↑
Employment												
Disease	★	★	★	★ ★ ★ ★ ★	★ ★ ★ ★ ★	★ ★ ★ ★ ★	★	★	★	★ ★ ★ ★	★ ★ ★ ★ ★	★ ★ ★ ★ ★ ★
Sufficient water												
Irrigation water demand	☆	☆ ☆ ☆	☆ ☆ ☆	☆ ☆ ☆					☆	☆ ☆ ☆	☆	☆
Food security	***** *****	*****	*****	*****	******	******	******	*	*	***** *****	***** *****	***** *****