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Water Scarcity, Seasonal Variation and Social Conflict in Mountain Regions of Bangladesh

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Abstract

The study intends to assess water scarcity, seasonal variations, and social conflicts through a cross sectional study based on people's perceptions. A well-structured questionnaire coupled with an interview schedule was used for data collection from the 60 households living in the mountainous two villages at Waga union of Kaptai Upazila under Rangamati District, Bangladesh. The study employed a multi-stage random sampling technique. The analysis reveals that 90% of respondents in Sapchari Monpara village mostly rely on spring for water, while 83% of respondents in Debotachari village depend on tube-wells. The study also shows that 80% of the respondents have experienced water scarcity in domestic use, while 90% of respondents have reported short duration of the rainy season causes water scarcity. More than 80% of respondents believe that shifting cultivation in upland catchments causes water quality degradation in the study villages. Most of the respondents obtain water easily in a monsoon at Sapchari Monpara, while others get from tube-wells and traditional wells in all seasons. About (87%) of respondents mention that forest conservation around the water sources can increase water availability.

Keywords

Water shortage; People's perception; Water harvesting; Catchment area

Introduction

Water is a valuable natural resource, vital for life, development, environments, and ecosystems (Sivakumar, 2011; Loucks and Beek, 2017). Water is essential for the growth, development, and survival of plants, animals, and human societies (Sivakumar, 2011). The availability of freshwater resources is essential for any development and quality of life, especially in mountainous areas (Tampakis, Manolas, and Matoli, 2011; UNEP, 2009). However, due to increased human activities, population growth, and industrialization, this precious resource is under heavy demand and threat (Abu-Zeid and Shiklomanov, 2003; Hafizur, Hossain and Rumainul, 2017). A rising scarcity of freshwater in comparison to human needs is now evident in many parts of the world (Postel, 2000; Rajat, Jagjit, and Harpreet, 2019). Several parts of the world face water shortages and water commoditization. But how this is perceived is problematic, and its consequences in the form of policy responses become critical (Fougner, 2008; Boelee *et al.*, 2017).

Today, inadequate water availability and quality have become a significant challenge to human livelihoods, food security, and natural ecosystems (Luijten, Knapp and Jones, 2001; Krishna, 2011). In many parts of the world, overexploitation of freshwater for agriculture, industry, and urban activities threatens the health of aquatic ecosystems and their life support systems (Krishna, 2011; Covich, 1993; Postel and Carpenter, 1997). The current water consumption rate will only worsen the situation (Gobarah *et al*., 2015). It is estimated that two-thirds of the world's population may experience severe water shortage by 2025 (Luijten, Knapp and Jones, 2001; Gobarah *et al*., 2015; Seckler, Barker and Amarasinghe, 1999). In the coming decades, water experts predict that more than half of the world's population will suffer acute water scarcity by 2050 (Gobarah *et al*., 2015). People in developing countries are predominantly at risk in areas experiencing rapid population growth and limited means of managing water resources (Luijten, Knapp and Jones, 2001). Therefore, for appropriate management and planning of water resources, watershed management is crucial. Watersheds have been extensively recognized as suitable biophysical or socioeconomic units for water resources management (Brooks *et al*., 2003; Lal, 2000; Luijten, Knapp and Jones, 2001), and streams in a watershed are the primary water source for domestic and agricultural practice in hilly rural areas (Luijten, Knapp and Jones, 2001).

There are many discussions on the water crisis worldwide (Daniel and Eelco, 2017). The developing countries, where much of the world population lives, face severe water scarcity and freshwater crisis (Sivakumar, 2011). Therefore, population growth, industrialization, urbanization, water pollution, deforestation, and water demand have also played a significant role in water scarcity (Fougner, 2008; Daniel and Eelco, 2017). An estimation suggests that 1.2 billion people do not have access to safe and affordable drinking water for their household use (Daniel and Eelco, 2017; WHO, 2003). According to the UN and UNICEF, most of the rural populations of 900 million live on less than a dollar per day without access to safe drinking water for their livelihoods (Rijsberman, 2006; FAO, 2006), and 2.6 billion populations are without proper sanitation facilities (UNICEF, 2019; UN, 2010). Lack of access to freshwater has significant impacts on the well-being of the population. It is estimated that lack of access to safe drinking water and inadequate sanitation and hygiene will cost the lives of 2.18 million people and have massive health consequences from diarrheal diseases (Khan, Rahim and Salam, 2003). Besides, extreme water shortage affects 400 million people today and 4 billion people by 2050 (Pruss *et al*., 2002; Biswas *et al*., 2012).

Rangamati district is the Southeastern part of Bangladesh under the Chittagong division, and the topography has a hilly slope and a moderate slope to the valley (Kamrul, Jashimuddin and Hossain, 2017). However, most of the local population, who are Indigenous communities, in the Rangamati district of Bangladesh is also suffering from water scarcity for six years (Miah *et al*., 2012). Many people even live with less income and suffer from other deprivations such as limited access to and low quality of social services, including water access (Dhali, 2008; Rasul, 2007; Thapa and Rasul, 2006). The overexploitation of natural resources, deforestation, and soil erosion may lead to water scarcity in the hilly areas (Verner, 2010). Further, removal of vegetation may affect the rainfall producing convection circulation in a local area and reduces precipitation in soil (Eriksen, 2001). The seasonal variations in rainfall and accelerated runoff may reduce the soil precipitation, affecting the underground water levels height resulting a shortage of surface and sub-surface water supplies (Miah *et al*., 2012; Biswas and Vacik, 2008). This can be detected through low water levels of rivers, reservoirs, swamps, lakes, and basins (UNESCO, 2006). Shifting cultivation is the principal land uses activity, with soil degradation often not taken into account in land management, enhancing the rate of soil erosion (Gafur *et al*., 2003; Biswas *et al*., 2012). As a result, the upland watersheds have seriously affected the lowland environment, particularly water quality degradation (Karmakar *et al*., 2011; Biswas *et al*., 2012).

Water management is a vital issue due to increasing demand and rising conflict between alternative uses. Furthermore, the availability of freshwater is very seasonal, depending on the monsoon's presence. Moreover, the population growth and global climate change could potentially bring additional difficulties in future planning and water management. Given these observations, previous studies assumed that there will not be enough freshwater to sustain all lives and ecosystems globally and that there will be water scarcity and crisis (Sivakumar, 2011; Chowdhury, 2010). The previous studies have assessed increasing water scarcity and analyzed improvement opportunities in rural areas of the Chittagong Hill Tracts in Bangladesh (Malley *et al*., 2009; Biswas *et al*., 2012). However, limited research has been conducted on this issue in the hilly catchment areas in the Rangamati district. Therefore, a well understanding situation is necessary for proper management of water resources management in the hilly catchment area. However, it is also important to understand the water management challenges in terms of water's role in exploring the types and nature of socio-economic aspects affecting people's livelihoods. Thus, the study has been undertaken to assess the water scarcity, seasonal variations, and social conflicts through a cross-sectional survey based on people's perceptions of the study area.

Methodology

Description of the study area

The study was carried out in the mountainous two villages, Sapchari Monpara and Debotachari of Kaptai Upazila in the Rangamati District of Bangladesh. The study area lies between 22°21' and 22°35' north latitudes and in between 92°05' and 92°18' east longitude (BBS, 2009). The Kaptai Upazila is part of the Rangamati District of Chittagong Division, which is 259 km^2 (Kamrul, Jashimudin and Hossain, 2017; RHDC, 2011). The study villages topography has a hilly slope and a moderate slope to the valley (Table 1). The sources of drinking water are tube-well (23%), tap water (43%), pond (2.6%), and others (31%) (RHDC, 2011). These two villages were chosen for this study as most of the population is indigenous and has been suffering from water scarcity for six years (Miah *et al*., 2012). The study areas experienced severe environmental degradation due to shift cultivation; deforestation due to stone collection (Eriksen, 2001).

The water bodies, main rivers are Karnafuli and Kaptai lake. The Kaptai Hydroelectric Power Station, the only hydroelectric power plant in Bangladesh, is located here. This region has a tropical monsoon weather, and the annual temperature varies from 10˚C to 35˚C. The mean minimum temperature of 24˚C is experienced from December to January, and a maximum temperature of 34˚C is experienced from March to May (BMD, 2011). The annual rainfall varies from 2,200 mm to 3,000 mm, roughly 80% of rain takes place in May to September, which creates severe soil erosion on the prevailing steep slopes, and the rest of the months of the year remain nearly dry (Miah *et al*., 2012). Landforms of Rangamati are mainly composed of high hills and medium hills (Miah *et al*., 2012). The elevation of hills influences local rainfall and temperature. The soil physical and chemical characteristics also changed with an elevation of hills and, consequently, determine the crop suitability (Biswas *et al*., 2012).

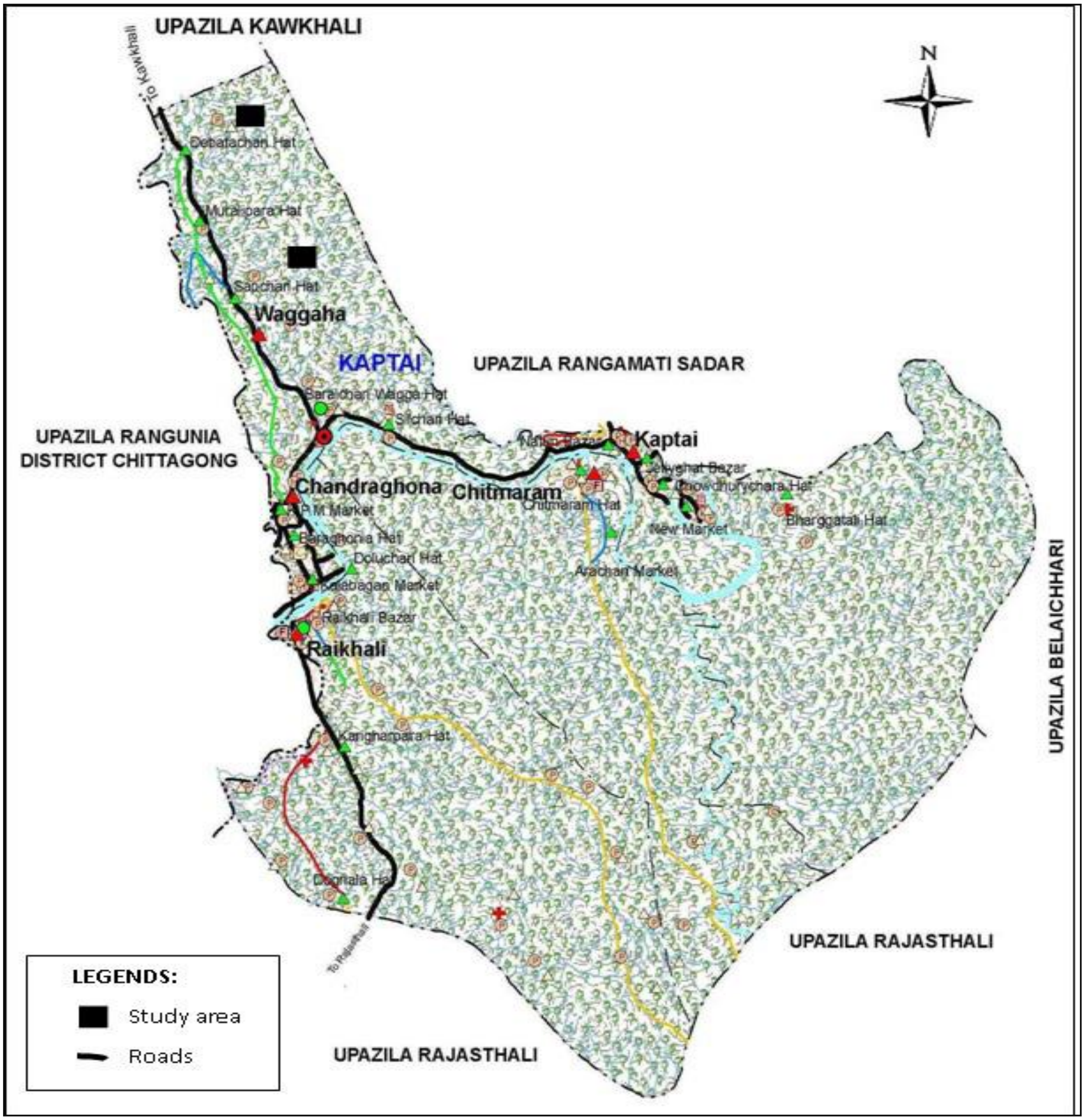

Figure 1: Location of the study area

Sampling methods

The population of the study area comprises both males and females in rural households of Indigenous communities. A multistage sampling procedure was employed to assemble primary data. Firstly, one (1) union was purposively selected from the five unions of Kaptai Upazila. Secondly, two (2) villages, namely Sapchari Monpara and Debotachari (Figure 1), were randomly selected from the union. Thirdly, thirty (30) respondents, including male and female, were randomly selected from rural households from each of the villages. Thus a total sample size of 60 respondents was selected for the survey. In Debotachari village, the rate of household sampling was 63% and Sapchari Monpara village the household sampling rate was75%. This study has been conducted at Waga union of Kaptai Upazila under Rangamati District, Bangladesh from January to March, and June to August, 2018.

Research tools

A range of research tools was used to collect information. A semi-structured questionnaire coupled with personal interview was used to elicit information from the respondents. The respondents were selected randomly for the interview. Five focus group discussions (FGDs) were arranged with the older people of the villages at familiar places where local people usually gather and sit. Total 30 people were randomly chosen for FGD session. Key questions were asked based on study objectives such as water shortage, seasonal variation, social challenges, and its solution. This approach helped reduce personal prejudice and verify the common knowledge among the villagers (Muhammed *et al*., 2013). Three key informant interviews (KIIs) were conducted with various sectoral specialists, leaders, and professionals to obtain the accurate information about the reasons, trends, and water scarcity. After completing data gathering, data were coded and tabulated into an excel sheet (Excel 2016), and statistical analysis was carried out by SPSS version 22. Data were carefully cleaned and validated to increase reliability. However, data were analyzed using both descriptive statistics and mean score and graphical representation by Microsoft Vision 2016.

Measurement of major indicators

Based on the people's perception, the water scarcity of the mountain households has assessed households' access to water sources, water use pattern, the extent of water scarcity, duration, quantity, and quality. A seasonal variation also affects water availability and creates challenges for mountain households. It has assessed by measuring the household's access to water in the different seasons to stream, spring, tubewells, and traditional well. Similarly, social conflicts have been measured by assessing gender involvement in fetching water, social challenges, and opinions to improve water availability. A number of context specific sub-indicators have been selected from existing literature (Biswas *et al*., 2012), results from FGDs, and key informant interviews. The nature of water shortage may be a social construct or the result of altered supply patterns stemming from climate change (FAO, 2007; Hossain *et al*., 2019; Sarker *et al*., 2020). In Kaptai, villagers experience a water shortage in two dimensions: the available amount for use and its suitability for human consumption. FGDs and household surveys analyzed the causes and processes of these two aspects of water scarcity.

Results

Water scarcity

Water plays an essential role in various aspects of people's livelihoods. Access to an adequate water supply can regulate a wide range of tangible and intangible activities such as better health, time savings, expenditure savings, empowerment, community capacity, food security, productivity, income, etc. Previous study found that the poorest people in the Bushbuckridge district (South Africa) obtained 17-33% of their annual income through small scale productive activities, with water being a critical input (Moriarty, Butterworth and Koppen, 2004). From this study, it is very apparent that only 20% of respondents of Debotachari used stream as an essential source of water. The number of respondents from Debotachari used tube-well and traditional well as their primary water source, which is 83% and 40%, respectively (Table 1).

In contrast, the majority of the residents of Sapchari Monpara were entirely dependent on stream (87%) and spring water (90%) (Table 1). Observation shows that the respondents' choice of water sources varied due to the geographical location of villages. Sapchari Monpara village is situated in a hilly area, so it is challenging to construct tube-wells up there. Nevertheless, the other village Debotachari is located in the valley, which has created an opportunity for the villagers to access tube-wells and traditional wells as their essential water sources for their livelihood (Figure 2).

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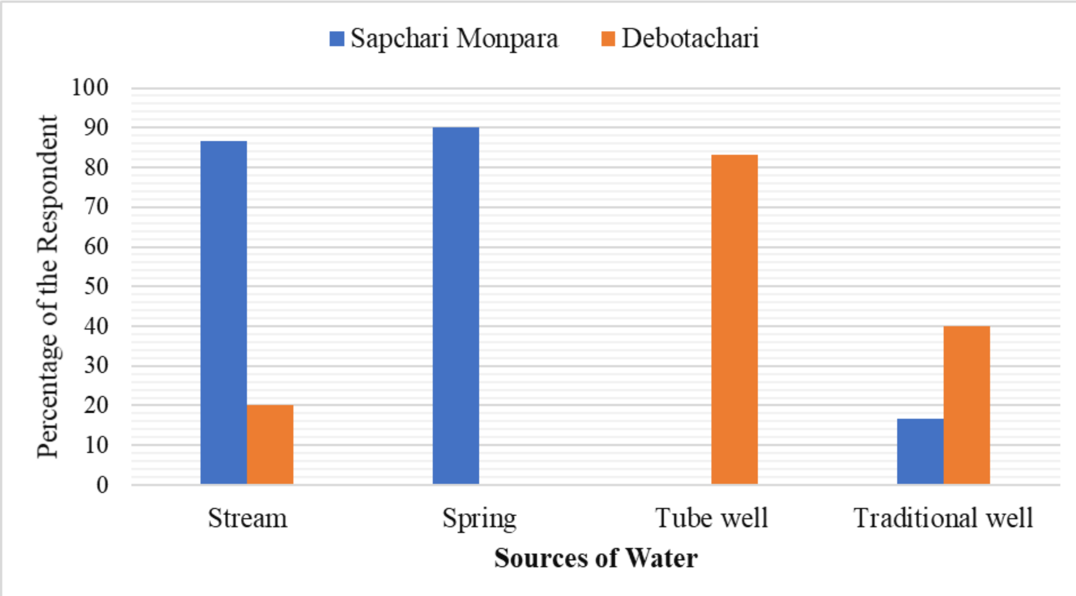

Figure 2: Sources of water

However, water sources impact on livelihoods is not always clear or equally distributed (Sivakumar, 2011). Previous study has found that a village in South Africa can better access better water supplies and is therefore in a better position to derive the maximum benefit from the water (Hope, Dixon and Maltitz, 2003). Thus, it is usually evident that improving water supply is likely to positively impact many aspects of people's livelihoods.

Table 1: Household perceptions on the important water sources in Kaptai

Responses	*Percentage of the respondents (%)*	
	Sapchari Monpara	*Debotachari*
*Important water sources (N=30) **	*100*	*100*
Stream	86.7	20
Spring	90	-
Tube-well	-	83.3
Traditional well	16.7	40

*More than one response was recorded; - No response was recorded.

The people of Sapchari Monpara are reliant on rain, streams, and springs for water (Table 2). It is only because of the non-availability of the tube-wells and traditional wells due to the village's geophysical location. In contrast, residents of Debotachari depended on tube-wells and conventional wells for water (Table 2). However, all the residents of Sapchari Monpara used spring water for drinking purposes, whereas 80% and 47% of respondents of Debotachari drink water from a tube-well and a traditional well, respectively. Besides, the stream water is used very wisely in both villages, as the general groups of villagers used it entirely for domestic use (100%), and the other groups of villagers used it both in household consumption[1] (73%) and irrigation (93%). However, Sapchari Monpara villagers do not use water for irrigation purposes as they are dependent on shifting agriculture and entirely rely on rainwater for irrigation. Moreover, a few respondents from both villages harvest rainwater for drinking purposes; the percentage was 10% in Sapchari Monpara and only 3% in Debotachari.

[1] Water uses (cooking, sanitation, cleaning and washing) besides drinking.

Table 2: Water sources used for different purposes in Kaptai

Responses	*Percentage of the respondents (%)*					
	Sapchari Monpara			*Debotachari*		
*Water use purposes (N=30) **	*Drinking*	*Domestic*	*Irrigation*	*Drinking*	*Domestic*	*Irrigation*
Stream	26.7	100	-	-	73.3	93.3
Spring	100	10	-	-	-	-
Rainwater	46.7	-	-	6.7	30	-
Traditional well	16.7	-	-	46.7	36.7	-
Tube-well	-	-	-	80	63.3	-

*More than one response was recorded; - No response was recorded.

Water scarcity and its extent

The FAO identified water scarcity as the point at which all consumers overall impact affects the supply of water under existing institutional mechanisms to such an extent that all sectors demand, including the environment, are not completely satisfied (FAO, 2007). This survey found that 73% and 80% of the respondents belonging to Sapchari Monpara and Debotachari villages, respectively, have been facing water scarcity for more than 6 years (Figure 3). This means that most of the respondents of the study area are experiencing water shortages. These findings highlight water scarcity severity as a social problem (water conflicts, waterborne diseases, and poor sanitation) faced by the communities in the study area (Figure 5). From the study, it was apparent that only 10% of respondents of both villages are facing water scarcity for 2-4 years. Whereas 10% of respondents of Debotachari said that the problem of water scarcity existed for less than 2 years, and 17% of respondents have admitted it remain for 4-6 years. Therefore, most of the respondents of Sapchari Monpara and Debotachari mentioned facing water scarcity problems for more than 6 years by 73% and 80%, respectively (Figure 3). The FGD analyses reveal that Sapchari Monpara and Debotachari respondents are getting less water from the streams and springs in recent years. They perceive that due to the destruction of forests in the upland hills, the water shortage has existed. Besides, the stone collection from the stream for business purpose and forest destruction in catchments decrease the water infiltration capacity of soil in the catchment, while the stone collection from streams helps the water flow smoothly.

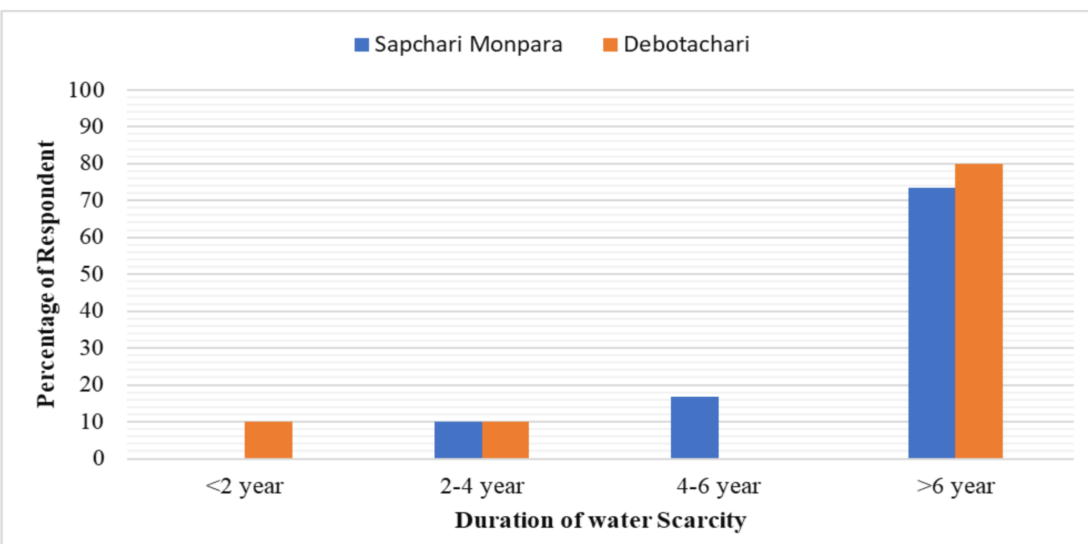

Figure 3: Household perceptions on the duration of experiencing water scarcity in Kaptai

Decline in water quantity and quality

Water scarcity is mostly related to the water supply needed for various purposes. This fact becomes even more apparent as both the villages have poor water supply due to the low availability of water. The reasons for this low availability of water are the uneven distribution of rainfall, increased water demand, and the removal of vegetation from upland catchment areas (Biswas *et al*., 2012). According to the analysis, both villages' respondents agreed that the increased water demand and deforestation have contributed to water scarcity, which is 80% and 60%, respectively. A number of respondents of Sapchari Monpara perceived that decreased rainfall duration and amount are the causes of water shortage, which is 90% and 83%, respectively (Table 3). Considering people's perception, the Debotachari respondents have reported water misuse due to poor quality, leading to social water shortage. Besides, 30% of respondents have revealed that sedimentation in the natural water sources is responsible for water quality degradation. In contrast, 17% reported that watering livestock in the streams is another cause of water quality degradation (Table 3).

Table 3: Household perceptions about the causes of water scarcity in Kaptai

*Perceived causes of water scarcity**	*Percentage of the respondent (%)*	
	Sapchari Monpara	*Debotachari*
A decline in the quantity of water supply		
Decreased rainfall duration	90	23
Declined rainfall amount	83	43
Increased water demand	73	80
Deforestation	80	60
Degradation of quality of human use		
Sedimentation in the natural water sources	-	30
Watering livestock in the stream	-	17

*More than one response per respondent was recorded.

Activities degrading water quality

Agricultural activities, which are considered an important way of life in rural areas, cause environmental quality degradation and subsequently impair water quality. 83% of respondents from Sapchari Monpara and 90% of respondents from Debotachari attributed the shifting cultivation in upland watersheds responsible for harm water quality. However, 40% of respondents in Sapchari Monpara and 50% of respondents in Debotachari have said that the low conservation measures in the upland catchment are causing the degradation of water quality in the stream (Table 4). 17% of respondents of Debotachari believe that watering the livestock may degrade the water quality. Furthermore, 40% of people revealed that natural sediment and debris accumulation in the stream might impair the water quality.

Table 4: Household perceptions for human activities for water quality degradation in Kaptai

*Anthropogenic activities degrading the water quality**	*Percentage of the respondent (%)*	
	Sapchari Monpara	*Debotachari*
Low conservation measures in upland catchments	40	50
Shifting cultivation in upland catchments	83	90
Watering livestock in the stream	-	17
Sediment load and accumulation of debris	13	40

*More than one response was recorded.

Seasonal variation of water availability in stream

The availability of water in different water sources varies with seasons. 83% of the respondents in Sapchari Monpara have given their response the water is more available in monsoon season, whereas in Debotachari, 73% respondents have reported the water is more available in monsoon. However, 67% of the respondents also have reported that water becomes less available during summer in Sapchari Monpara and in Debotachari at winter (Table 5). 10% of respondents have said that water is not available in winter in Sapchari Monpara, while 33% respondents of Debotachari articulated the same. In Debotachari, 27% of respondents have reported that water is available in monsoon, whereas in Sapchari Monpara, 17% of respondents indicated that water is available both in winter and monsoon season.

Table 5: Seasonal variation of water availability in the stream in Kaptai

Categories	*Percentage of the respondents (%)*					
	Sapchari Monpara			*Debotachari*		
	Winter	*Summer*	*Monsoon*	*Winter*	*Summer*	*Monsoon*
More available	-	-	83	-	-	73
Available	17	13	17	-	-	27
Less available	73	67	-	67	17	-
Not available	10	20	-	33	83	-

Seasonal variation of water availability in spring

The study has found that only residents of Sapchari Monpara had access to spring water. 80% of the respondents in Sapchari Monpara have reported that water is more available in the monsoon season. In contrast, 93% of the respondents opined that water is less available in winter season. Further, 80% of the respondents of Sapchari Monpara have given their opinion water is less available in summer season (Table 6).

Table 6: Seasonal variation of water availability in spring in Kaptai

Categories	*Percentage of the respondents (%)*					
	Sapchari Monpara			*Debotachari*		
	Winter	*Summer*	*Monsoon*	*Winter*	*Summer*	*Monsoon*
More available	-	-	80	-	-	-
Available	7	20	20	-	-	-
Less available	93	80	-	-	-	-
Not available	-	-	-	-	-	-

Seasonal variation of water availability in tube well

It is evident from the result that tube-well is the primary water source for residents of Debotachari (Table 7). Water remains available in tube-wells throughout the year in Debotachari, but the availability level varies significantly according to seasons. 67% of respondents in Debotachari village have revealed that water is more available during the monsoon. 23% respondents of Debotachari village have reported that water is available throughout the year. Besides, 47% of the respondents in Debotachari village have said water is less available in summer season (Table 7).

Table 7: Seasonal variation of water availability in tube-well in Kaptai

Categories	Percentage of the respondents (%)					
	Sapchari Monpara			Debotachari		
	Winter	Summer	Monsoon	Winter	Summer	Monsoon
More available	-	-	-	47	20	67
Available	-	-	-	23	23	23
Less available	-	-	-	30	47	10
Not available	-	-	-	-	10	-

Seasonal variation of water availability in a traditional well

In different seasons, water availability in conventional wells varies in Kaptai Upazila. In Debotachari, 33% and 20% of respondents, respectively, said that water is available in winter, and monsoon seasons. In contrast, there were no traditional wells in Sapchari Monpara village. However, 57% of respondents in this village said that water is less available during winter, and 53% of the respondents said that water is less available during summer. More than 70% of respondents from Sapchari Monpara stated that water is unavailable in traditional wells during monsoon (Table 8).

Table 8: Seasonal variation of water availability in traditional well in Kaptai

Categories	*Percentage of the respondents (%)*					
	Sapchari Monpara			*Debotachari*		
	Winter	*Summer*	*Monsoon*	*Winter*	*Summer*	*Monsoon*
More available	-	-	-	-	-	-
Available	-	-	-	33	20	10
Less available	-	-	-	57	53	17
Not available	-	-	-	10	27	73

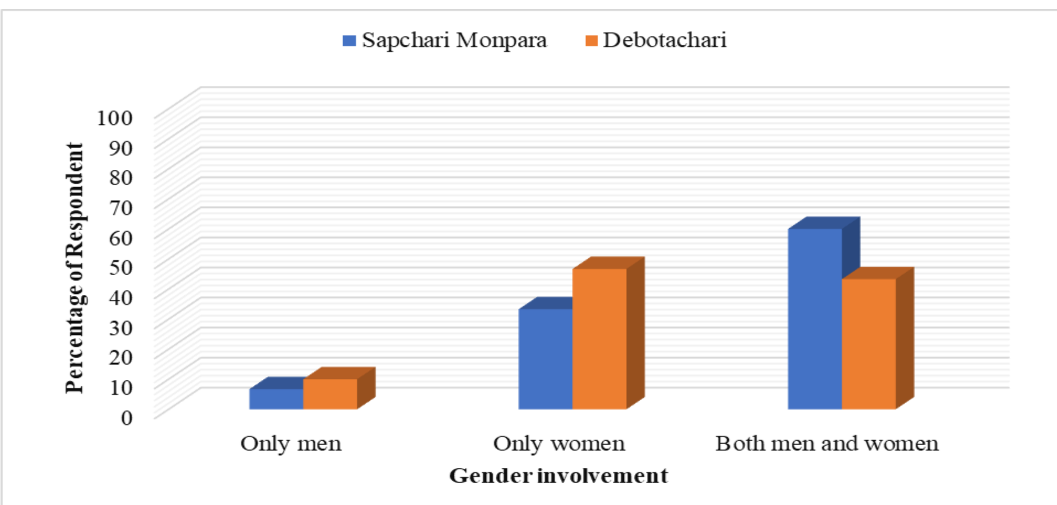

Figure 4: Gender involvement in fetching water in Kaptai

Social Conflicts

Gender involvement in fetching water

In most of the developing countries, women and girls are ritually responsible for managing the household water supply and sanitation (UNICEF, 2008). As key persons at the household level, women are more interested in improving water and sanitation services and sustaining facilities. Survey in both the villages showed a higher percentage of women than men participating in fetching water. Only 6% and 10% of men were engaged in bringing water in Sapchari Monpara and Debotachari villages, respectively. Men do not even go frequently for water fetching in the village of Sapchari Monpara. In contrast, the proportion of women in Debotachari and Sapchari Monpara who fetch water was 47% and 33%, respectively. Thus, even though the percentage of women in fetching water was higher in Debotachari than in Sapchari Monpara, when both men and women were combined, the total percentage of both men and women in bringing water became higher in Sapchari Monpara than Debotachari (Figure 4). Therefore, the study assumed that women were more involved than men in fetching water both individually and together with men in the study area.

Social Problems due to water scarcity

Based on the respondent's opinions and FGD analyses, it was found that water scarcity leads to various social problems like conflicts in households, waterborne diseases, and poor sanitation, etc. The people of Sapchari Monpara rely on the spring for drinking water and the stream for domestic purpose. They have better water access in monsoon season, and less access in spring and dry season (winter and summer). In contrast, the respondents of Debotachari village get water from tube-wells and traditional wells in all seasons. However, the stream supplies less water in the first days of the winter season and completely dry out for the rest of the winter, and continues until the end of monsoon. Consequently, the people have to spend more time to collect water, which creates conflicts between them during collection and bathing. Water scarcity also creates conflicts within family members due to cooking delays, water unavailable for domestic use, and improper sanitation. These challenges further develop waterborne diseases like diarrhea, dysentery, cholera, etc. (Figure 5).

Opinions for improving water availability

Most of the respondents (87% in Sapchari Monpara and 77% in Debotachari) believed that forest conservation around the water sources increased water availability (Table 9). However, 53% of respondents of Sapchari Monpara and 63% of respondents of Debotachari believed that constructing a dam in the stream would make water more available. 50% of Sapchari Monpara respondents have also reported that water is harvested in the rainy season to make water more accessible. Besides, 40% of respondents in Debotachari have reported digging boreholes and wells may improve water availability. The Chittagong Hill Tracts based NGO, Hill Flower, implements a community-based forest resources conservation project in Sapchari Monpara village and improving rural livelihoods and strengthening their capacities and awareness about the environment. Another local NGO, Green Hill, implemented a drinking water supply project in Debotachari village that resolves the water scarcity.

Table 9: Household perceptions for improving water availability in Kaptai

*Opinions for improving water availability**	*Percentage of the respondents (%)*	
	Sapchari Monpara	*Debotachari*
Conserving the forests around the source	86.67	76.67
Water harvesting in the rainy season	50	20
Constructing a dam in the stream	53	67
Digging boreholes and well	17	40

*More than one response was recorded.

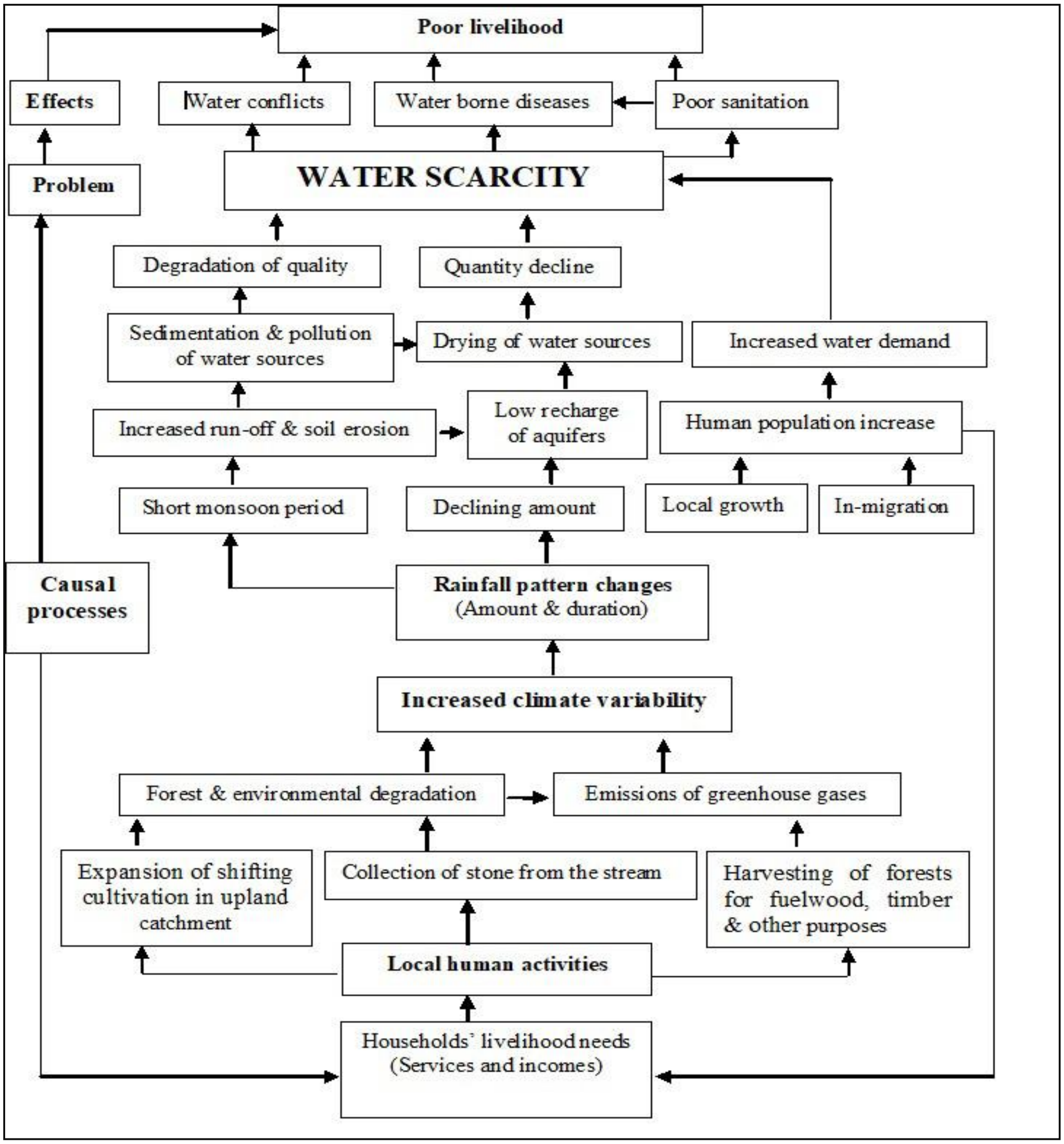

Figure 5: Cause-effects link model of water scarcity to the environment in Kaptai

Discussion

Generally, Chittagong Hill Tracts' weather has been characterized by rainfall (2,200-3,000 mm/year) (LGED, 2011). Nevertheless, during the FGDs, it was reported that the climate variability had increased in the Chittagong Hill Tracts region. Firstly, a notable increase of frequencies in precipitation deficiency, short heavy storms, and change in its timing were reported by respondents. Most of the households in the study areas associated with the increasing precipitation variability patterns faced water scarcity. This can be viewed from the perspective of rising hydrological changes, manifested by declines in surface and underground water supplies from springs, streams, traditional wells, and tube-wells. The rural livelihood activities based on natural resources (fuel and timber wood collection, edible fruits, and vegetable) keep pressure on forests, land, and water resources for agricultural production, which are degrading the environment. Previous authors reported that the degradation of forest and water resources are important sinks of Green House Gases (GHGs), and these degradations may alter the physical properties of the environment (Malley *et al.*, 2009). Droughts and seasonal variations in rainfall may reduce the soil precipitation, affecting the height of the under-groundwater levels. In this study, the respondents reported that water scarcity is associated with a shortage of rainfall. Besides, heavy storms result in runoff and soil erosion, reducing rainwater infiltration to recharge groundwater aquifers (Eriksen, 2001). Water sources, water availability and seasonal variation, water management, water scarcity duration, and social problems exist due to water scarcity. Reid and Alam (2016) have discussed ecosystems-based adaptation (EbA) emphasizes the importance of the multiple social, economic, and cultural benefits of ecosystems and their services to local communities. Healthy ecosystems provide drinking water, living space, shelter, food, raw materials, genetic materials, disaster prevention, a source of natural resources, and many other ecosystem services on which people depend (GIZ, 2019). This study supports these claims because the natural resources and ecosystem services at the hilly area offer various household benefits and livelihoods that contribute to community adaptive capacity and resilience.

The natural sediment loads come from mountain landslides that contribute to water pollution and can deteriorate water quality (Reid and Alam, 2016). Polluted water is not suitable for human consumption because pathogens and germs may be harmful to human health. Moreover, an increasing population may directly create pressure on water resources and increasing water demand needs (Rijsberman, 2006). The study shows that water shortages lead to several social risks: firstly, the risk of conflicts over the scarce water resource among the rural community; secondly, the risk of waterborne diseases (diarrhea, dysentery, cholera, etc.); and thirdly, the risk of diseases associated with inadequate sanitary and hygiene system. Most of the respondents suffer diarrhea and dysentery every year, which have been revealed in FGDs due to poor sanitation. Besides, the source of water is polluted by natural sediment from the Hilly catchment area. WHO also found similar results in their study that people experienced different waterborne diseases due to polluted water (WHO, 2003). Thus, the present study confirmed that the study villages are considerably facing water scarcity. Households have been found dependent on stream, spring, and tube-well for water as their livelihood support, and these water sources could not provide available water in the dry season. The increased demand for water, forest degradation, and reduced rainfall volume, water quantity, and quality are the prime reasons for the water shortage in the two villages (Malley *et al*., 2009). Besides, stone collection from streams for business purposes and fuelwood collection to meet the demand of brickfields further accelerated water scarcity. Shifting cultivation in the upland catchment, reduced conservation measures, and excessive water use for agriculture was also associated with water quality degradation. Consequently, the respondents have experienced poor livelihood, water conflicts, waterborne diseases, and poor sanitation. Flash flood is considered one of the significant natural hazards that directly and indirectly alter people's lives and livelihood by damaging agricultural production and ecosystems, increasing water pollution, and disrupting communication networks and neighboring economies (Abedin and Khatun, 2019).

Conclusion

Water is an essential for human survival and civilization. People of the mountain areas have limited access to modern life, and water availability. The present study focuses on the water scarcity, seasonal variations, and social conflicts in mountain areas. A number of indicators like people's perception of water scarcity, seasonal water availability, and their impact on social cohesiveness have been assessed. The study reveals that respondents mostly rely on stream (86.7%) and spring (90%) for water. The analysis also shows that 80% of respondents in Debotachari village have experienced water scarcity in domestic use for more than 6 years. More than 80% of respondents opined that shifting cultivation in upland catchments causes water quality degradation. 83% of respondents mentioned that water was more available in a monsoon in Sapchari Monpara village. The respondents of Debotachari village get water from tube-wells and traditional wells in all seasons, while in Sapchari Monpara village, the people rely on the spring for drinking and stream for domestic purposes. The study shows that the women participating in fetching water is higher than men in both the villages. Besides, women are bound to spend more time to collect water, which creates conflicts during water collection, bathing, cooking, water unavailability, and domestic use. About (86.67%)

respondents in Sapchari Monpara village agree that forest conservation around the water sources increases water availability. The study will be helpful to the mountainous region for sustainable water conservation.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4	Author 5
Conceived and designed the research or analysis	Yes	No	Yes	Yes	No
Collected the data	Yes	No	Yes	No	No
Contributed to data analysis & interpretation	Yes	Yes	No	Yes	No
Wrote the article/paper	Yes	Yes	No	No	No
Critical revision of the article/paper	No	Yes	No	Yes	No
Editing of the article/paper	No	Yes	Yes	No	Yes
Supervision	No	Yes	No	Yes	Yes
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