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Impact of climate change on human health: evidence from riverine island dwellers of Bangladesh

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ABSTRACT

This study aims to explore the impact of climate change on health, including local adaptation strategies. A mixed-method approach has been used in this study. The results reveal that increasing the frequency of flooding, severity of riverbank erosion and drought, and rising disease outbreak are the highest indicators of climate change perceived by riverine island (char) dwellers, which is similar to the observed data. It also uncovers, approximately all respondents encounter several health-related issues during different seasons where prevailing cold and cough with fever, skin diseases, and diarrhoea are the leading ailments. Several adaptation strategies are accommodated by char inhabitants in order to enhance resilience against the climate change health impacts, but the paucity of money, disrupted communication, lack of formal health-care centre are the most obstacles to the sustainability of adaptation. This research recommends that healthcare-associated project should be performed through proper monitoring for exterminating char dwellers' health issues.

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Climate change perception; natural disasters; health vulnerability; environmental pollution; adaptations' barrier; char dwellers

Introduction

The world has encountered enormous challenges and threats as a result of climate change in the twenty-first century (Rahman and Lateh 2017; Tajrin and Hossain 2017). It poses a great peril to the globe, where the developing countries are confronting absolute vulnerabilities owing to snowballing rate of occurrence and severity of calamities and intense weather (IPCC 2014). The shifting trend of temperature, rainfall, sea-level rise, and the alteration of severe climate indicators are all manifestations of climate change and its consequences (Weart et al. 2014). Climate change has a significant impact on global economic, social, and political activities, as well as a slew of chronic health issues (Lai et al. 2012; Du et al. 2013). Therefore, the negative effect of climate change is one of the myriad challenges to human beings throughout the world (Frumkin et al. 2008; Haque et al. 2013). IPCC repeatedly argued that climate change is now playing a role in the global burden of illness and premature death (Lai et al. 2012). The international community has made out that both the direct and indirect effects of climate change on human health can cause long-term harm (Ebi and Semenza 2008; Frumkin et al. 2008; Singh and Purohit 2014). Besides, the climate change implications on human health will be worldwide (WHO 2008). The result of the health effect will be spread out disproportionately across the areas, occupation, gender, and age, and reliant on community susceptibility level (Preet et al. 2010).

Bangladesh is such a country that is one of the most vulnerable and exposed to climate change because of its unique geographical location, fragile socio-economic conditions, growing population, extreme poverty, and low level of economic and technological capability (Shahid and Behrawan 2008; The Asian Foundation 2012). Due to drastic climate change, it is being estimated that this country is going to confront approximately 25 cm and 1 m sea-level escalation by the year 2050, and 2100 in turn, that will push 33 million and 43 million people homeless by the year 2050 and 2080, respectively (Huhtala et al. 2010; Haq and Ahmed 2017). Besides, the average temperature of Bangladesh is changing day by day as such approximately 1.0°C and 1.4°C will grow due to climate change by the year 2030 and 2050, respectively (IPCC 2014). It is ranked as the fifth most vulnerable country in the globe in terms of severe weather (Habiba et al. 2013). As a result, more or less every year, this country is facing recurrent extreme climatic events, such as floods, riverbank erosion, cyclones, waterlogging, salinity intrusion, landslides, storm surges, droughts, and so on (Catenazzo et al. 2012; Jordan 2015; Rakib et al. 2018); which leads to increase numerous complications along with severe direct and indirect health issues (Kabir et al. 2016).

However, among the susceptible areas to climate change in Bangladesh, the riverine island (char) is one of the most vulnerable to climate change due to its nearness to flood-prone rivers. Char land is such a place that is formed by a continuous phase of riverbank erosion and sediment deposition in major rivers and coastal zones, and it lasts for around 2–3 years. This land is mainly isolated from the mainland, although some of the chars are situated near to the mainland but most of them are far away from the mainland (Karim and Thiel 2017). This area is generally very low-lying and criss-crossed by the river systems. This zone is historically familiar as one of the most neglected and poor (Haque & Zaman 1993). Environmentally, this area is very vulnerable to recurrent natural disasters, such as floods, riverbank erosion, and so on. Besides, the people of this area face catastrophe like storms in the summer, flood, riverbank erosion in the rainy season and also drought in the summer, and spring, and cold waves in the winter season (Hossain et al. 2020a). Approximately 10% of the population lives in the riverine island of the world. Besides, there is an estimation that approximately 4–5% of the population in Bangladesh lives in the chars land (Hossain 2020). The majority of the char household is involved in agriculture, either directly or indirectly. Char regions in developing countries like Bangladesh are characterized by significant isolation from the mainland, deprivation from essential public facilities, and a backward region (Sarker et al. 2020). Char regions encompass a large portion of Bangladesh's north. Most of the housing features are very fragile. Mainly, the houses are made with Corrugated Iron (CI) and mud, thatch roofs, and Kaisha' made walls. Households dwelling in the island areas are regarded as most vulnerable community to the impact of climate change globally (Shah et al. 2013). The climatic hazards are continuing the process to destroy their crops, crops lands, and homesteads. As a result of these unique characteristics, char dwellers are more vulnerable, extremely impoverished, and food insecure. Char dwellers also have limited access to basic needs, such as food, agriculture, education, health, and finance, they are more likely to fall into poverty trap. Climate change consequences have a negative impact on char dwellers' earnings and job opportunities (Brammer 2014). Thus, it has been documented that these types of similar characteristics in the riverine islands are found around the world particularly in developing countries like Bangladesh (Adger et al. 2003). As the char dwellers are facing climate change-induced extreme hazards every year such as floods, riverbank erosion, drought, and so on. Therefore, the major climate-sensitive diseases (cholera, diarrhea, heart stock, mental disorders, high blood pressure, malaria, typhoid, malnutrition, etc.) have risen over the last decade (Wright et al. 2019; Hossain 2020). On the other hand, several as usual diseases like cold and cough, fever, headache, back pain, chest pain, energy loss, crack in feet, breath problem, physical injure, tonsil, and so on have also been increased by the severe climate events (Haque et al. 2013). Furthermore, climatic drivers will escalate the outbreak of numerous water-borne and vector-borne diseases along with normal health issues (Costello et al. 2011; Hall and Crosby 2020). This is why this research has focused on the riverine island in Bangladesh, where most of the people are living under the ultra-poor level (Islam 2018) along with low-level income and occupation. It has already been

established that disasters disproportionately affect the poor (Dayton-Johnson 2006; Parvin and Shaw 2013), and climate disasters are expected to wreak havoc on these people the most; and such people don't have sufficient defensive approaches (Brouwer et al. 2007).

Char dwellers form more or less adaptation strategies to respond to the health issues caused by climate change. Adaptation techniques are differed from one region to another region and from one culture to another (Khan et al. 2020). Specific adaptation strategies in a context are more effective in disaster areas (Ofori et al. 2017; Luo et al. 2018). Adaptation measures are developed according to the presence of the people's technological societal, environmental, economic, and physical resources (Thoai et al. 2018; Kubicek et al. 2019). Since the way of life and resilience of the char dwellers is highly reliant on agricultural-related work, and they are the supreme sufferer of the harmful effect of changing climate (O'Donnell 2019; Saptutyningsih et al. 2020). Thus, adaptation techniques have been widely essential for impoverished rural people to deal with changing climate effects (Randall and Van Woessik 2015; Jacquet et al. 2018). However, the approach may not be efficient without a thorough perception of climate change impacts alongside local adaptation tactics among char dwellers, which is crucial for improving resilience to climate change's harmful effects (Zijp et al. 2017; Kosanic et al. 2019; Tang and Hailu 2020). Also, local knowledge is the pivotal indicator for designing an adaptation mechanism (IPCC 2014).

A number of studies on climate change-related issues, such as livelihood, human displacement and resettlement, and health, including adaptation strategies, have already been conducted (Zaman 1993; Hutton and Haque 2003; Haines et al. 2006; Haque et al. 2013; Alam et al. 2017), but very little attention has been given to climate change-related health issues. More specifically, almost no research has yet been done on climate change's impact on health, and adaptation strategies in the char areas of Bangladesh. Therefore, this study attempts to fill some of this gap by analysing the climate change impacts on health based on people's perception and uncovering local adaptation strategies in the char areas of Bangladesh, including focusing on the loopholes and drawbacks of their coping strategies. Since the health complications have been increasing in the char regions with a great deal of inequality, addressing the health vulnerability from climate change is essential to reduce the intensity. Simultaneously, it is also crucial to understand the obstacles to adaptation practices among the char dwellers for making easy the appropriate adaptations to climate change. This study would enrich the expertise of adaptation attempts against the effects of climate change and support to ascertain the impediments of climate change for adapting practices of riverine char dwellers in Bangladesh.

Materials and methods

General descriptions of the study area

Char (island) land is such a place where approximately globally, 10% of the inhabitants live in this land (Kelman and Khan 2013). It's a location in the riverbed that's cut off from the mainland. Although some of the chars are located close to the mainland but the majority of the riverine islands are very remote from the main landmass. For char dwellers and mainland dwellers, these attributes of the char areas make it unreachable. Due to inaccessibility and inadequate connectivity, public service providers and other public authorities overlook the char dwellers to offer their services to the char regions. The study area's socio-economic profile is very crumbly, and the education facilities are abysmal level even it's scarce in some char areas. Besides, some fragile aspects of the char areas, such as no proper health services, low work opportunities, etc., make char inhabitants more defenseless to any stress that occurred by climate change (Hossain 2020). Approximately 56 large and 226 small islands (char) exist in Bangladesh, which covers almost 7200 km² (Banglapedia 2014). The riverine island is the most susceptible to recurrent floods, riverbank erosion, and other disasters triggered by climate change, and the inhabitants of these locations are extremely vulnerable (Islam 2021). Jamuna River carries more chars as a larger river and occupies 45% of the entire riverine

island in Bangladesh (BBS 2012; Paul and Islam 2015). As per estimates, nearly 4–5% of Bangladesh's population lives in char territory. The majority (65%) reside in the many chars along the Jamuna River (Kelly and Chowdhury 2002; Sarker et al. 2020).

Locale of the study

Gaibandha district was considered purposively, and the multi-stage area sampling technique was applied to select subsequent administrative units and the ultimate sampling unit that is the village. Therefore, two upazila, namely Fulchari and Saghata under the Gaibandha district in Bangladesh, were purposefully selected in accordance with the ruthlessness of the catastrophes based on people affected, death toll, casualties, and damages through the review of literatures, Government reports, newspapers, expert opinion, and NGOs documents. Eight riverine char villages were selected under the upazila of Fulchari and Saghata. The study locations are the most vulnerable to natural disasters and approximately 287-km away from the capital city of Dhaka, Bangladesh. Since the Gaibandha district is so close to the river basin, and all of the chars selected for this study are located within the Jamuna River. This char area's common phenomenon caused by climate change effects is recurrent flooding, riverbank erosion, drought, massive rainfall, and severe fogs.

Sampling and data collection

A mixed-method approach was used in this research combined with qualitative and quantitative approaches. Face-to-face interviews with questionnaires were used to obtain quantitative data. On the contrary, the qualitative data were accumulated through focus group discussion (FGDs), key informant interviews (KIIs), and participant observation from the study villages that were mostly affected by the climatic hazards brutally. Besides, secondary data were also used that collected from various journals, books, and websites of institutions. In addition, a pilot survey was conducted on 30 char dwellers to run-through the suitably for the questionnaire and get off any superfluous and worthless substances in the interview schedule. Therefore, the researchers organized two sets of structured interview programs with close- and open-ended questions to gather data in terms of the purpose of this study. In the beginning, respondents were selected among the climatic hazards-prone char villages (total 2638 households) of eight selected villages by using simple random sampling. Almost all households in Bangladesh are placed by the male heads of households due to the prevalent culture. In addition, respondents were the household's heads because they know almost everything about their family affairs.

This study used the following statistical formula to determine a representative sample size (G. Cochran 2017).

$$n = \frac{z^2 \times p \times q \times N}{e^2(N - 1) + z^2 \times p \times q}$$

$$= 336$$

Here,

n = sample size, N = total number of households, z = confidence level (at 95% probability = 1.96, p = estimated population proportion (0.5 this maximizes the sample size), q = 1-p, e = error limit of 5% (0.05)

Participants for FGDs were drawn from the household questionnaire survey, and respondents were asked if they would be interested in participating in a focus group discussion to delve deeper into some of the key issues. 6–12 number of participants were had in each of the FGDs along with two or three numbers of the research team. Besides, eight key informant interviewers were purposefully selected from a variety of government and non-government stakeholders working

on several issues for the char dwellers triggered by climate change and disasters, along with local representatives from Fulchari and Saghata upazila. The survey was carried out from September 2018 to April 2019.

Ethical issues were very carefully considered. The researchers introduced themselves during the fieldwork and expressed the purpose of doing this study. In addition, prior to planning the interview session, recording, and taking a snapshot of the respondent's activities, consent was received from all respondents. The purpose of the study was informed to the respondents and assured not to reveal their identity in the study.

Measurement of climate change perceptions and index

Climate change perception data were collected from respondents using a four-point scale in relation to 18 climatic events. The scale goes from 'no perception' to 'high perception,' with 'low perception' and 'medium perception' in between these two lower and upper limits. We have assigned values to each perception scale in ascending order for ease of examination, such as 0 for no perception, 1 for low perception, 2 for medium perception, and 3 for high perception.

The Climate change perception index (CCPI) was adapted from Sarker et al. (2020) and used in this study to measure the impact of climate change on Bangladesh's riverine island areas. The index is calculated on a four-point scale. The CCPI was used to investigate char dwellers' views on climate change. Participants were asked to express their thoughts on 18 remarks concerning climate change. To meet the objective, the following formula was used to measure a climate change perception score (CCPS) (Eq. 1).

$$\text{ClimatechangeperceptionscoreCCPS} = \text{CCPn} \times 0 + \text{CCPl} \times 1 + \text{CCPm} \times 2 + \text{CCPh} \times 3 \quad (1)$$

Here,

CCPn = Number of char dwellers having no perception, CCPl = Number of char dwellers having low perception, CCPm = Number of char dwellers having medium perception, CCPh = Number of char dwellers having high perception.

Since there were 336 household heads who responded to the survey, the CCPS for each of the designated attributes could extent from 0 to 1008, with 0 representative the lowest perception and 1008 representative the highest. Using the following formula, the obtained CCPS was transformed to a standardized climate change perception index (SCCPI) (Eq. 2).

$$\text{SCCPI} = \frac{\text{ComputedCCPS}}{\text{PossiblehighestCCPS}} \times 100 \quad (2)$$

Here,

SCCPI = Standardized Climate Change Perception Index, Computed CCPS = Calculated Climate Change Perception Score, against an indicator of climate change impact, Possible highest CCPS = Total possible score against all indicators of climate change impact.

The SCCPI was applied to gain a deeper understanding of the impact of climate change. The SCCPI of a climate change impact indicator could vary from 0 to 100. In this regard, 0 represents no perception of climate change impacts and 100 demonstrates the highest perception of climate change impacts among char dwellers.

Measuring approach of health impacts

The climate change impact on human health was measured through collected data from the respondents. For which, three seasons, including the disaster period, were selected, such as summer, rainy, water, and natural disaster period to explore various diseases of char dwellers. On the other hand, the char dweller's adaptation strategies for minimizing health issues were measured using the

three scales like low, medium, and high based on households' income patterns. Besides, this study found two types of adaptation strategies like (1) individual-level adaptation (ILA) and (2) planned adaptation (PA) that mainly char dwellers follow to cope with the health issues. For this reason, the study employed it to understand more in detail concerning char dwellers adaptation practice.

Data analysis

After accumulating all sorts of data, the collected data were analyzed according to the purpose of this study. The quantitative data were analysed using statistical tools, i.e. Statistical Package for Social Sciences (SPSS) and Microsoft Excel. The univariate and bivariate examine carried out one by one from char dwellers' replies in the context of climate change, health issues, adaptation tactics, including difficulties to adaptation in the riverine chars in Bangladesh. On the other hand, the qualitative data figured out via textual and document analyses. Simultaneously, tables, charts, graphs were categorized to make the data more relevant and easily realizable to the readers. Besides, the researchers delivered their clarifications based on results and observations during the review of the primary and secondary data and interviews with the informants.

Results and discussion

The findings of this study as regard climate change and local adaptation strategy to health have been illustrated in some sub-heads section. Basically, two sub-head sections have been considered to present the findings of this research. The first sub-head section portrayed the socio-economic condition and climate change perception of the riverine island inhabitants, and the subsequent sub-head section displayed the riverine island dwellers' adaptation strategies in Bangladesh.

Socio-economic condition of the respondents

The leading purpose of this segment is to know the socio-economic profiles of the respondents in the study area. In order to obtain in-depth information about the respondents, this section has been designed on the basis of the socio-economic status of people affected by climate change, which is related to their age, gender, education, main occupation, family size, sanitation facilities, source of water, and household income. **Table 1** has been presented the noticeable aspects of the various attributes of the riverine island inhabitants.

The findings showed that 94.9% were male and 5.1% were female among the respondents in the study villages in which 45.2% were young aged below 35 years, while, respectively, 37.1% and 17.6% were middle and old aged. The education status of the study villages is very low compared to the national level of education (BBS 2016). In addition, 67.6% of the respondents were illiterate, while 25%, 4.8%, and 2.7% of respondents were primary, secondary, and above the secondary level of education status in turn. Approximately 55.1% and 27.1% of the study areas' people were engaged with day laborer and agriculture while, respectively, 7.1%, 2.7%, 4.8%, and 3.2% of the respondents' occupation were small business, service, fishing, and others. **Table 1** also displayed that about 60.4% of the respondents had small family size while 31% and 8.6% had medium and large family size in turn. On the other hand, the sanitation facilities were not satisfactory level in the char study char villages where the majority (62.5%) of the sanitation was kutchha with the slab. Only 2.7% and 6.5% had pucca and semi-pucca sanitation facilities. In the case of drinking water facilities, all respondents usually were collected drinking water from tube-well in which 22.9% and 77.1% of respondents' drinking water source was own and neighbor tube-well, respectively. Approximately 64.6% of households' monthly income was low, while 27.1% of household income was medium. Only 8.3% of monthly household income was high.

Table 1. Socio-economic conditions of the respondents.

Characteristic	Marking system	Categories	Respondents		Mean	SD
			N	%		
Age	Years	Young (≤ 35)	152	45.2	34.1	15.9
		Middle (36–50)	125	37.2		
		Old (> 51)	59	17.6		
Gender	Code	Male (1)	319	94.9	1.1	0.2
		Female (2)	17	5.1		
Education	Year of schooling	Illiterate (0)	227	67.6	1.8	2.5
		Primary level (1–5)	84	25.0		
		Secondary level (6–10)	16	4.8		
		Above secondary (> 10)	9	2.7		
Occupation	code	Day Laborer (1)	185	55.1	1.8	1.3
		Agriculture (2)	91	27.1		
		Small Business (3)	24	7.1		
		Service (4)	9	2.7		
		Fishing (5)	16	4.8		
		Others (6)	11	3.2		
		Family size	Number	Small (≤ 4)		
Medium (5–6)	104	31.0				
Large (> 6)	29	8.6				
Sanitation facilities	Code	Pucca (1)	9	2.7	3.2	0.7
		Semi pucca (2)	22	6.5		
		Kutcha with Slab (3)	210	62.5		
		Kutcha without Slab (4)	80	23.8		
		Hanging (5)	15	4.5		
Source of water	Code	Own Tube-well (1)	77	22.9	1.8	0.4
		From other's Tube-well (2)	259	77.1		
Household monthly income	BDT.	Low (up to BDT 5000)	217	64.6	4687.5	3212.3
		Medium (BDT 5000–1000)	91	27.1		
		High ($>$ BDT 1000)	28	8.3		

Source: Field survey September 2018 to April 2019

Perceptions of char dwellers on the changing of climatic variables

Measurement of climate change perception is a complicated process that is influenced by societal, cultural, environmental, and demographic variables (Cutter 1996). Perception is a conceptual construct, and char dwellers' views of climate change are remarkable in the sense that it allows for a distinction between observable real-world threats, such as climate change, and intuitive judgments of those risks (Ahmed et al. 2021). Many studies hugely indicated that climate change has far-reaching consequences on the human way of life globally, particularly it is more ferocious for developing countries like Bangladesh (Hossain 2020). Besides, char dwellers are the most vulnerable in the face of disasters triggered by climate change (Menne and Murray 2013). Thus, this study tried to investigate the char dwellers' perception as regard climate change. We used CCPS and SCCPI to calculate the char dwellers' perception regarding climate change implications. Some researchers have already used the same method to appraise the climate change perception from the char dwellers' experience through using the four dimensions (Akanda and Howlader 2015).

The computed CCPS ranges from 491 to 964, which is denoted that the riverine island inhabitants are enormously vulnerable due to the impact of climate change. Thus, it has been cleared that the char inhabitants are pivotal sufferers since they are recurrently confronting the harmful effects of climate change, which many studies have already been documented (Tajrin and Hossain 2017; Blackmore et al. 2021). On the contrary, the calculated SCCPI ranges from 48.7 to 95.6, which means most island inhabitants associate with the high perception index. It indicated the actual scenario of the char dwellers' life under climate change. In addition, the impact of climate change obstructs their way of life immensely and induces repeated climatic disasters to their life and livelihood. It is one of the most reasons for several acute health issues along with severe

Table 2. Char dwellers' perception on climate change.

S. N	Variables	High Perception	Medium Perception	Low Perception	No Perception	CCPS	SCCPI	Rank
1	Increased frequency of flooding	304	20	12	0	964	95.6	1
2	Severity of riverbank erosion	287	37	12	0	947	93.9	2
3	Amplify rain intensity	243	75	11	7	890	88.1	3
4	Severe drought	255	48	22	11	883	87.6	4
5	Increased of diseases outbreak	254	49	21	12	881	87.4	5
6	Increased temperature (Summer)	212	108	8	8	860	85.3	6
7	Heavy fog	237	57	32	10	857	85.0	7
8	Decreased winter season	211	77	22	26	809	80.3	8
9	Extreme temperature (winter)	214	55	36	31	788	78.2	9
10	Increased rainfall season	230	17	59	30	783	77.7	10
11	Long duration of summer	178	67	56	35	724	71.8	11
12	Increased food shortage	160	59	99	18	697	69.1	12
13	Damaging soil productivity and fertility	168	48	64	56	664	65.9	13
14	Increasing sandy soil	162	59	48	67	652	64.7	14
15	Increased water logging condition	135	64	75	62	608	60.3	15
16	Decreasing crop yield	157	43	48	88	605	60.0	16
17	Scarcity of safe drinking water	112	96	57	71	585	58.0	17
18	Frequent cyclone	48	114	119	55	491	48.7	18

Source: Field survey September 2018 to April 2019

complications in the study villages. Table 2 displayed the char dwellers' perception concerning climate change by pursuing the predestined assertions and depicts in accordance with score and index.

The calculated score and index were displayed in terms of rank for better comprehension. The perception index indicated that massive regular flood disasters, riverbank erosion, increased rainfall, severe drought, changing seasonal features are the supreme effects caused by climate change in the char regions in Bangladesh. The calculated results and the observed data from the NASA Power were approximately similar to the perception of the riverine island inhabitants.

Impacts of climate change on health

Climate change has numerous implications on human health due to the shifting forms of climatic variables along with the rising magnitude and frequency of disasters (Haines et al. 2006; Jarraud and Steiner 2012). This study found the char dwellers' enormous health issues, and the degree of prevalence in accordance with the people's perception has been shown Figure 1.

Most of the respondents reported that they confronted huge health problems during the summer season due to changing climate variables like increasing temperature. As a result, approximately 71.4% of the respondents revealed that headache is the main problem during the summer. In this case, one study interviewers figure out that headache problems usually face due to the increasing intensity of the sun during the summer period. Besides, char dwellers convey their views to feeling feeble (66.6%), loss of energy (65.1%), dryness of throat (35.7%), eyesight difficulties (18.7%), breath issue (19.1%), chest pain (23.8%), skin issue (9.5%) which are related to severe health complications in summer. In this regard, FGDs reveal that these kinds of diseases are common features in our region now during the summer. The intensity of conditions increased ferociously than earlier, which baffled people's work strength and pushed us into fragile circumstances.

On the contrary, respondents were affected by several diseases in the winter season due to the changing behavior of winter season in Bangladesh. As a result, cold and cough (89.5%) was the most common health issue for the char inhabitants. Furthermore, the char dwellers identified various diseases in this time such as fever, tonsil, chest and body pain, arthritic, and crack in feet. In the case of the rainy season, the char inhabitants were suffering from many diseases like skin diseases

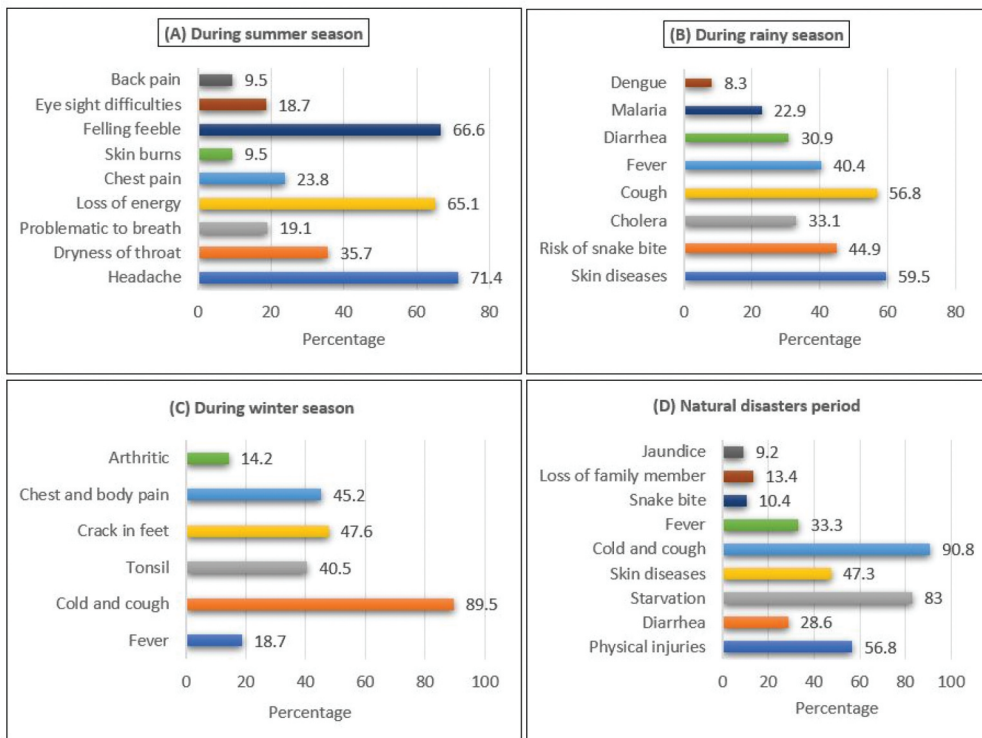


Figure 1. People's perception regarding the health impact caused by climate change. Source: Field survey September 2018 to April 2019; (Multiple responses have been considered)

(59.5%), cough (56.8%), diarrhea (30.9%), fever (40.4%) due to altering rainfall patterns, as well as many people also experienced for snake bit, malaria, and dengue. Moreover, most of the respondents stated that they usually face huge difficulties during natural disasters. Basically, they identified starvation (83%), physical injuries (56.8%) along with enormous health issues and also conveyed that these are the most significant complications. Apart from these, the affected char dwellers experienced diarrhea, fever, cold and cough, skin diseases. Since the char dwellers figure out numerous diseases, these were either short-term or long-term diseases that are induced due to the changing climate variables. In this context, many researchers found the same kind of health issues from the perspective of different regions (Goodman et al. 2004; Patz et al. 2005; O'Neill and Ebi 2009; Xu et al. 2012). Since most char dwellers are living with fragile socio-economic conditions, which account for many types of diseases of char dwellers. Šprocha and Bleha (2021) stated that poor socio-economic aspects play a vital role to susceptible several health issues in a particular area. In addition, Marmot (2010) argued that it is a well-established phenomenon that people in poor living conditions are marked by higher mortality and poorer health.

Adaptation strategies for minimizing health complications

Adaptations in both physical and environmental directions at diverse levels are needed to promote viable life and livelihood in the face of climate change impacts (Adger et al. 2005; Fussel 2008). Char dwellers have used numerous adaptation practices during various seasons, such as summer, rainy, and winter seasons, as well as during hazards. In contrast, this study also comes across additional coping approaches. In this study, adaptive strategies to address the health-related problems employed by char dwellers were similarly followed by different studies (Cheng and Berry 2013;

Haque et al. 2013). The char dwellers have followed more than a strategy for sustaining their livelihood, which is known as the process of livelihood resilience. As well, riverine island inhabitants mainly practice two kinds of adaptation strategies like (1) Individual Level Adaptation (ILA) and (2) Planned Adaptation (Alam et al. 2017). Table 3 displayed the char dwellers' adaptation strategies to health in the face of climate change.

In the context of adaptation strategies, most char dwellers (78%) figured out that they practiced drinking more water than at the other time while the second-highest practice, approximately 75.9% of respondents, used traditional hand fan to evade illness in the period of summer. Besides, they also took several approaches to eliminate sickness in this time, such as drinking water with oral saline,

Table 3. Adaptation strategies of char dwellers in the context of health issues.

Categories	Adaptation strategies	Responses (%)	Household income category			Comments	
			Low	Medium	High		
To eliminate illness during the summer season	Habit on drink more water than at other times	78.0	x	x	x	ILA/PA	
	Don't go outside unless urgency	28.6		x	x	ILA	
	Never go out at the high temperature	50.0	x	x	x	ILA/PA	
	Use the traditional hand fan	75.9	x	x	x	ILA	
	Don't go out at noon	31.0		x	x	ILA/PA	
	Take rest under the tree	38.1	x	x	x	ILA	
	Try to finish all work prior in the morning	35.4		x	x	ILA/PA	
	Using traditional cap while working in farm	34.2	x	x	x	ILA	
	Use an umbrella while going outside	26.8		x	x	ILA/PA	
To eliminate illness during the rainy season	Drink water with oral saline	59.2	x	x	x	ILA/PA	
	Use mosquito net to prevent vector-borne diseases	96.7	x	x	x	ILA/PA	
	Beware from snakes	89.9	x	x	x	ILA	
	Clean the waterlogging around the homestead	88.1	x	x	x	ILA/PA	
	Arrange emergency medicine	49.1	x	x	x	ILA/ILA	
	Try to stay at home while raining	54.8	x	x	x	ILA	
	Evade canal and river water for drinking water	45.2	x	x	x	ILA/PA	
	Use cooked water for drinking	35.7	x	x	x	ILA/PA	
	Take an umbrella in case of an emergency	35.1		x	x	ILA/PA	
	Use purify table to drinking water	31.0		x	x	ILA/PA	
	Storage foods	14.3		x	x	ILA	
	To eliminate illness during the winter season	Habit of drinking light hot water	41.4	x	x	x	ILA/PA
		Use mustard oil on skin	97.9	x	x	x	ILA
Use lotion to fungal skin disease		12.2		x	x	ILA/PA	
Use hot water while bathing		35.7	x	x	x	ILA/PA	
Use warm clothes		100	x	x	x	ILA/PA	
Take herbal medicine		31.0	x	x	x	ILA	
Don't go out until the sun rises		18.8		x	x	ILA	
Take medication from <i>kabiraj</i>		53.3	x	x	x	ILA	
Additional adaptation strategies	Consult with neighbors about the disease	81.0	x	x	x	ILA	
	Take relatives advise about health issues	73.8	x	x	x	ILA	
	Take medication from the village doctor	84.8	x	x	x	ILA	
	Take advice from experience people	44.6	x	x	x	ILA	
	Treatment from upazila health complex	33.9	x	x	x	ILA/PA	
	Take advice from health workers	6.8	x	x	x	ILA/PA	
	Receive NGOs' health care service	33.9	x	x	x	ILA/PA	
	Participate in organizational training (GOs and NGOs)	65.3	x	x	x	ILA/PA	

ILA = Individual level adaptation based on experience and knowledge, PA = Planned adaptation (supported by GOs & NGOs)
Source: Field survey September 2018 to April 2019, Multiple responses have been considered.

taking shelter under a tree, don't go outside at noon and high temperature, and so on. On the contrary, to eliminate sickness during the rainy season, 97.7% of the char dwellers reported using mosquito nets to ward off vector-borne diseases. In contrast, almost 89.9% and 88.1% uncovered that they were cautious from snakes and tried to clean waterlogging around the homestead, respectively. Furthermore, nearly 49.1% of the respondents tried to arrange first aid medicine to confront sudden health issues, while 45.2% avoid drinking water from unhealthy sources, such as river water, pond, and so on. Besides, people were also adapted various strategies during the winter season to exterminate illness; for this reason, almost all households used mustard oil on the skin to avoid skin diseases and cold. In this case, the interviewers believed that mustard oil is a widespread tactic to use different purposes for health issues, and it is used widely in our locations. On the other side, all respondents informed that they wear warm dresses during the winter. Besides drinking hot water, lotion, herbal medicine were also popular approaches to encounter health issues. However, observation showed that the low-income household could not properly practice these strategies compared to high- and medium-income households.

Moreover, the char dwellers adapted some additional coping strategies along with a seasonal-based mechanism to make sure sustainable healthy life. For this reason, people reported that they consult with their neighbors (81%) and relatives (73.8%) when faced with critical health problems. About 84.8% of the respondents took treatment from villages doctor besides NGOs health-care services, participated in several GOs and NGOs training programs, and received advice from health workers as popular additional adaptation strategies in char areas. In this regard, Haque et al. (2013) also recommended the same types of strategies like treatment received from doctors, discussion with relatives, friends, and neighbors to eliminate the health impacts triggered by the changing climate variables. Ebi and Semenza (2008) and Brouwer et al. (2007) stated that following up on the effectiveness of adaptation in ensuring viable health in the face of climate change, and Sheffield and Landrigan (2011) emphasized the significance of implementing appropriate adaptation mechanisms in developing countries like Bangladesh.

Components of the health adaptation obstacles

Since the char dwellers adopted several forms of adaptation strategies to combat against the massive health issues triggered by climate change, they found some obstacles while practicing adaptation strategies that somehow baffle their adaptation efficacy and even have not met up the coping capacity. Figure 2 demonstrated the components of adaptation obstacles to climate change in the context of health perspective.

Figure 2 displayed that all respondents confronted enormous difficulties due to a lack of formal health service centers like government hospitals. At the same time, respondents also had the same perception concerning the disrupted communication since it is essential to moderate the development and prompt responses for all sorts of strategies. But the char dwellers are being faced massive complications because of disrupted communication; a respondent sorted his opinion in this regard as follows-

We are hard-working poor man living in geographically detached char areas despite the recurrent antagonistic consequence of climate change, and surviving by employing some mechanisms. But our all kinds of strategies smash due to bad communication even though it is also not anomalous in health adaption. As a result, we are being unable to take medication at the right time, even a poor man like me it is very difficult to spend the entire money for the purpose of treatment with char transport cost. (Interviewee# 18)

On the other hand, the paucity of money to receive treatment (88.4%) and limited access to health-care information (66.7%) also played a significant role in obstructing health-related adaption strategies. Moser and Ekstrom (2010) argued that the fragile monetary condition is one of the predominant hindrances to reduce the effectiveness of adaptation competencies. Simultaneously, the economic crisis is also a significant impediment for the riverine char dwellers areas because

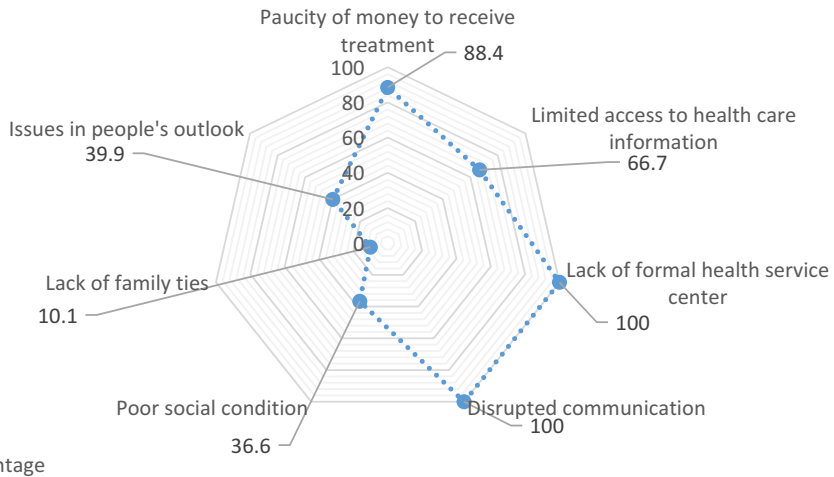


Figure 2. Radar chart on components of adaptation obstacles to climate change in the context of health perspective. Source: Field survey September 2018 to April 2019; (Multiple responses have been considered)

most of the respondents are engaging with day laborer, farmers, pretty businesses, and so on. Besides, poor social conditions (36.6%) and lack of family ties also generated health recovery problems. Davidson et al. (2007) and Shaw and Goda (2004) stated that lack of family and community ties are greatly impeded to overcome the overwhelming health obstacles.

Similarly, poor social conditions like fragile housing, unhealthy sanitation, low income, etc., escalate the rate of recurrence of numerous diseases, such as cholera, diarrhea, and so on, since the char dwellers standard of living condition was not as much as blameless (Leichenko et al. 2010). Besides, low-income households are susceptible to various vector-borne diseases as their precaution approaches are not more proactive (Rahman and Lateh 2017). Approximately 39.9% of the respondents claimed that people's discouraging outlook also pivotal for disrupting the health consciousness. One of the respondents said as follows-

I always keep trying to eliminate health problems. For this, I normally take several personal bits of knowledge along with health workers' advice but often face criticism from people in the community even they say, you are so afraid of death! as you will never die? which definitely somehow interrupt my attempt. (Interviewee# 57)

Approaches to managing money for getting health service

Since char dwellers took different measures to adapt the adverse situation to health due to climate change, and they also confronted some barriers while taking the adaptation initiatives. In which, the financial crisis is one of the most problems regarding health-care service, as the majority of the char dwellers are not financially solvent. For this reason, they grasped some degrees to accomplish money to accord with financial demands concerning health-care facilities. Table 4 illustrated the financial coping approaches of the char dwellers. Predominantly, they followed four categories approaches, such as taking a loan from various sources, selling domestic and productive assets, and selling liquid assets, and these are categorized based on low popularity, medium popularity, and high popularity. Moreover, the financial coping strategies are somewhat different among the char dwellers in terms of households' income capacity. Among those approaches, 81% of respondents took a loan from relatives while 70.8%, 38.4%, and 7.5% took loans from neighbors, money lenders, and NGOs. In this regard, Huang et al. (2011) stated that financial coping through these approaches mainly relies on a personal capacity and social relationship, so those connected with their surrounded people usually get more opportunities.

Table 4. Strategies to manage money to receive health service.

Category	Source of money	Responses (%)	Household income category		
			Low	Medium	High
Taking loan	Money lender	38.4	xxx	xxx	x
	NGOs	7.5	-	x	x
	Neighbors	70.8	xxx	xxx	x
	Relatives	81.0	xxx	xxx	xx
Selling domestic assets	Selling stock rice and grain	56.0	x	xx	xxx
	Selling household's equipment	25.9	xx	x	-
Selling productive assets	Selling livestock	34.2	xxx	xxx	xxx
	Selling poultry and hen	52.1	xxx	xxx	xx
	Selling fish	8.0	xxx	x	-
Selling liquid assets	Selling mature tree	23.2	xx	xx	xx
	Selling ornament	4.5	-	x	-

Note: xxx = high popular, xx = medium popular, x = low popular

Source: Field survey September 2018 to April 2019; Multiple responses have been considered.

On the other hand, char dwellers sold various household assets to manage the financial capacity to receive health-care services. The most popular approaches were selling stock rice and grain (56%), selling poultry, and hen (52.1%). Besides, respondents managed money by selling livestock, mature trees, ornaments, and household equipment to get medication. Pertaining to this, FGDs revealed that these assets are the most crucial for every household, which is why approximately none of the households were willing to sell those assets. But they are bound to sell these assets due to lack of money; even women have not wanted to sell their rearing hen, duck, goat to get treatment. Thus, at last, they made more prioritize on their health care than the family finance.

Conclusion

The people living in the detached riverine islands are the supreme vulnerable due to the adverse implications of climate change and its associated hazards. As a result, char dwellers encounter numerous complications as well as acute health issues, which makes them even more vulnerable. This research sought to explore the impact of climate change on human health, including local adaptation strategies. It is uncovered that almost there was no variance between people's perception and observed climate change information. The char dwellers figured out that every month more or less suffered a disease, which generated massive problems in their daily lives. Although, they adapted several adaptation strategies like use mosquito net, clean waterlogging, used mustard oil, consult with relatives and neighbors, use warm clothes, visit village doctors, etc., particularly in the three seasons like summer, rainy, and winter, including additional measures to eradicate the health issues in order to ensure a healthy life. But the sustainable adaptation mechanisms were interrupted due to various barriers, such as lack of formal health-care center, disrupted communication, poor social conditions, paucity of money, and so on. Besides, the adaptation strategies in char areas differ based on the household's income capacity since most households' income is not good enough. This study also revealed the char dwellers' way of managing ability of money to receive health service, where most respondents took four measures like taking loan from neighbor and relatives, selling stock rice, grain, poultry, hen were the most popular approaches.

However, government and non-government organizations should undertake a necessary long-term development plan to ensure a sustainable adaptation mechanism, including avoiding various shapes of hindrances for the char dwellers. Thus, the study findings will be helpful for the policymakers, aid organizations, and development practitioners to prepare development policies as regard health services for the vulnerable char dwellers. Since this study was conducted only eight riverine char villages, further research could be directed with many char villages

alongside depth medical diagnosis to understand the intensity of climate change on human health.

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