



ISSN: 2308-1597

Journal of the Sylhet Agricultural University

Journal home page: <http://www.jsau.sau.ac.bd>

Research Article

ASSESSING SOCIOECONOMIC VULNERABILITY AND ADAPTIVE STRATEGIES IN THE NIKLI HAOR COMMUNITY OF BANGLADESH: A DESCRIPTIVE APPROACH

A Mahmud¹, S Siddika¹, TB Shan², AC Chanda³, K Hasan⁴ and JU Ahmed^{5*}¹Post Graduate, Department of Agricultural Economics and Policy, Sylhet Agricultural University, Bangladesh.²Department of Agricultural Economics and Policy, Sylhet Agricultural University, Bangladesh.³Post Graduate, Department of Agricultural Finance and Banking, Sylhet Agricultural University, Bangladesh.⁴Bangladesh Agricultural Development Corporation (BADC), Muktagasa, Mymensingh, Bangladesh^{5*}Department of Agricultural Economics & Policy, Sylhet Agricultural University, Bangladesh.

Article info

Article history

Received: 07.08.2024

Accepted: 03.11.2024

Published: 30.12.2024

Keywords

Haor, Vulnerability Index, Climate Change, Adaptive Measures

*Corresponding author

Jasim Uddin Ahmed

E-mail:

jahmed.aep@sau.ac.bd

Abstract

In Bangladesh, climate change variations have made haor communities more vulnerable in socioeconomic aspects. Thus, people face several hazardous situations and take adaptive measures to counter this socioeconomic vulnerability. This present study aimed to thoroughly understand these issues and portray the socioeconomic vulnerability conditions and adaptive measures taken among households in Nikli haor communities in the Kishoreganj district. A multistage cluster sampling technique was used to collect 120 samples data from six villages in Nikli haor. Descriptive statistics were used to present the socioeconomic status and the socioeconomic vulnerability index was used to find out the most common and severe vulnerability issues. Among study findings, 93% of respondents were found to be literate and 54% of them had medium household size. The majority of the sampled respondents were engaged in farming activities and 72% of respondents had small farms. Flash floods and settlement erosion were found to be ranked primary vulnerabilities among haor communities. The study revealed that the Nikli haor community had taken several adaptive measures to cope with the challenges posed by climate change and socioeconomic vulnerabilities. The findings suggest that the community has embraced a diversified livelihood strategy, with homestead gardening and changes in crop patterns emerging as significant adaptive strategies. However, the reliance on migration and asset sales raises concerns about the long-term viability of certain coping mechanisms. So, in light of these research findings, valuable steps might be taken to minimize these worsening situations.

Copyright ©2024 by authors and SAURES. This work is licensed under the creative Commons attribution International License (CC-BY-NC 4.0)

Introduction

Climate change, a global phenomenon with far-reaching consequences, has become a critical focus of research and concern in recent times. The impacts of climate change are felt differently across the world, and regions like Bangladesh are particularly vulnerable due to their geographical and socioeconomic characteristics (Rahman and Latch, 2017; Shaw *et al.*, 2013). Currently, Bangladesh, a low-lying delta, is considered the 7th most climate risk-affected country in the last two decades (Eckstein *et al.*, 2021). In Bangladesh increasing frequency and severity of extreme weather events such as hurricanes, floods, droughts, and wildfires have disastrous effects on agriculture, infrastructure, and human life (Norman *et al.*, 2021). Therefore, human populations residing in remote and geographically fragile floodplain regions of Bangladesh are especially vulnerable to the risks associated with climate change (Monwar *et al.*, 2018).

Cite This Article

Mahmud A, Siddika S, Shan TB, Chanda AC, Hasan K and Ahmed JU. 2024. Assessing Socioeconomic Vulnerability and Adaptive Strategies in the Nikli Haor Community of Bangladesh: A Descriptive Approach. J. Sylhet Agril. Univ. 11(2): 01-10, 2024. <https://doi.org/10.3329/jsau.v11i2.82739>

These floodplain regions of northeastern Bangladesh are locally known as '*Haors*'. In a definitive aspect, *haors* are part of wetland areas and inherently related to human societies, and *haors* have been recommended as "settings" for people's health, the context in which people live and obtain their livelihoods (Horwitz and Finlayson, 2011). More than 373 *haor* areas can be found in the districts of Sunamganj, Sylhet, Habiganj, Maulvibazar, Netrakona, Kishoreganj, and Brahmanbaria (BHWDB, 2012). Due to its unique geographical and hydrological features, the *haor* region in Bangladesh faces severe threats to natural resources and livelihoods from runoff water, flash floods, and extreme rainfall, exacerbated by climate change-induced extreme events. (Suman et al., 2014; Hossain and Naser, 2014; Jakariya and Islam, 2017; Ali, 1999; UNDP, 2012).

Haor vulnerability depends on exposure to risks, their impact, and the *haor's* capacity to manage or mitigate them. Also the ideas of adaptability, sensitivity, and coping capacity are all included under the overarching concept of vulnerability (Gitay et al., 2011). In Bangladesh the *haor* region has experienced pre-monsoon flash floods a minimum of nine times in the past three decades, causing damage to the nearly harvested *Boro* crop on each occasion (Parvez et al., 2022). Thus, the escalation of flooding in the wetlands is a significant concern, with projections indicating a further increase in the future (Hoq et al., 2021; Dey et al., 2021). Single crop dependency and limited livelihood opportunities along with this climate change scenario always worsen the woes for the marginal communities in *haor* regions (Ferdushi et al., 2019). Consequently, floods and other natural disasters frequently force individuals to remain unemployed, leading to poverty and food insecurity, which can occasionally precipitate famine-like conditions (Dey et al., 2021). In general, *haor* region residents are more vulnerable in terms of their livelihoods, income, fundamental services, infrastructure, literacy, assets, and skills (Jakariya and Islam, 2017).

Furthermore, adequate climate change adaptation measures are essential in *haor* regions to reduce socioeconomic vulnerability, enhance resilience, and ensure sustainable livelihoods (Ferdushi et al., 2019). In fact, the future of the *haor* people depends on how well the government along with other stakeholders handles disasters and develops policies, as well as on how well countries around the world work together to fight climate dangers (Ferdushi et al., 2019; Raihan and Hossain, 2021). An essential element in enhancing resilience against vulnerability is the dissemination of knowledge and insights regarding adaptation. Furthermore, as climate vulnerability may vary from place to place the adaptation strategies should be tailored to the local conditions.

While several studies explored climate vulnerability and adaptation in Bangladesh, most focused on coastal regions (Ahsan and Warner, 2014; Felsenstein and Lichter, 2014). Additionally, in many researches *haor* vulnerabilities have been studied but socioeconomic vulnerability remained unexplored and critical research gap also remains in developing localized adaptation strategies for *haor* (Hoq et al., 2021). Therefore, this study aims to give findings about Nikli *haors'* socioeconomic vulnerability and adaptation strategies to cope with climate change and provide necessary insights for the resilience of the Nikli *haor* community.

Materials and Methods

Selection of Study Area

Among the different *haors* in Bangladesh, Nikli Upazila in Kishoreganj District was chosen for this study (figure 1). The total area is 214.40 square kilometers, lying between 24°15' and 24°27' north latitudes and 90°52' and 91°03' east longitudes. It is bordered to the north by the Karimganj and Mithamain Upazilas, to the south by the Bajitpur Upazila, to the east by the Mithamain and Austagram Upazilas, to the west by the Katiadi and Karimganj Upazilas, and to the south by the Austagram and Mithamain Upazilas.



Figure 1. Map of the study area (Nikli Upazila)

Selection of Sample Size

The primary dataset was collected using multi-stage cluster sampling from 120 households located in the *haor* area in Nikli Upazila of Kishoreganj in Bangladesh. The selection procedure of sample respondents from the household level survey was followed first, selecting the Nikli Upazila from the other 13 Upazilas in Kishoreganj (because the Nikli Upazila consists of the biggest *haor* with the most number of population); In the second stage, Nikli union was selected purposively among seven unions in Nikli Upazila; In the third stage, Nikli union consist of 20 villages in total and out of 20 villages 6 villages were selected randomly, the villages were Mirzapur, Mohorkona, Ananda Nagar, Koutubhati, Manjilhati, Kumarchara. Finally, these 6 villages were considered as final sampling clusters, and from each cluster 20 equal samples were collected randomly resulting final 120 samples in total.

Data Processing

Following the gathering of primary data from the research region, these data were thoroughly analyzed and summarized before being tabulated. The transformed data were added to a Microsoft Excel. The real tabulation was started after the pre-tabulation task was finished. A list of the tables was created, and after that, the data that had been tabulated was examined in light of the study's goals. Statistical Package for Social Science (SPSS) version 23, STATA version 14.2, and Microsoft Excel were used to analyze the data.

Analytical Techniques

Descriptive statistics

To find out the socioeconomic status and adaptation measures of the *haor* community, descriptive statistics were used to determine frequency, averages, percentages, etc. It is very simple in the calculation, widely used, and easy to understand.

Socioeconomic vulnerability index

To calculate the socioeconomic vulnerability, a socioeconomic vulnerability index was used where the respondents were asked about 9 socioeconomic vulnerability issues related to the *haor* community. This index was used and found to be valid according to (Sharma, 2010). The respondents were asked to give their opinion on 9 selected vulnerability issues. A three-point rating scale was used for computing the index score of a respondent. For each issue, a score of 3, 2, and 1 was assigned to indicate the sensitivity of vulnerability as high, medium, and low respectively. The total socioeconomic vulnerability index was computed for each respondent by adding his scores for all the issues. The socioeconomic vulnerability index was computed using the following formula used by Sharma, (2010):

$$SVI = (VI_H \times 3) + (VI_M \times 2) + (VI_L \times 1)$$

Here,

SVI = socioeconomic vulnerability index;

VI_H = vulnerability issues with high extent;

VI_M = vulnerability issues with medium extent;

VI_L = vulnerability issues with low extent;

Results and Discussion

Socioeconomic status of the respondent

Table 1 presents an overview of the respondents' socioeconomic characteristics. In the present study, the age of respondents was divided into various age groups, including 18 to 25 years, 26 to 35 years, 36 to 45 years, 46 to 55 years, and over 55 years. Similar age group segregation was also followed on an article done by (Rahman *et al.*, 2013). The largest group was aged 36-45 years, making up 42% of the respondents, while the smallest group was aged 18-25 years, accounting for 3% of the respondents. From this finding, it is observed that the majority of the sample respondents are middle aged. On the other hand, the size of household is divided into 3 categories. Among the respondents, 54% of the respondents live in a household consisting of 4-6 members. According to HIES, (2022), the average household size in Bangladesh was found to be 4.26. So, the study area household size is found to be larger than the national average household size.

Table 1. Socioeconomic characteristics of the respondents in the survey area

Variable		Frequency	Percentage
Age of respondents	18-25	3	3
	26-35	36	30
	36-45	50	42
	46-55	20	17
	>55	11	8
Household size	Small household (up to 3)	2	2
	Medium household (4-6)	65	54
	Large household (7 and above)	53	44
Educational status of respondents	Illiterate	8	7
	Literate	112	93
Annual income from different source (in BDT)	Farming	53335	
	Daily labour	6901	
	Fishing	19115	
	Business	12245	
	Others	2960	
Farm size	<0.05 (landless)	13	10
	0.05-2.49 (small farm)	86	72
	2.50-7.49 (medium farm)	21	18
	7.50 & above (large farm)	-	-

Source: Author's estimate based on field survey, 2023

The study findings shows that only 7% of the respondents were illiterate whereas 93% of the respondents were found to be literate in the study area. The literacy level of the respondents was found to be greater than the national literacy level which is 74% (HIES, 2022). The study found that the majority of the population earns their income through farming, with an average annual income of 53,335 BDT. Fishing is the second most common source of income due to the *haor* region, with an average annual income of 19,115 BDT. Based on land holdings by BBS, (2021) the farm size is divided into three different categories. It is seen in Table 1, most of the farm sizes were found to be to be small (72%). Besides that, 10% and 18% of respondents are found landless and have medium farms respectively. No large farm size in the study area.

Socioeconomic Vulnerability Profile

A socio-economic vulnerability context characterizes the *haor* areas in Bangladesh. These regions, situated in low-lying depressions, are prone to frequent flooding and waterlogging, leading to significant challenges for the local population. The Socioeconomic Vulnerability Index (SEVI) is a measure of the overall level of vulnerability that individuals, families, and communities experience in terms of their economic security. In the study area, 120 respondents were asked about the extent of several socioeconomic vulnerability situations. Their responses were sorted into three different scales to understand the actual impact of vulnerability on their life. The socioeconomic vulnerability context was then ranked according to the respondent's feedback in Table 2.

Table 2. Socioeconomic vulnerability table

Types of Socioeconomic Vulnerability	Vulnerability extent			Vulnerability index score	Rank order
	High (3)	Medium (2)	Low (1)		
1. Extent of flooding in the village	86	16	18	277	1***
2. Extent of village and settlement erosion	37	60	23	254	2**
3. Extent of shifting to another place for a short period of time for livelihood	37	40	43	234	3*
4. Extent of deterioration of internal communication systems	38	34	48	230	4
5. Extent of the lack of financial support	17	75	28	229	5
6. Extent of the lack of food consumption in the family	22	59	39	223	6
7. Extent of health insecurity in family	36	30	54	222	7
8. Extent of sanitation and hygiene status of home	21	47	52	209	8
9. Extent of family suffering due to natural calamities	24	19	77	187	9

Source: Author's estimate based on field survey, 2023

Flooding in the village

The first vulnerability that is listed in Table 2 is a flash flood. It was found that the *haor* in Nikli Upazila contains a significant quantity of fertile agricultural land. The study found 86 of the respondents stated that the land area and village were highly vulnerable to flood during the rainy season. Sometimes, the entire *haor* region becomes overwhelmed with water and transforms into floodplains during the wet season, making it an ideal location for fishing in freshwater. So, the majority of the land in the *haor* areas is devoted to the production of single crops, most notably *Boro rice* during the winter months. Because of the high seasonality of the economy that is dependent on *haor*, the local people are forced to be unemployed for a large amount of time, and as a result, they are unable to guarantee their food supply. It was the obstacle that prevented the development of sustainable livelihoods. This result is similar to a study findings given by Brouwer *et al.*, (2010). The author stated the ranking of the most severely vulnerability-struck districts was impacted by factors like a flash flood in the coastal district of Vietnam.

Village and settlement erosion

The combination of continuous annual erosion of villages and settlements and the occasional collapse of families and communities was identified as the area's second ranked source of vulnerability for the people who live there. Table 2 shows that 60 of the people in the study area marked this vulnerability to a medium extent. At the beginning of the monsoon season, homeowners shelled out a significant amount of cash to safeguard their homes against the impending floods. During these months, when most of the village was flooded, many families had to leave. Those who stayed often had no choice but to take expensive loans from untrustworthy lenders to pay for their yearly home protection costs. However, a study done by Sharma, (2010), gave a more similar view of the socioeconomic vulnerability. The author found the flash flood issue was the first in rank in the study area. This only implies that the severity of flash floods has decreased over the decade until now.

Shifting to another place for a short period of time for livelihood

The lack of options to make a living in the *haor* region resulted in the third vulnerability which was temporary migration. Table 2 shows that 43 of the respondents faced these problems to a low extent whereas 37 of the respondents felt this was a high-vulnerability context. During mono-crop planting and harvesting seasons, households relying on wage labor are often forced to do temporary migration. Household-earning members seek work elsewhere to earn money for basic needs like food, especially when monsoon river erosion threatens their livelihoods and leaves them with few options in works. This migration is also found to be correlated with other studies to the context of anthropogenic climate change often approached as vulnerability elements: exposure, system sensitivity, and adaptive capacity (McLeman and Hunter, 2010). In this article, climate change and vulnerability are examined through case studies of dry-season migration in the Sahel, Caribbean basin,

US Sun-belt, and Great Plains which are similar to the temporary migration of Nikli *haor* people.

Deterioration of internal communication systems

The communication system became fragile throughout the flood season, making it currently unable to contact anybody in the *haor* region. Table 2 shows that only 38 of the respondents stated they are highly vulnerable to this communication vulnerability. Therefore, it was ranked fourth in the research area's socioeconomic vulnerability categories. These issues can be compared to a study done by EL Khaled & Mcheick, (2019). The researchers contend that communication system failures may cause catastrophic damage to human life and economic activity because individuals cannot communicate promptly and conveniently.

Lack of financial support

Lack of financial support was found to be a critical issue in respondents' feedback. It was found in Table 2 that 28 of the respondents marked the lack of financial support vulnerability at the low context and 75 of them felt this vulnerability to a medium extent. A study done by Sharma, (2010) marked the lack of financial support issue in rank 8 which is less significant. But this issue has become more severe now resulting in a rank of five in the study area.

Lack of food consumption in the family

The sixth vulnerability that was discovered was that the family did not consume enough meals on many occasions during the year. It was found that 59 of respondents faced this vulnerability to a medium extent. But still, 22 of the respondents in the study area felt this was a high extent of vulnerability. Because of the high seasonality of the economy that is dependent on *haor*, the local people are forced to be unemployed for a large amount of time, and as a result, they are unable to guarantee their food supply. The approaches for ensuring food security were inadequate in that they did not sufficiently address the underlying causes of assuring food security, including production, employment opportunities, education, and access to necessities like housing and sanitation. Another study indicated that more families with small children or elderly persons are food insecure following COVID-19 pandemic. Additionally, households in environmentally vulnerable zones like drought-prone or river erosion-affected areas are more food-susceptible than those in other parts of the country (Bidisha *et al.*, 2021).

Health insecurity in the family

The seventh vulnerability was the insecurity of one's health. Every year, a significant number of infants lose their lives as a result of prevalent infectious diseases, notably diarrhea, and pneumonia. Table 2 shows that 54 of the respondents faced this vulnerability to a low extent. Households seldom make some effort to use government-run healthcare facilities, particularly while the rainy season is underway. This is because low-income people, in particular, do not perceive that the services provided by the government are there to meet their needs.

Sanitation and hygiene status of homes

Sanitation was found to be a major challenge for many of the homes in the area under study. Because of the lack of access to water and sanitation infrastructure, unhealthy sanitation practices were commonplace. In the study area, 21 of the respondents faced this vulnerability to a high extent (Table 2). Inadequate hygiene practices, including open defecation, lack of handwashing facilities, polluted drinking water, and improper waste disposal, contribute to environmental pollution and public health risks like cholera and diarrhea. Lower socioeconomic status and lack of awareness about preventative measures exacerbate the problem. In addition, Sharma, (2010) identified the sanitation and hygiene status in rank three in the Nikli area. So, it can be understood that the vulnerability of sanitation and hygiene status in the Nikli *haor* community has lessened over the years.

Family sufferings due to natural calamities

Family sufferings due to natural calamities in the study area had been immense yet respondents marked it as their least vulnerability issue. It was shown in Table 2 that 19 of respondents suffered this vulnerability to a medium extent but 77

respondents marked this vulnerability with a low extent. Monsoon flooding, hailstorms, and flash floods have caused extensive destruction, eroding local communities' land and livelihoods, resulting in numerous deaths and reducing economic activities like farming, leading to breadwinner-less households and poverty. Similarly, Brouwer *et al.*, (2007) found that community-level income and asset inequality are larger at higher risk exposure levels, meaning that vulnerable families are also collectively more susceptible.

Adaptation Measures to Mitigate Socioeconomic Vulnerability

There were several adaptation measures that were adopted by the respondents in the study area. Table 3 highlights the adaptive strategies adapted by the Nikli *haor* community to address the challenges of climate change and socioeconomic vulnerabilities. It provides valuable insights into the percentage of respondents who adopted these strategies. Among the strategies, homestead gardening emerges as an important and practical adaptive strategy, with an adaptation rate between (48%) and non-adaption (52%), signifying a practical stance towards sustaining livelihoods and diversifying income sources. More than half of the surveyed population (56%) has embraced changes in crop patterns, demonstrating flexibility in agricultural practices to cope with changing environmental conditions. Another adaptation strategy was making houses in higher areas and 50% of respondents adopted this strategy. This indicates an awareness and preparedness for increased water levels and flash floods. To have a diversified livelihood during times of vulnerability, respondents engaged in multiple seasonal occupations. This ensures income diversification while they pursue multiple occupations (53%). In the study area, several occupations are found like agricultural labor work, animal rearing, making boat and fishing, and seasonal migration for construction work which was very common in *haor* areas. It is found in the study area that respondents mostly engaged in multiple seasonal occupations like fishing, labor in other areas, duck rearing, etc.

Table 3. Adaptation measures taken by the surveyed respondents in the study area

Adaptive Measures	Adaptation Response	Frequency	Percentage
Homestead gardening	No	63	52
	Yes	57	48
Crop pattern change	No	53	44
	Yes	67	56
Making house in high area	No	60	50
	Yes	60	50
Seasonal occupation	No	64	53
	Yes	56	47
Use of HYV rice	No	64	53
	Yes	56	47
Income diversification	No	56	47
	Yes	64	53
Making a house with brick	No	51	43
	Yes	69	57
Migration	No	54	45
	Yes	66	55
Loan from relative	No	53	44
	Yes	67	56
Domestic animal production	No	58	48
	Yes	62	52
Asset sale	No	44	37
	Yes	76	63

Source: Author's estimate based on field survey, 2023

However, the reliance on migration (55%) and asset sales (63%) raises concerns about the long-term viability of certain coping mechanisms. The study found that respondents in the area had sold valuable assets, primarily livestock such as cattle, goats, and ducks, as well as stored paddy intended for future use. During the flood season and other periods of vulnerability,

some respondents moved to higher ground, such as Kishoreganj's main town and other village areas. Most affected individuals moved to unaffected areas where short-term employment opportunities were more readily available. Additionally, during times of hardship, those without work or income often relied on loans from relatives, highlighting a strong social support system within the community (56%). These findings can be further related to a study conducted by Alam *et al.*, (2017) where it was explored that the local knowledge of adaptation in response to the perceived impacts of climate change and climatic vulnerability. Important adaptation strategies included adopting new crop varieties, changing planting times, homestead gardening, planting trees, and migration.

Conclusion

Conclusion and Policy Recommendations

This study has provided a comprehensive view of the socioeconomic vulnerability and adaptation measures in the Nikli *haor* area of Bangladesh. It is clear from this study that socioeconomic vulnerability and adaptation measures in Nikli *haor* communities are interrelated. The respondent's socioeconomic status has similar trends to other *haor* communities in Bangladesh. In the Nikli area majority of the people are engaged in farming activities and during the wet season they convert their occupation to mainly fishing activities. People are more educated and they also have a small land holding of their own. However, most people are vulnerable to flash floods and settlement erosion in the wet season. Socioeconomic vulnerability exists in other categories like lack of financial aid, health hygiene, and communication failure during the rainy season, etc. The study also found that the community actively employs a diverse array of adaptive measures to navigate the challenges posed by climate change and socioeconomic vulnerabilities. The prevalence of certain strategies, such as raising houses, changing crop patterns, and engaging in multiple occupations, underscores the community's resilience and adaptive capacity. However, the reliance on asset sales and migration raises questions about the sustainability and long-term viability of some coping mechanisms.

To counter the vulnerability, the government may increase investment in local construction to prevent vulnerabilities like flash floods and settlement erosion, roads, sanitation systems, and health facilities so that everyone can benefit from improved services. From this contribution, productivity might be increased at the same time. The government may provide economic opportunities by investing in local businesses that create jobs and increase incomes for people unable to find employment elsewhere. Most importantly, the government may ensure investing in helping the adoption of different effective strategies to mitigate socioeconomic vulnerability. This nuanced understanding is crucial for informing targeted interventions and policies that can enhance the adaptive capacity of the Nikli *haor* community and similarly vulnerable populations, ensuring a sustainable and resilient future.

References

- Ahsan MN and Warner J. 2014. The socioeconomic vulnerability index: a pragmatic approach for assessing climate change led risks-a case study in the south-western coastal Bangladesh. *International Journal of Disaster Risk Reduction*. 8:32-49.
- Alam GMM, Alam K and Mushtaq S. 2017. Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. *Climate Risk Management*. 17:52-63.
- Ali A. 1999. Climate change impacts and adaptation assessment in Bangladesh. *Climate Research*. 12:109-116.
- Banglapedia. (2021). Nikli Upazila - Banglapedia. Retrieved May 20, 2023, from https://en.banglapedia.org/index.php/Nikli_Upazila
- BBS. 2021. Bangladesh bureau of statistics, statistical yearbook Bangladesh 2021. Statistics & Informatics Division (SID), Ministry of Planning Government of the People's Republic of Bangladesh Dhaka.
- BHWDB. 2012. Master plan of haor area. Ministry of Water Resources, Government of the People's Republic of Bangladesh. I 1-82.
- Bidisha SH, Mahmood T and Hossain MB. 2021. Assessing food poverty, vulnerability and food consumption inequality in the context of covid-19: a case of Bangladesh. *Social Indicators Research*. 155:187-210.
- Brouwer R, Admiraal A, Dusseldorp K, Bui T and Tran TH. 2010. Measuring and explaining socio-economic vulnerability to disaster flooding in Vietnam. 1-37.

- Brouwer R, Akter S, Brander L and Haque E. 2007. Socioeconomic vulnerability and adaptation to environmental risk: a case study of climate change and flooding in Bangladesh. *Risk Analysis*. 27:313-326.
- Felsenstein D and Lichter M. 2014. Social and economic vulnerability of coastal communities to sea-level rise and extreme flooding. *Natural Hazards: Journal of the International Society for the Prevention and Mitigation of Natural Hazards*. 71:463-491.
- Ferdushi KF, Ismail MT and Kamil AA. 2019. Perceptions, knowledge and adaptation about climate change: a study on farmers of haor areas after a flash flood in Bangladesh. *Climate*. 7(7):85.
- Gitay H, Finlayson C and Davidson N. 2011. A framework for assessing the vulnerability of wetlands to climate change.
- HIES. 2022. Household income and expenditure survey, report of the household income and expenditure survey 2010. Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID) Ministry of Planning, Bangladesh.
- Hoq MS, Raha SK and Hossain MI. 2021. Livelihood vulnerability to flood hazard: understanding from the flood-prone haor ecosystem of Bangladesh. *Environmental Management*. 67:532-552.
- Horwitz P and Finlayson CM. 2011. Wetlands as settings for human health: incorporating ecosystem services and health impact assessment into water resource management. *BioScience*. 61:678-688.
- Hossain MAR and Naser MN. 2014. Assessment of agro-ecological zone-specific risks, vulnerabilities of disaster and climate change, and climate change adaptation (cca) in fisheries sector of Bangladesh draft report. Disaster and Climate Risks Management in Fisheries Project. Department of Fisheries/CDMP-II, Matshya Bhavan, Ramna. 97.
- Jakariya M and Islam MN. 2017. Evaluation of climate change induced vulnerability and adaptation strategies at haor areas in Bangladesh by integrating gis and diva model. *Modeling Earth Systems and Environment*. 3:1303-1321.
- Eckstein D, Kunzel V and Schafer L. 2021. Global climate risk index, 2021.
- EL Khaled Z and Mcheick H. 2019. Case studies of communications systems during harsh environments: a review of approaches, weaknesses, and limitations to improve quality of service. *International Journal of Distributed Sensor Networks*. 15(2):1550147719829960.
- McLeman RA and Hunter LM. 2010. Migration in the context of vulnerability and adaptation to climate change: insights from Analogues. *Wiley Interdisciplinary Reviews: Climate Change*. 1:450-461.
- Monwar M, Mustafa G, Khan NA and Hossain MS. 2018. Indigenous adaptation practices for the development of climate resilient ecosystems in the hail haor, Bangladesh, *Global Social Welfare*. 5:125-136.
- Nepal C, Dey, Mahmood Parvez MRI. 2021. A study on the impact of the 2017 early monsoon flash flood: potential measures to safeguard livelihoods from extreme climate events in the haor area of Bangladesh. *International Journal of Disaster Risk Reduction*. 59:102247.
- Norman LM, Ruddell BL, Tosline DJ, Fell MK, Greimann BP and Cederberg JR. 2021. Developing climate resilience in Aridlands using rock detention structures as green infrastructure. *Sustainability*. 13:11268.
- Parvez M, Islam MR and Dey NC. 2022. Household food insecurity after the early monsoon flash flood of 2017 among wetland (haor) communities of northeastern Bangladesh: a cross-sectional study. *Food and Energy Security*. 11:1-14.
- Rahman MA, ABKA R, Rahman MS and Sarma PK. 2013. Poverty and food security analysis: a study of fishermen households in a selected area of Bangladesh. *Journal of the Bangladesh Agricultural University*. 11:293-300.
- Rahman R and Lateh H. 2017. Climate change in Bangladesh: a spatio-temporal analysis and simulation of recent temperature and rainfall data using is and time series analysis model. *Theoretical and Applied Climatology*. 128:27-41.
- Raihan F and Hossain MM. 2021. Livelihood vulnerability assessments and adaptation strategies to climate change: a case study in Tanguar haor, Sylhet. *Journal of Water and Climate Change*. 12:3448-3463.
- Shaw R, Mallick F and Islam A. 2013. Climate change adaptation actions in Bangladesh. Tokyo: Springer Japan.
- Sharma P. 2010. Scenario of haor vulnerabilities and other obstacles for sustainable livelihood development in Nikli Upazila. *Journal of the Bangladesh Agricultural University*. 8:283-290.
- Suman A, Akther F and Bhattacharya B. 2014. Climate change impact on haor flooding in Bangladesh using three global circulation models. *International Journal of Scientific Engineering and Technology*. 3(9):1170-1174.
- UNDP. 2012. GEF terminal evaluation-coastal and wetland biodiversity management at Cox' s Bazar and Hakaluki haor.