

Food and health security impact of climate change in Bangladesh: a review

Monira Parvin Moon ^{a,b}

^a Department of Rural Development, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur 1706, Bangladesh

^b Nagoya University, Nagoya, Japan

E-mail: moniramoon@bsmrau.edu.bd

 MPM, 0000-0002-6596-4623

ABSTRACT

There are major threats to Bangladesh's food and health security posed by climate change, including a higher risk of food shortage, hunger, and waterborne illnesses. The country's coastline regions, which are most susceptible to the effects of climate change, are where these problems are most severe. The influence of climate change on Bangladesh's food and health security is examined in this research study. The report analyzes the existing level of understanding on this subject, identifies knowledge gaps, and proposes future research possibilities. Based on the literature review, the study found a number of issues, such as crop failure and lower health status, that worsen the effects of climate change on food and health security. The evaluation emphasizes the serious threats that climate change poses to Bangladesh's food and health security, such as a higher risk of food shortage, hunger, and waterborne illnesses. The harshest effects of climate change are on people's health. The report makes a number of suggestions for academics and politicians to address these issues and how policymakers and scholars may approach these problems.

Key words: Bangladesh, climate change, food security, health security, impacts

HIGHLIGHTS

- This review article has a greater influence on making the policy for eradication of threats.
- This study will be helpful to assess the future of projected food and health security impacts by climate change.

INTRODUCTION

Bangladesh is one of the most densely populated countries in the world, having a total population of about 160 million. As 80% of the country is made up of low-lying floodplains, Bangladesh's rural areas are its main economic sectors. However, the country is rapidly urbanizing, and its agricultural manufacturing, transportation, trade, and other economic activities are growing. Climate change has a greater risk for Bangladesh (Agrawala *et al.* 2003), and there have been around 290 deaths per 1,000 people, including both fatalities and injuries (Nelson 2003). The world has been experiencing climate change, which has led to extreme drought in Asia and Africa as well as heat waves in Bangladesh, India, China, and the UK. Because of climate change, the global climate temperature has been increasing, which gets warmer due to the greenhouse gas (GHG) emissions resulting from human activities. So, Bangladesh is considered as one of the most vulnerable countries in the world (BBC 2006; Maplecroft 2014). Additionally, at least 150,000 people worldwide pass away each year because of climate change. In recent years, Bangladesh has achieved notable strides in decreasing poverty, raising food production, and improving health outcomes. Despite this, the nation continues to confront significant issues with regard to food and health security, particularly in light of the COVID-19 epidemic, natural catastrophes, and climate change. Approximately 25 million people in Bangladesh are food insecure, with approximately 11 million of them experiencing acute hunger as a result of the pandemic and other circumstances, according to a recent study by the World Food Programme (WFP 2021). The impact of COVID-19 on health and nutrition is also highlighted in the study, with supply chains disrupted, access to health care decreased, and rates of malnutrition among children and expectant women rising. Similar findings were made by the Bangladesh Bureau of Statistics (BBS), which discovered that the pandemic had reduced household income and food consumption, with low-income families being severely impacted (BBS 2021).

This is an Open Access article distributed under the terms of the Creative Commons Attribution Licence (CC BY 4.0), which permits copying, adaptation and redistribution, provided the original work is properly cited (<http://creativecommons.org/licenses/by/4.0/>).

Children and elderly people are the most disadvantaged communities in the world. So, this has a severe health impact. Malnutrition and infectious illnesses are important concerns for vulnerable groups including women and children, and these issues have broad consequences for health. Climate change has been changing and it has direct and indirect effects. Government policy-making bodies need to be made aware of these effects. Globally, both direct and indirect effects of climate change and fluctuation are causing psychological health difficulties (Speldevinde *et al.* 2009; Berry *et al.* 2011). According to Swim *et al.* (2009), marginalized populations, communities that depend most heavily on the local ecosystems, and areas with a history of mental illness or other issues are all expected to experience widespread, cumulative, and severe psychological health effects from climate change (Swim *et al.* 2011). The majority of the study to date has come from Australia, Canada, and the USA, with very little research being done in Bangladesh (Berry *et al.* 2011). The strength and availability of social support networks, economic stability, cultural practices, physical health, kinship ties, previous historical events, access to psychological health resources, the ability to engage in fishing, hunting, trapping, foraging, and traveling for sustenance and livelihoods, the availability of housing, the quality of early life, access to education, and sense of belonging are all factors that influence psychological health (Kirmayer *et al.* 2009). One of the most significant new threats to humanity's psychological well-being is climate change. The effects of climate change on the psychological health of those suffering have been the subject of numerous studies (Green 2006; Berry *et al.* 2010). Malnutrition, food and waterborne illnesses, infectious diseases, and increased air pollution are all caused by climate change (Patz *et al.* 2005).

Heat waves and floods, which are brought on by greater temperatures, excessive rainfall, and the thermal expansion of the oceans, are the primary causes of injury and illness. GHG emissions are one of the factors responsible for creating food security and human security (Lake *et al.* 2012). Lobell *et al.* (2011) have given a good account of the effects of climate change on food security, defined as having access to sufficient, safe, nutritious food to maintain a healthy and active life (WHO 2014). Additionally, climate change has been considered an important factor that can cause the occurrence of food safety hazards in enormous stages from primary production to consumption (Tirado *et al.* 2010). Many researchers have found a greater global health impact and increasingly recognized as a public health priority which is occurring because of climate change in the 21st century (Young *et al.* 2002; WHO 2008; Yongyut *et al.* 2009). Bangladesh is prone to cyclones, earthquakes, floods, and other natural calamities (ICDDR 2011). The identification of the connections between Bangladesh's food systems, climate change, and health is one of the significant contributions of contemporary study. According to studies, climate change increases food poverty, water shortages, and decreased agricultural output. The significance of an integrated strategy for tackling food and health security in Bangladesh has also been underlined by recent research. This strategy acknowledges the connection of food systems, health, and climate change and aims to tackle these problems in a coordinated and all-encompassing manner. The Bangladesh Climate-Smart Agriculture Investment Plan, for instance, is a project that strives to promote sustainable and climate-resilient agriculture while highlighting the need for diversification, adaptation, and innovation (Siddique *et al.* 2022). These findings highlight the need for ongoing initiatives to enhance food and health security in Bangladesh, including increasing financial commitments to the country's agricultural sector, social safety net, and hospital infrastructure. There are still a number of research gaps that need to be filled despite the expanding amount of literature on Bangladesh's food and health security and the effects of climate change. First, more study is required to comprehend the socioeconomic and cultural elements that influence how vulnerable certain communities are to climate change. Second, further study is required to determine how non-communicable diseases like diabetes, hypertension, and cardiovascular conditions, which are on the rise in Bangladesh, may be impacted by climate change. Third, additional study is required to understand how gender affects climate change adaptation plans, particularly in terms of food and health security (Pierce *et al.* 2020). The main goal of this literature review is to investigate how climate change would affect Bangladesh's food and health security in light of the aforementioned knowledge gap. The goal of the paper is to present a thorough examination of the current body of information on this subject and to pinpoint areas that still require more study. The evaluation also aims to give suggestions for researchers and policymakers on how to deal with the problems Bangladeshi food and health security is facing as a result of climate change. Peer-reviewed studies, government reports, and other pertinent data sources, among others, are analyzed as part of the review research (Islam *et al.* 2020). Food security, health security, the effects of climate change on agriculture and fisheries, adaptation and mitigation strategies, and policy implications are only a few of the many themes covered in the review.

FOOD AND HEALTH SECURITY IMPACTS

Approximately 47% of Bangladesh's workforce works in the agriculture sector, which also generates 16% of the nation's gross domestic product (GDP) (World Bank 2021). Agriculture provides a livelihood for many rural communities, but it is facing significant difficulties from climate change. Food insecurity is a problem in the nation due to factors including rising temperatures, erratic rainfall patterns, and a rise in the frequency of natural catastrophes like floods, cyclones, and droughts. Climate change is having a substantial influence on health in Bangladesh in addition to issues with food security. Numerous health issues, such as high rates of hunger, infectious illnesses, and maternal and infant mortality, already exist in the nation. These problems are being made worse by climate change in a number of ways (Brown & Funk 2008). For instance, increasing exposure to heat waves and other extreme weather conditions increases the risk of infectious diseases, including diarrhea and respiratory illnesses (Costello *et al.* 2009; Friel *et al.* 2011). In addition to floods brought on by climate change, waterborne illness epidemics are being triggered by the exposure of humans to tainted water sources. According to 2016 research (Faruque *et al.* 2016), malnutrition rates in Bangladesh have already increased as a result of climate change, especially among children under the age of five. Overall, there are many different ways that climate change, food security, and health are intertwined in Bangladesh. Climate change is causing new problems and making old ones worse, especially for rural and underdeveloped areas. Risk is increased as a result of climate change, which is a potential threat for the future and reduce its current health implications are more vulnerable. A lot of study has been done on how communities are impacted by social vulnerability to climate change (Brooks *et al.* 2005). To lessen the effects of climate change on food and health security in Bangladesh, adaptation measures like boosting climate-resilient agriculture, enhancing food storage and distribution infrastructures, and improving healthcare systems to better address climate-related health risks are all imperative. Figure 1 shows how atmospheric conditions that lead to macro-scale climate change have an influence on local environmental factors. The geographic regions and historical eras that have a greater effect on climate change are highlighted by this macro-level connection. In addition, three categories of regional and localized climate change consequences have been identified that affect health security: (1) Modified social interaction patterns; (2) Modified agricultural development and food supply patterns; and (3) Changing Bioorganic Behavior and Patterns. These have dynamic relationships with varied implications on a person's health security.

CLIMATE CHANGE AND ITS IMPACT ON HEALTH IN BANGLADESH

Bangladesh is one of the most climate-vulnerable nations in the world, which has an impact on public health now and in the future (Figure 2). Human health is being compromised by climate change, and rare illnesses are now more widespread in Bangladesh (Ahmed & Atiqul Haq 2017). The health and well-being of millions of Bangladeshis are at risk due to rising temperatures, changing rainfall patterns, sea level rise, and an increase in the frequency and intensity of extreme weather events like cyclones, flooding, and drought through both direct and indirect pathways, with the most vulnerable populations frequently being at the greatest risk. The health industry is being negatively impacted by climatic factors and pollution (MOEF 2005; Abedin *et al.* 2019; Chowdhury *et al.* 2018; Ashrafuzzaman & Furini 2019). Malnutrition and the lack of access to clean water are both rising quickly (IPCC 2007; Parvin & Ahsan 2013). Furthermore, the lack of freshwater affects human health in both direct and indirect ways (Khan *et al.* 2011a, 2011b). The study found that Bangladesh's coastal regions

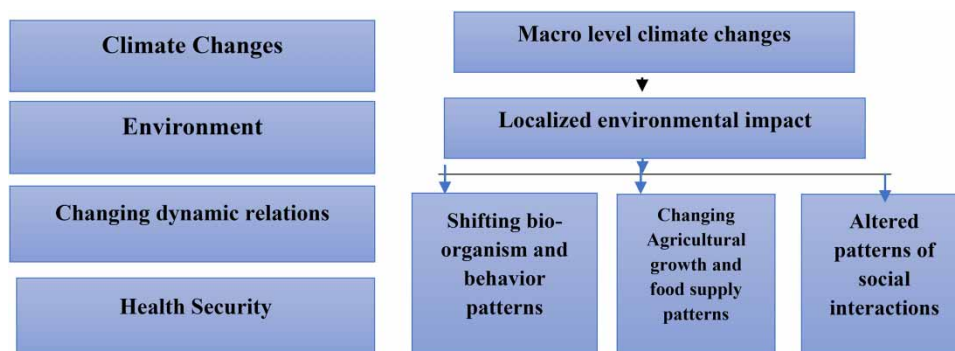


Figure 1 | The indirect effect of climate change on health security (self-prepared).

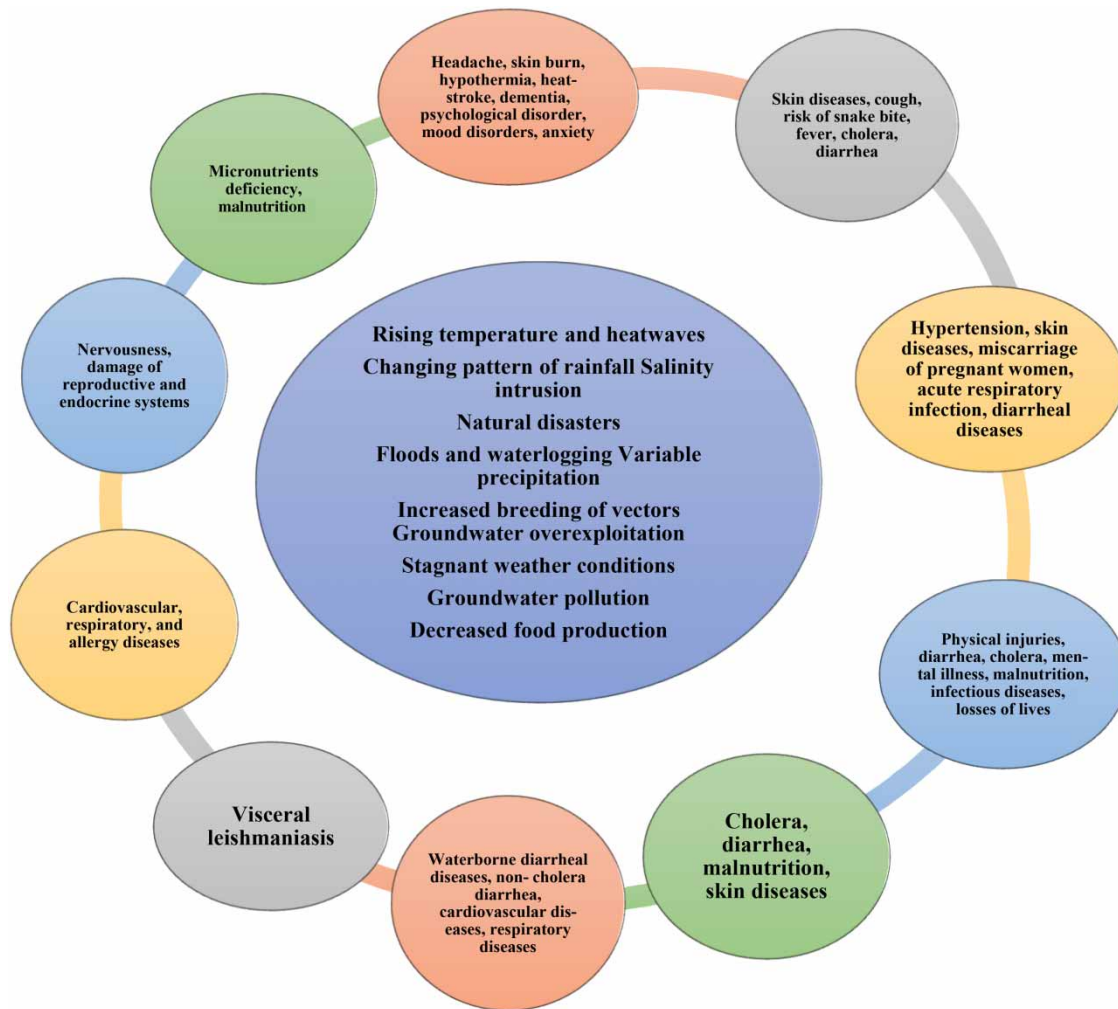


Figure 2 | Impacts of climate change on health in Bangladesh. Sources: Rahman (2008), Mondal *et al.* (2018), Shameem *et al.* (2015), Kabir *et al.* (2016), and Chowdhury *et al.* (2020).

had 8, 14, and 11% higher rates of water-borne, water-washed (water-washed illnesses are those which have been caused by poor personal hygiene because of an inadequate supply of clean water, like shigella, which is a type of skin disease, and scabies and trachoma, which is a type of eye infection), and water-related illnesses (Abedin *et al.* 2019; Asma & Kotani 2021) and vector-borne diseases like malaria and dengue, diseases linked to water, like cholera and other diarrheal diseases, undernutrition due to climatic effects on agricultural production, and deaths and injuries from natural disasters (Hasib & Chathoth 2016). Acute respiratory infectious illnesses, hypertension, and preterm birth have all been linked to contaminated groundwater (Alam 2007). Particularly sensitive to negative health effects are immigrant women (Toole 2019). Floods and cyclones are also directly destroying vital facilities for the food supply, basic services, and health care, which limits their ability to address new problems (Rawlani & Sovacool 2011). Inadequate health care, particularly a lack of gynecologic and obstetric care, worsens suffering and may become a cause of conflict in society (Carballo *et al.* 2008; Kabir *et al.* 2016). So, it is essential to strengthen people, communities, and the health system so they can adapt to climate change in order to maintain the physical, mental, and social wellness of every Bangladeshi person (Kabir 2018). There is a greater risk of death in places with high population density and wide coastal areas mixed with poverty due to the numerous natural catastrophes, such as floods, cyclones, earthquakes, heavy rains, rising temperatures, rising sea levels, and expanding salinity (WHO 2015).

In Figure 3, selected indices of Bangladesh's food and health security in 2019 and 2020 are shown. The hypothetical data are used to demonstrate how a table might look with both historical and current data. In this case, while the maternal

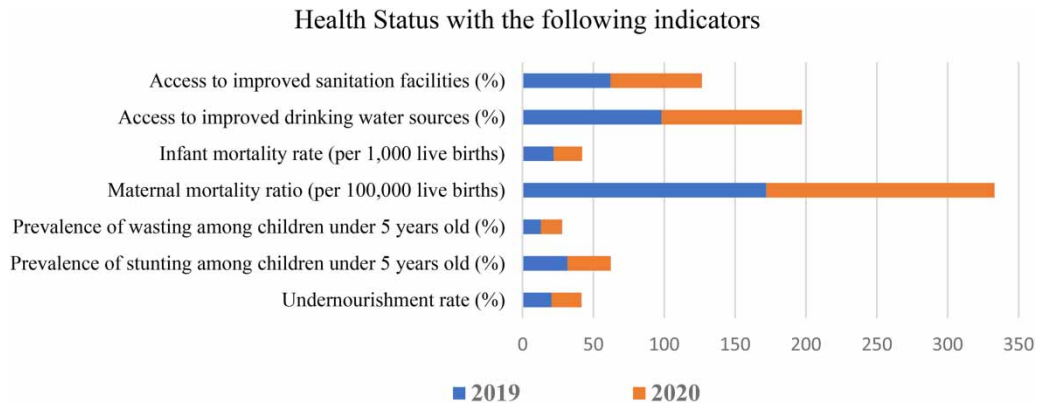


Figure 3 | Contemporary health status due to climate change. Source: UNICEF (2022).

mortality ratio and newborn death rate both declined from 2019 to 2020, the prevalence of stunting, wasting, and undernourishment all marginally rose. Both accessibility to better drinking water sources and sanitary infrastructure have marginally improved. The National Adaptation Plan (HNAP) containing a health component is shown below. This suggests when talking about climate change, health is seen as one of the most crucial issues, particularly in Bangladesh where all health sectors require policies for adaptation and mitigation (Figure 4).

IMPACT OF CLIMATE CHANGE ON FOOD SECURITY

The main climate-related natural disasters that affect Bangladesh include floods, droughts, cyclones, sea level rise, etc.; these events cause livestock loss, pastureland damage, increased fodder scarcity, destroyed shelters, decreased production, and higher management costs because of the occurrence of diseases, among other effects. The graph shows the total amount of agricultural output that has been lost during the past 6 years as a result of several natural catastrophes, such as cyclones, storm surges, floods, and excessive rainfall. In 2007 and 2012, ‘wind-based shocks in the coastal and northeastern regions reduced Boro output, resulting in 6.35% and 10.65% loss in production, respectively’ (Rahman 2008; Figure 5).

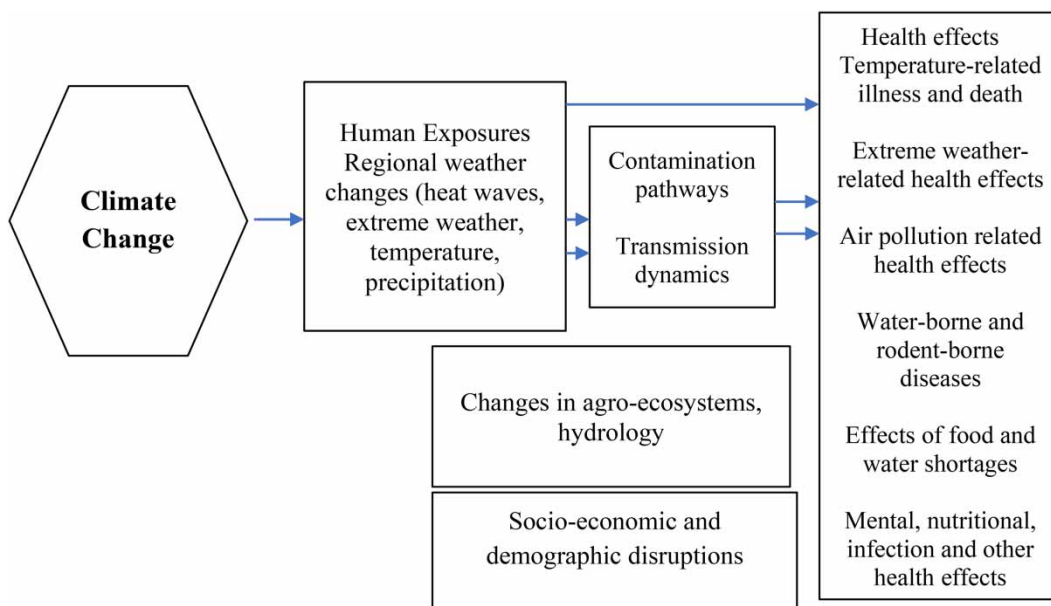


Figure 4 | Climatic health components. Source: WHO (2003), World Health Organization & United Nations (2015).

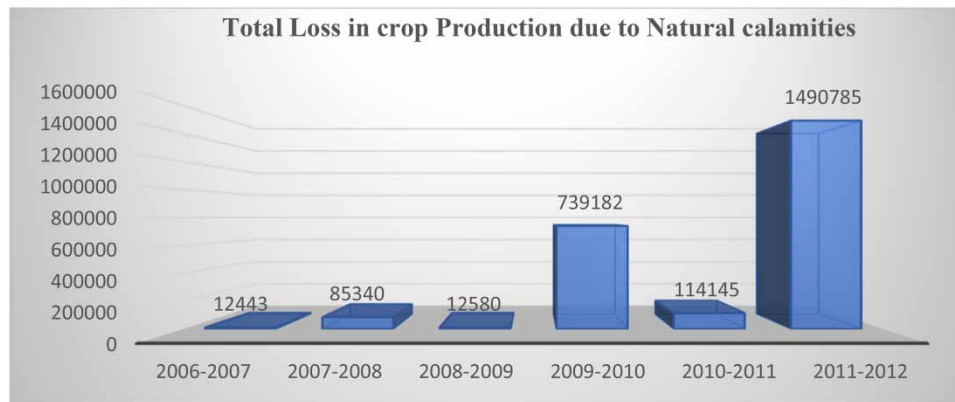


Figure 5 | Total loss in crop production (tons) due to natural calamities in the years 2006–2007 to 2011–2012. *Source:* Shubho (2013).

A number of factors, such as extensive agricultural land degradation, soil erosion, river erosion, a loss in soil fertility, water logging, acidification, and deforestation, among others, have a significant impact on agricultural production and food supplies or food security. Agriculture is a key economic sector in Bangladesh. A storm, a drought, or a flood are only a few examples of the climatic pressures that are putting strain on it. Other non-climatic stresses include population expansion and increasing urbanization. For instance, the nation loses 2% of its GDP annually as a result of climatic extremes, and it is anticipated that this loss will increase to 17% by 2050 (The Daily Star 2021). Islam *et al.* (2022) used the vector autoregression (VAR) model to analyze data between 1984 and 2017 to assess the association between food loss and national food security in Bangladesh with regard to climate change and extreme climatic occurrences. They discovered that food security is significantly harmed by food loss. According to research on ‘poverty and natural disasters’, Karim & Noy (2016) suggest heterogeneous household effects resulting from natural disasters, focusing on the fall in consumption and household per capita income. The household food security and consumption in Northern Kenya, as well as other rural livelihoods, are negatively impacted by drought and other extreme weather occurrences (Maione 2020). According to research on tropical storms’ severe occurrences and household food consumption, hurricane losses and damage resulted in a 1.1% decrease in per capita food consumption. Affected households were pushed to spend more on food consumption and divert money from non-food expenses (Henry *et al.* 2019). Thomas *et al.* (2010) and Aroui *et al.* (2015) show that extreme climatic events like storms significantly reduce family consumption levels by 1.5% in Vietnam using cross-sectional and panel data. Anttila-Hughes & Hsiang (2012) highlighted the fact that devastating typhoons caused a drop in household food consumption in the Philippines from 5.9 to 7.1% (Table 1).

Food security has been significantly impacted by climate change, which has increased the frequency and intensity of climatic disasters such as floods, droughts, and cyclones (Ali *et al.* 2020; Faisal & Parveen 2004). According to recent studies, Bangladesh’s shifting climate and extreme weather patterns have a substantial impact on crops, especially rice production, which is a staple grain for the nation. The southern coastal belt and Bangladesh’s northern area are particularly hard hit (Sarwar & Khan 2007). Food supply and accessibility are impacted by decreasing crop yields brought on by floods and

Table 1 | Cyclones with their economic losses because of climate change in Bangladesh

Year of cyclones in Bangladesh	Economic losses (in dollars)
July 2015 (Komen)	18.1 million
May 2016 (Roanu)	19.3 million
May 2017 (Mora)	34.2 million
November 2019 (Bulbul)	31 million
May 2020 (Amphan)	131 million
May 2021 (Yaash)	21.3 million

Source: ReliefWeb (a Humanitarian Information Portal) (2022).

saltwater intrusion into fields. According to a 2017 assessment by the Bangladeshi government, agricultural yields have decreased 7–10% as a result of climate change, costing farmers significantly more money (Government of Bangladesh 2017). Climate change is not just reducing agricultural yields in Bangladesh; it is also having an impact on food safety and quality. Pest and disease outbreaks are increasing as a result of warming temperatures and shifting precipitation patterns, which poses a threat to food safety and lowers crop quality. Extreme weather conditions can also deteriorate the infrastructure for food delivery and storage, causing food to decay and go to waste. All of these elements contribute to Bangladesh's rising food security dilemma, which is expected to get worse as climate change gets worse (Islam 2008). Bangladesh is among the nations that are most negatively impacted by climate change, according to the Climate Risk Index (2021). Due to the regular occurrence of extreme weather conditions such as cyclones, floods, droughts, and heat waves, it is vulnerable to climate change. The nation's food security has been negatively impacted by these incidents (Climate Risk Index 2021). According to a 2019 report by the International Food Policy Research Institute, Bangladesh's rice output might decrease by 10% by 2050 compared to a scenario without climate change due to variables associated with climate change. The study predicted that by 2050, heat stress, floods, and other climate change-related catastrophes might decrease the nation's output of wheat by 30%, maize by 14%, and potatoes by 6%. In a subsequent assessment released in 2020, the United Nations Development Programme (UNDP) noted that Bangladesh's food systems have been significantly impacted by climate change, which has resulted in food poverty and malnutrition (Bloem *et al.* 2009). According to the research, food insecurity and malnutrition would grow nationwide due to climate change, with the poorest and most vulnerable populations suffering the most (UNDP 2020). Climate change has had a huge influence on Bangladesh's fishing industry as well. According to 2018 research, climate change might significantly reduce the nation's fish supply, which would have an impact on the livelihoods of millions of people who depend on fisheries (FAO 2018). Fish breeding and survival are impacted by sea level rise and water temperature changes, which lowers fish productivity (Siddique *et al.* 2022). In conclusion, Bangladesh is suffering greatly from the effects of climate change, which are only becoming worse. To create resilience in the nation's food systems and to adapt to the changing environment, immediate action is needed.

PROBLEMS AND INNOVATION

The influence of climate change on Bangladesh's food and health security is a complex issue beset by several difficulties. The biggest obstacle to adaptation is a lack of institutional and financial resources. The majority of people are smallholder farmers, who have limited access to financing and insurance to make investments in climate-smart activities. Another major obstacle is inadequate infrastructure, such as inadequate irrigation, drainage, and water management systems (Ahmed *et al.* 2020). Farmers frequently rely on climate-sensitive agricultural techniques like monoculture due to a lack of institutional capacity and financial resources, which poses serious concerns to food security and environmental sustainability (Haider *et al.* 2018). Societal obstacles including gender inequity, limited access to education, and a lack of knowledge about climate-smart activities are among the other difficulties (Woodward *et al.* 1998). The nation's food and health security are suffering because of these implications. While there have been some attempts to address these issues through adaptation strategies, there have been glaring gaps in imagination and innovation when it comes to addressing the changing effects of climate change on Bangladesh's food and health security. The creation of sustainable and climate-resilient agriculture techniques is one area where innovation has been lacking. Although there have been some initiatives to encourage sustainable farming methods, such as crop diversification and soil preservation, these actions have not been scaled up or generally embraced. For instance, according to a 2018 assessment by the International Fund for Agricultural Development (IFAD), only around 20% of Bangladeshi farmers were employing climate-resilient farming practices. This shows that in order to enhance food security for rural areas and increase resilience to the effects of climate change, Bangladesh has to innovate and invest more in sustainable agriculture.

In order to address the effects of climate change on Bangladesh's health, innovation is also required in this field. Numerous health issues, such as high rates of hunger, infectious illnesses, and maternal and infant mortality, already exist in the nation (Shahid 2009). These problems are getting worse as a result of climate change, which is also creating new ones including higher heat stress risks and waterborne disease outbreaks. Although some initiatives have been made to address these problems, such as expanding access to clean water and health care, innovation is required to create more efficient and long-lasting solutions to these intricate health concerns. Expanding access to climate-resilient healthcare systems, for instance, might help lessen the health effects of extreme weather events, as could creative methods to better

manage water resources and enhance sanitation and hygiene. In addition to these particular sectors, there has not been much creativity in creating all-encompassing, integrated solutions to the problems with food and health security brought on by climate change. While some specific interventions have been made to increase access to food and health care, there has not been a lot of attention on creating a more comprehensive and integrated strategy to address these issues. Given the intricate linkages between climate change, food systems, and health, this points to a need for increased creativity in establishing integrated approaches to food and health security in Bangladesh. Despite these obstacles, various initiatives have been made to encourage creativity and imaginative solutions to the climate change-related issues to Bangladesh's food and health security. For instance, initiatives have been made to support environmentally friendly food and agricultural practices, such as the Bangladesh Climate-Smart Agriculture Investment Plan. Additionally, there have been initiatives to increase accessibility to cutting-edge medical technology like telemedicine, which can enhance access to health care in rural and distant sections of the nation (Ghosh *et al.* 2021). Similar efforts are being made in the health sector by the government and non-governmental organizations to provide access to sanitary facilities and clean water, particularly in flood-prone areas, in an effort to lower the prevalence of waterborne illnesses (Islam *et al.* 2020). Overall, nevertheless, more ingenuity and originality are required to address the changing effects of climate change on Bangladesh's food and health security. This could entail enhancing access to cutting-edge healthcare technologies, improving the sustainability and climate resilience of agricultural practices, and creating integrated strategies to tackle problems with food and health security that take into account the intricate interactions between climate change and these vital spheres of human development (Figure 6; Table 2).

LIMITATIONS

First, there might not be enough technical or financial resources to help smallholder farmers make the shift to climate-resilient methods. Secondly, even though research and development initiatives are essential, Bangladesh may not have the resources or the expertise to do studies on climate change and its effects on the country's food and health security. Last

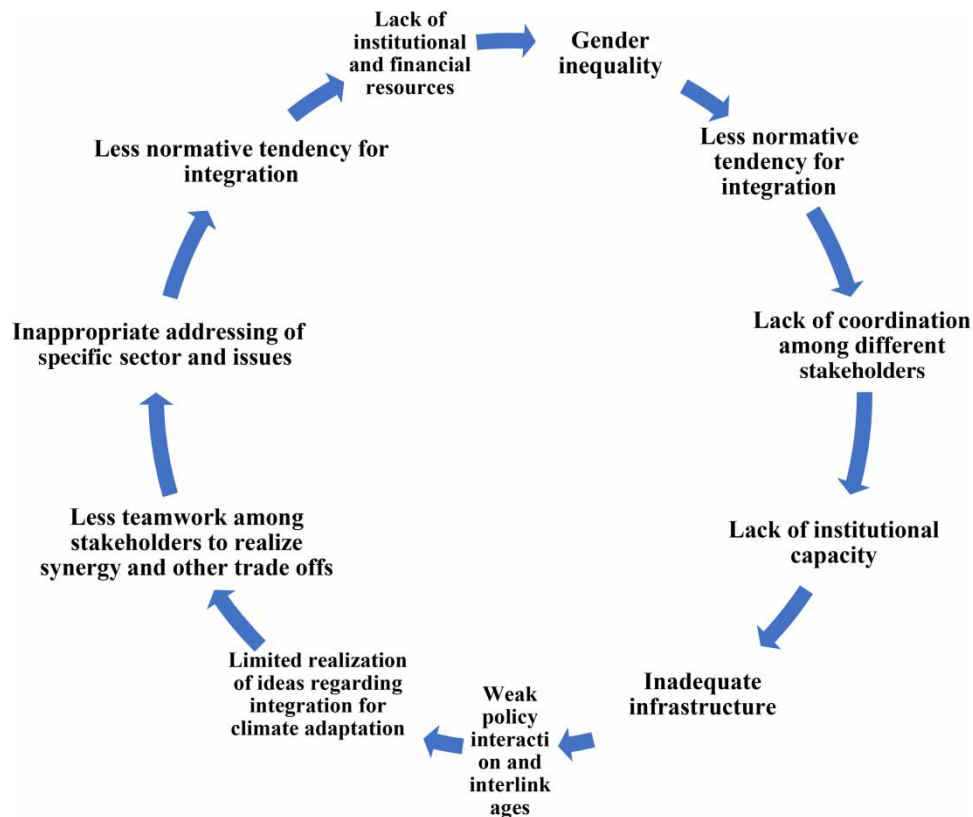


Figure 6 | Major obstacles for climate adaptation. Source: Haines *et al.* (2006a, 2006b) and Rahman (2008).

Table 2 | Adaptation to climate change-related health problems in Bangladesh

Issues	Coping mechanisms for health
Undernutrition	Increased agricultural production
Access to health care	Making a choice between competent and unqualified suppliers
Psychological health	Discuss with relatives, friends, and neighbors, and avoid self-medication and traditional practices
Unusual weather conditions	Self-medication and customary methods of preparing meals and meds in advance
Parasitic illness	Avoiding going outside at dawn and dark, and netting beds
Diseases that are transmitted by food	Maintaining cleanliness when preparing and eating meals
Waterborne illness changes in air quality	Precautions regarding health impacts of algal blooms
Cold waves/heat waves	Precautions on how algal blooms may affect your health, regular surveillance and warnings on days

Sources: Haines *et al.* (2006a, 2006b), Haque *et al.* (2013), Haider (2018), and WHO (2020).

but not least, there can be sociocultural obstacles to successful climate change adaptation, such as ingrained gender norms or conventional beliefs, which cannot be resolved exclusively through technological measures.

CONCLUSION AND RECOMMENDATIONS

In Bangladesh, a few programs and actions have been implemented to address the effects of climate change on food and health security. To support sustainable development, the government has presented the Bangladesh Climate Change Strategy and Action Plan, which is described in its Nationally Determined Contributions under the Paris Agreement. In order to boost agricultural output and foster resilience among populations impacted by climate change, the government and non-governmental organizations (NGOs) have increased the adoption of climate-resilient strategies, technologies, and practices (Schmidhuber & Tubiello 2007; Kabir *et al.* 2019). These include promoting agricultural variety, agroforestry, crop intensification, and a decrease in the use of chemical fertilizers in agriculture. According to the report, it is advised that a coordinated effort be made to solve the issues with Bangladesh's food and health security caused by climate change. This entails collaboration between the government, NGOs, farmers, and other stakeholders to develop a policy environment that prioritizes spending on infrastructure that is climate-resilient and providing financial assistance to smallholder farmers. In addition, encouraging sustainable agricultural methods including crop diversification, crop intensification, and agroforestry can aid in boosting climate change resistance. In order to effectively adapt to climate change, it is also necessary to address socio-cultural impediments and strengthen institutional capacity. Additionally, efforts in research and development have to concentrate on locating crop kinds and farming techniques that are climate-resilient and appropriate for Bangladesh's regional situations.

AUTHORS' CONTRIBUTIONS

All authors included a review of the literature, reports analysis for making comparisons, and created figures based on the previous and current data write-up of the manuscript.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

- Abedin, M. A., Collins, A. E., Habiba, U. & Shaw, R. 2019 *Climate change, water scarcity, and health adaptation in southwestern coastal Bangladesh*. *International Journal of Disaster Risk Science* **10** (1), 28–42. doi:10.1007/s13753-018-0211-8.

- Agrawala, S., Ota, T., Ahmed, A. U., Smith, J. & Aalst, M. V. 2003 *Development and Climate Change in Bangladesh: Focus on Coastal Flooding and the Sundarbans*. Organization for Economic Co-Operation and Development (OECD). <https://www.oecd.org/env/cc/21055658.pdf>.
- Ahmed, M. N. Q. & Atiqul Haq, S. M. 2017 *Indigenous people's perceptions about climate change, forest resource management, and coping strategies: a comparative study in Bangladesh*. *Environment, Development and Sustainability*, 1–30. doi:10.1007/s10668-017-0055-1.
- Ahmed, I., Hasan, M. M. & Shafi, D. 2020 *Climate resilience in agriculture: a study on the adaptation measures of farmers in coastal Bangladesh*. *Sustainability* **12** (19), 8214.
- Alam, M. 2007 *Human Health and Climate Change: Bangladesh Case Study*. Bangladesh Cent Adv Stud (BCAS), Dhaka, Bangladesh.
- Ali, M. H., Musa, R. M., Afroz, S., Azam, M. S. & Rashid, M. T. 2020 *Impact of climate change on rice productivity in Bangladesh: a review*. *Journal of Agricultural Studies* **8** (3), 175–184.
- Anttila-Hughes, J. & Hsiang, S. 2012 *Destruction, Disinvestment, and Death: Economic and Human Losses Following Environmental Disaster*. Social Science Research Network Working Paper.
- Aroui, M., Nguyen, C. & Youssef, A. B. 2015 *Natural disasters, household welfare, and resilience: evidence from rural Vietnam*. *World Development* **70**, 59–77.
- Ashrafuzzaman, M. & Furini, G. L. 2019 *Climate change and human health linkages in the context of globalization: an overview from global to southwestern coastal region of Bangladesh*. *Environment International* **127**, 402–411. doi:10.1016/j.envint.2019.03.020.
- Asma, K. M. & Kotani, K. 2021 *Salinity and water-related disease risk in coastal Bangladesh*. *Ecohealth* **18**, 61–75. doi:10.1007/s10393-021-01517-z.
- Bangladesh Bureau of Statistics (BBS) 2021 *Impact of COVID-19 on Informal Sector and Household Economy*.
- BBC 2006 *Climate Fears for Bangladesh's Future*. Available from: <http://news.bbc.co.uk/2/hi/science/nature/5344002.stm> (accessed 28 April 2019).
- Berry, H. L., Bowen, K. & Kjellstrom, T. 2010 *Climate change and mental health: a causal pathways framework*. *International Journal of Public Health* **55**, 123. <https://doi.org/10.1007/s00038-009-0112-0>.
- Berry, H. L., Hogan, A., Owen, J., Rickwood, D. & Fragar, L. 2011 *Climate change and farmer's mental health: risks and responses*. *Asia-Pacific Journal of Public Health* **23**, 1295–1325.
- Bloem, M. W., Semba, R. D. & Kraemer, K. 2009 *Castel Gandolfo workshop: an introduction to the impact of climate change, the economic crisis, and the increase in the food prices on malnutrition*. *The Journal of Nutrition* **140**, 132–135. <http://dx.doi.org/10.3945/Jn.109.112094>.
- Brooks, N., Neil Adger, W. & Mick Kelly, P. 2005 *The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation*. *Global Environmental Change* **15**, 151–163.
- Brown, M. E. & Funk, C. C. 2008 *Food Security Under Climate Change*, *Science* **319** (5863), 580–581. doi: 10.1126/science.1154102.
- Carballo, M., Smith, C. B. & Pettersson, K. 2008 *Health challenges*. *Forced Migration Review* **31**, 32–33.
- Chowdhury, F. R., Ibrahim, Q. S. U., Bari, M. S., Alam, M. M. J., Dunachie, S. J., Rodriguez-Morales, A. J. & Patwary, M. I. 2018 *The association between temperature, rainfall and humidity with common climate-sensitive infectious diseases in Bangladesh*. *PLoS ONE* **13** (6), e0199579. <https://doi.org/10.1371/journal.pone.0199579>.
- Chowdhury, M. A., Hasan, M. K., Hasan, M. R. & Younos, T. B. 2020 *Climate change impacts and adaptations on health of Internally Displaced People (IDP): An exploratory study on coastal areas of Bangladesh*. *Heliyon* **6** (9), e05018. doi: 10.1016/j.heliyon.2020.e05018.
- Climate Risk Index 2021 Germanwatch. Available from: <https://germanwatch.org/en/crri>
- Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., Friel, S., Groce, N., Johnson, A., Kett, M., Lee, M., Levy, C., Maslin, M., McCoy, D., McGuire, B., Montgomery, H., Napier, D., Pagel, C., Patel, J., Oliveira, J. A., Redclift, N., Rees, H., Rogger, D., Scott, J., Stephenson, J., Twigg, J., Wolff, J. & Patterson, C. 2009 *Managing the health effects of climate change*. *Lancet* **373**, 1702–1705, 1709–1710. [http://dx.doi.org/10.1016/S0140-6736\(09\)60935-1](http://dx.doi.org/10.1016/S0140-6736(09)60935-1).
- Faisal, I. M. & Parveen, S. 2004 *Food security in the face of climate change, population growth and resource constraints: implications for Bangladesh*. *Environmental Management* **34** (4), 487–498.
- FAO (Food and Agricultural Organization of the United States) 2018 *Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options*. Adapted from: <https://www.fao.org/3/i9705en/i9705en>.
- Faruque, F., Choudhury, A. A., Ahmed, T., Ahmed, A. A. & Rahman, A. S. 2016 *Climate change and child undernutrition in Bangladesh: a systematic review and meta-analysis*. *Public Health Nutrition* **20** (13), 1–13.
- Friel, S., Bowen, K., Campbell-Lendrum, D., Frumkin, H., McMichael, A. J. & Rasanathan, K. 2011 *Climate change, noncommunicable diseases, and development: the relationships and common policy opportunities*. *Annual Review of Public Health* **32**, 133–147.
- Ghosh, R., Islam, S. M., Mondal, M. N., Hossain, M. T. & Ahmed, T. 2021 *Telemedicine: a solution for healthcare services in rural Bangladesh*. *Journal of Primary Care and Community Health* **12**, 1–6.
- Government of Bangladesh 2017 *Bangladesh Climate Change Strategy and Action Plan 2009*. Ministry of Environment and Forests, Bangladesh.
- Green, D. 2006 *Climate Change and Health: Impacts on Remote Indigenous Communities in Northern Australia*. Commonwealth Scientific and Industrial Research Organisation, pp. 6–9.

- Haider, M. Z., Huq, S. M. I. & Rahman, M. M. 2018 Assessment of climate change impacts on poverty and food security in Bangladesh: a micro-simulation approach. *Environmental Science and Pollution Research* **25** (18), 17329–17343.
- Haines, C., Kovats, A., Campbell-Lendrum, R. S. & Corvalan, D. 2006a Climate change and human health: impacts, vulnerability and public health. *Public Health* **120** (7), 585–596.
- Haines, C., Kovats, A., Campbell-Lendrum, R. S. & Corvalan, D. 2006b Climate change and human health: impacts, vulnerability, and mitigation. *Lancet* **367** (9528), 2101–2109.
- Haque, M. A., Budi, A., Malik, A. A., Yamamoto, S. S. & Louis, V. R. 2013 Health coping strategies of the people vulnerable to climate change in a resource-poor rural setting in Bangladesh. *BMC Public Health* **13** (1), 565. doi:10.1186/1471-2458-13-565.
- Hasib, E. & Chathoth, P. 2016 Health impact of climate change in Bangladesh: a summary. *Current Urban Studies* **4**, 1–8. <http://dx.doi.org/10.4236/Cus.2016.41001>.
- Henry, M., Spencer, N. & Strobl, E. 2019 The impact of tropical storms on households: evidence from panel data on consumption. *Oxford Bulletin of Economics and Statistics*, 0350–9049. <http://doi.org/10.1111/obes.12328>
- ICDDR, B. 2011 Our Strategy. Available from: http://www.icddr.org/what-we-do/publications/cat_view/52-publications/10043-icddr-documents/10055-annualreport/10056-annual-report-2009/10063-our-strategy
- IPCC 2007 *Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK, p. 1000.
- Islam, M. A. 2008 *Climate Change and Development Risk: Local Perspective*. The Daily Star, Bangladesh.
- Islam, S., Mainuddin, M., Bell, R. & King, E. 2020 Climate change and agriculture in Bangladesh: current and projected impacts and adaptation options. *Bangladesh Journal of Agricultural Research* **45** (1), 1–19.
- Islam, T. A. R. Z., Tasnuva, A., Sarker, S. C., Rahman, M. M., Mondal, M. S. H. & Islam, M. M. U. 2022 Drought in Northern Bangladesh: social, agroecological impact and local perception. *International Journal of Ecosystem* **4** (3), 150–158. <http://doi.org/10.5923/jije.20140403.07>.
- Kabir, S. M. S. 2018 Psychological health challenges of the hill-tracts region for climate change in Bangladeshian. *Journal of Psychiatry* **34** (2018), 74–77.
- Kabir, R., Khan, H. T. A., Ball, E. & Caldwell, K. 2016 Climate change impact: the experience of the coastal areas of Bangladesh affected by cyclones Sidr and Aila. *Journal of Environmental and Public Health*. 2016. doi:10.1155/2016/9654753.
- Kabir, E., Ahammad, R. & Hoque, M. S. 2019 The impacts of climate change on food security in Bangladesh: a review. *Food Security* **11** (6), 1411–1424.
- Karim, A. & Noy, I. 2016 Poverty and natural disasters: a meta-regression analysis. *Review of Economics and Institutions* **7** (2). doi:10.5202/rei.v7i2.222.Article2. Available from: <http://www.rei.unipg.it/rei/article/view/222>
- Khan, A. E., Ireson, A., Kovats, S., Mojumder, S. K., Khusru, A., Rahman, A. & Vineis, P. 2011a Drinking water salinity and maternal health in coastal Bangladesh: implications of climate change. *Environmental Health Perspectives* **119** (9), 1328–1332. doi:10.1289/ehp.1002804.
- Khan, A. E., Xun, W. W., Ahsan, H. & Vineis, P. 2011b Climate change, sea-level rise, & health impacts in Bangladesh. *Environment: Science and Policy for Sustainable Development* **53** (5), 18–33. doi:10.1080/00139157.2011.604008.
- Kirmayer, L., Fletcher, C. & Watt, R. 2009 Locating the ecocentric self: Inuit concepts of mental health and illness. In: *Healing Traditions: the Mental Health of Aboriginal Peoples in Canada* (Kirmayer, L. & Valaskakis, G., eds). UBC Press, Vancouver, pp. 289–314.
- Lake, I. R., Hooper, L., Abdelhamid, A., Bentham, G., Boxall, A. B. A., Draper, A., Fairweather-Tait, S., Hulme, M., Hunter, P. R., Nichols, G. & Waldron, K. W. 2012 Climate change and food security: health impacts in developed countries. *Environmental Health Perspectives* **120** (11), 1520–1526.
- Lobell, D. B., Schlenker, W. & Costa-Roberts, J. 2011 Climate trends and global crop production since 1980. *Science* **333**, 616–620.
- Maione, C. 2020 Adapting to drought and extreme climate: Hunger Safety Net Programme, Kenya. *World Development Perspectives* **20**, 100270. doi:10.1016/j.wdp.2020.100270.
- Maplecroft 2014 *Climate Change Vulnerability Index 2014*. Available from: <https://maplecroft.com/portfolio/newanalysis/>
- MOEF 2005 *National Adaptation Program of Action*. Ministry of Environment and Forest, Government of the People's Republic of Bangladesh.
- Mondal, M. S., Islam, S. A. K. M., Haque, A., Islam, M. R., Biswas, S. & Mohammed, K. 2018 Assessing high-end climate change impacts on floods in major rivers of Bangladesh using multi-model simulations. *Global Science and Technology Journal* **6** (2), 1–14. <https://zantworldpress.com/wp-content/uploads/2018/10/1>.
- Nelson, D. I. 2003 Health impact assessment of climate change in Bangladesh. *Environmental Impact Assessment Review* **23**, 323–341. <http://www.ingentaconnect.com/content/els/01959255/2003/00000023/00000003/art00102>, [http://dx.doi.org/10.1016/s0195-9255\(02\)00102-6](http://dx.doi.org/10.1016/s0195-9255(02)00102-6).
- Parvin, G. A. & Ahsan, S. M. R. 2013 Impacts of climate change on food security of rural poor women in Bangladesh. *Management of Environmental Quality: An International Journal* **24** (6), 802–814. doi:10.1108/MEQ-04-2013-0033.
- Patz, J. A., Campbell-Lendrum, D., Holloway, T. & Foley, J. A. 2005 Impact of regional climate change on human health. *Nature* **438**, 310–317.

- Pierce, M., Hope, H., Ford, T., Hatch, S. L., Hotopf, M., John, A. & Abel, K. M. 2020 Mental health before and during the COVID-19 pandemic: a longitudinal probability sample survey of the UK population. *The Lancet Psychiatry* 7 (10), 883–892. doi:10.1016/S2215-0366(20)30308-4.
- Rahman, A. 2008 Climate change and its impact on health in Bangladesh. *Regional Health Forum* 12 (1), 16–26.
- Rawlani, A. K. & Sovacool, B. K. 2011 Building responsiveness to climate change through community-based adaptation in Bangladesh. *Mitigation and Adaptation Strategies for Global Change* 16 (8), 845–863. doi:10.1007/s11027-011-9298-6.
- ReliefWeb (a Humanitarian Information Portal) 2022 United Nations Office for the Coordination of Humanitarian Affairs (OCHA). Multiple issues related to cyclone in Bangladesh.
- Sarwar, G. M. & Khan, M. H. 2007 Sea level rise: a threat to the coast of Bangladesh. *Internationals ASIAN Forum* 38 (3–4), 375–397.
- Schmidhuber, J. & Tubiello, F. N. 2007 Global food security under climate change. *Proceedings of the National Academy of Sciences* 104, 19703–19708.
- Shahid, S. 2009 Probable impacts of climate change on public health in Bangladesh. *Asia Pacific Journal of Public Health* 22, 310–319. <http://dx.doi.org/10.1177/1010539509335499>.
- Shameem, M., Momtaz, S. & Kiem, A. 2015 Local perceptions of and adaptation to climate variability and change: the case of shrimp farming communities in the coastal region of Bangladesh. *Climatic Change* 133 (2), 253–266. <https://ideas.repec.org/a/spr/climat/v133y2015i2p253-266.html>.
- Shubho, M. H. 2013 *Impacts of Climate Change on Food Security in Bangladesh – A GIS-Based Analysis*.
- Siddique, M. A. B., Ahammad, A. K. S., Bashar, A., Hasan, N. A., Mahalder, B., Alam, M. M., Biswas, J. C. & Haque, M. M. 2022 Impacts of climate change on fish hatchery productivity in Bangladesh: A critical review. *Heliyon* 8 (12). doi: 10.1016/j.heliyon.2022.e11951.
- Speldewinde, P. C., Cook, A., Davies, P. & Weinstein, P. 2009 A relationship between environmental degradation and mental health in rural Western Australia. *Health Place* 15 (3), 880–887.
- Swim, J., Clayton, S., Doherty, T., Gifford, R., Howard, G., Reser, J., Stern, P. & Weber, E. 2010 Psychology and Global Climate Change: Addressing a Multifaceted Phenomenon and Set of Challenges. A Report of the American Psychological Association Task Force on the Interface Between Psychology and Global Climate Change. *American Psychologist* 66 (4), 241–250.
- Swim, J., Stern, P., Doherty, T., Clayton, S., Reser, J., Weber, E., Gifford, R. & Howard, G. 2011 Psychology's contributions to understanding and addressing global climate change. *American Psychologist* 66 (4), 241–250.
- The Daily Star 2021 *Extreme Climatic Events: Bangladesh Loses 2% of GDP a Year*. The Daily Star.
- Thomas, T., Christiaensen, L., Do, Q. T. & Trung, L. D. 2010 *Natural Disasters and Household Welfare: Evidence from Vietnam*. World Bank Policy Research Working Paper Series (5491).
- Tirado, M. C., Clarke, R., Jaykus, L. A., Mcquatters-Gollop, A. & Frank, J. M. 2010 Climate change and food safety: a review. *Food Research International* 43, 1745–1765.
- Toole, M. J. 2019 *Forced Migrants: Refugees and Internally Displaced Persons*. In: Levy, B. S. (ed.) *Social Injustice and Public Health*. Oxford University Press, New York, pp. 213–228. doi: 10.1093/oso/9780190914653.003.0011.
- UNDP 2020 Transforming food and agriculture: Creating food security while fighting climate change. Accessed from <https://reliefweb.int/report/world/transforming-food-and-agriculture-creating-food-security-while-fighting-climate-change>.
- WHO 2003 *Climate Change and Human Health: Risks and Responses*. https://apps.who.int/iris/bitstream/handle/10665/42742/924156248X_eng.
- WHO 2008 *Climate Change and Health: Resolution of the 61st World Health Assembly*. Available from: http://apps.who.int/gb/ebwha/pdf_files/a61/a61_r19-en.pdf.
- WHO 2014 *Trade, Foreign Policy, Diplomacy and Health. Food Security*. World Health Organization. Available from: <http://www.who.int/trade/glossary/story028/en/>
- World Health Organization & United Nations 2015 *Climate change and health country profile 2015: Bangladesh. Bangladesh*. World Health Organization & United Nations Framework Convention on Climate Change, iris. <https://apps.who.int/iris/handle/10665/208856>.
- WHO 2020 Climate and Health Country Profile – 2020: Bangladesh. World Health Organization. <https://climate-adapt.eea.europa.eu/en/metadata/publications/who-climate-and-health-country-profiles>.
- Woodward, A., Hales, S. & Weinstein, P. 1998 Climate change and human health in the Asia Pacific region: who will be most vulnerable? *Climatic Change* 11, 31–38. <http://dx.doi.org/10.3354/cr011031>.
- World Bank 2021 *Agriculture, Forestry, and Fishing, Value Added (% of GDP)*. World Development Indicators. Available from: <https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS>.
- World Food Programme (WFP) 2021 *Bangladesh: Food Security Monitoring Bulletin*. Available from: https://documents.wfp.org/stellent/groups/public/documents/ena/wfp303530.pdf?_ga=2.263776043.1978246556.1634326936-1363628476.1634326936.
- Yongyut, T., Rob, A. & Eric, A. 2009 Projecting forest tree distributions and adaptation to climate change in northern Thailand. *Journal of Ecology and the Natural Environment* 1 (3), 055–063.
- Young, K., Ulloa, C., Luteyn, J. & Knall, S. 2002 Plant evolution and endemism in Andean South American: an introduction. *Botanical Review* 68, 4–21.

First received 3 March 2023; accepted in revised form 15 August 2023. Available online 28 August 2023