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RESEARCH ARTICLE

IMPACT OF CLIMATE CHANGE ON SOIL-WATER QUALITY, FOOD, AND NUTRITIONAL SECURITY IN THE COASTAL AREAS OF BANGLADESH: A CLIMATE CRISIS MANAGEMENT-BASED REVIEW TO ACHIEVE SDGS

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ABSTRACT

Climate change has already received global attention as it is threatening vulnerable communities, sectors, regions, and countries. Bangladesh, especially in coastal areas, is not of exception, because of witnessed the adverse effects of climate change. Increasing industrialization, urbanization, and the greenhouse effect are affecting the climate and causing scenarios like increased soil and water salinity, deforestation, surface water contamination, reduced groundwater level, heavy metal pollution in soil, water, and food, malnutrition, temperature rise, late precipitation, and cropping season shifting etc. These adverse effects affect people's well-being, particularly vulnerable communities, agricultural production, and natural biodiversity. This paper is focused on reviewing literature about the impact of climate change on the soil-water, food, and nutrition sectors in coastal areas of Bangladesh. According to this study, climate change has made the coastal region of Bangladesh even more vulnerable to problems with nutrition, food security, and soil-water quality. Sustainable farming methods, climate-smart agriculture (CSA), and creative approaches to water management, livelihood diversification, and enhancing emergency and humanitarian responses should be the main focuses of climate crisis solutions. Thus, coordinating these initiatives with the management of the climate crisis will enhance sustainable development goals (SDGs) and promote long-term prosperity and food security for the coastal community.

KEYWORDS

Bangladesh; Climate change; Climate crisis; Food security; Nutritional security; Soil-water quality; Sustainable Development Goals

1. INTRODUCTION

Climate change is a big issue that threatens the entire planet today (Islam et al., 2002). Climate change has emerged as a serious threat to Bangladesh's coastal areas, significantly impacting soil-water quality, food production, and nutritional security. Rising sea levels, salinity intrusion, and extreme weather events have all jeopardized soil fertility and water resources, resulting in food shortage and malnutrition (Figure 1). This, in turn, alters crop production and puts at risk the supply of nutritious food, exacerbating issues for already vulnerable to local communities (Beer, 2018). A comprehensive study emphasizes the critical need for adaptive solutions to offset these impacts and maintain long-term livelihoods in the face of climate-induced changes.

Bangladesh has a total land area of 147,570 km (Beer, 2018). The coastal area accounts for around 20% of the country and more than 30% of the net cultivable land. It stretches for up to 150 kilometers from the coast

(BBS. Statistical Yearbook Bangladesh 2023). Around 0.83 million hectares of the 2.85 million hectares of coastline and offshore areas are arable lands, accounting for more than 30% of Bangladesh's total cultivable lands. The Sundarbans, a section of the coastal area, is a natural mangrove forest reserve covering approximately 4,500 km². The remaining coastal land is used for agriculture (Haque, 2006). Jessore, Narail, Gopalganj, Shariatpur, Chandpur, Satkhira, Khulna, Bagerhat, Pirojpur, Jhalokati, Barguna, Barisal, Patuakhali, Bhola, Lakshimpur, Noakhali, Feni, Chittagong, and Cox's Bazar are among the 19 coastal districts (Figure 2) of Bangladesh (Ahmad, 2019).

The possible impact of climate change on coastal locations includes progressive inundation from sea-level rise, greater storm damage, loss of wetlands, and increased salinity from saltwater intrusion (Dasgupta et al., 2015). Extreme heat waves, floods, and draughts are also impacting climate change (Huq et al., 2015; Shamsuzzoha, 2023). Now, the effect of climate change is distinct in various sectors of the environment including

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Table 1: Highlights of the existing major studies on the impacts of climate change on the food production and security in Bangladesh		
Major studies	Major findings	Reference
Climatic hazards, food insecurity, and human displacement	Most households face difficulties maintaining food security and displacement due to climatic hazards.	Alam, et al., 2020
Climate change impacts on agricultural production and food security	Climate change potentially affects coastal agricultural, livestock, and fisheries sectors	Shahjahan et al., 2019; Muna, et al., 2025
Climate Change, Salinization, and Rice Production in Coastal Bangladesh	Rice production would decline 15.6% in nine sub-districts where soil salinity will exceed 4 Deci- Siemens/ meter by 2050	Dasgupta, et al., 2018
Fisheries for food security in climate-vulnerable deltas	Temperature changes could reduce fish productivity and fisheries income, especially in the Bangladeshi Delta.	Lauria, et al., 2018
Impact of salinity on paddy production	If salinity increases by 1%, paddy production will be reduced by 0.08%.	Nahar and Hamid, 2016
Agricultural vulnerability in Bangladesh due to sea level rise	Cropland, production, income, and employment of the farmers are highly vulnerable due to SLR	Islam et al., 2015
Climate change and food security in Bangladesh	Climate change directly influences the condition of food security due to a significant decline in agricultural production.	Amir and Ahmed, 2013
Salinity-induced loss and damage to farming households in coastal Bangladesh	Loss is estimated at 1.9 million USD in the four surveyed villages.	Rabbani, et al., 2013
Effect of salinity on the farmer's livelihood	It reveals that salinity intrusion negatively affects farmer's income, expenditure, and employment opportunity	Haider and Hossain, 2013
Impact of sea level rise on coastal agriculture in Bangladesh	Sea level rise affects coastal agriculture by decreasing soil quality and rice production.	Sarwar and Khan, 2007; Islam et al., 2022
Shoreline alternations and adjacent agricultural land use area changes in Bangladesh	Shoreline changes through accretion and erosional process of the Bangladesh delta have reduced the agricultural lands in the coastal regions of the entire Bangladesh delta.	Shamsuzzoha and Ahamed, 2024

3. FACTORS AFFECTING CLIMATE CHANGE

Climate change is one of the most urgent crisis issues facing experts around the world (Alavipanah, et al., 2022). It is characterized as large changes in the average values of meteorological components such as precipitation and temperature over a long period (Malhi et al., 2021). Identifying climate crisis has a key role in assessing climate change impacts for the specific crisis management for the management of climate emergencies (Figure 5). Therefore, climate change is caused by a variety of variables (Gaskin et al., 2017). For example, the greenhouse effect, deforestation, excessive carbon emissions, urbanization, and so on (Driga and Drigas, 2019; Lawrence and Vandecar, 2015; Anenberg et al., 2012; Chapman et al., 2017). The main factors of climate change are discussed below.

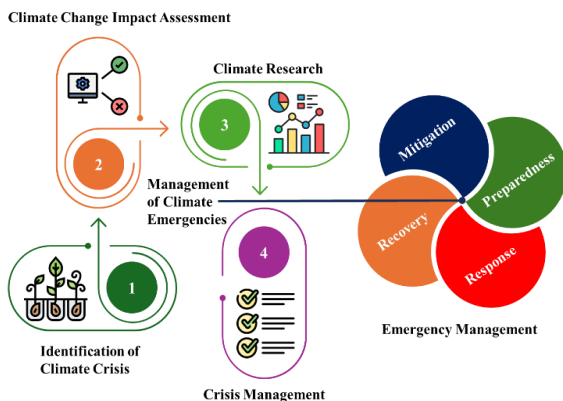


Figure 5: Management of climate emergencies through identification of climate crisis (Author Generated, 2025)

3.1 Global Warming

Global warming may be the most serious and important challenge that humanity has ever faced, with terrible consequences and costly detrimental effects (Ming, et al., 2014). According to Singh and Purohit, the rise in the average temperature of the Earth's atmosphere and oceans, as well as its expected continuation, is referred to as global warming (Singh and Purohit, 2014). The greenhouse effect is the process through which gases in the atmosphere absorb and emit infrared radiation, warming the planet's lower atmosphere and surface. Since the early twentieth century, the average surface temperature of the Earth has increased by around 0.8C (1.4F), with roughly two-thirds of the increase occurring since 1980. Water vapor, CO₂, CH₄, and ozone are the principal greenhouse gases (Singh and Purohit, 2014; Singh and Khatoun, 2022).

3.2 Deforestation

Forests provide several public and private benefits, such as carbon storage, biodiversity habitat, water filtering, storm mitigation, disease

suppression, wood and non-timber products, wild foods and medicines, and recreation (Busch and Ferretti-Gallon, 2017). Deforestation has far-reaching and long-term environmental repercussions. These implications include habitat degradation and biodiversity loss, deterioration of water quality and quantity regulatory services, air pollution, and greenhouse gas (GHG) emissions that cause climate change (Austin, et al., 2019). The primary causes of deforestation include agricultural development and forest clearing, poor environmental legislation, corruption, and high tenure costs, among other things (Leblais et al., 2017). Also, deforestation is linked to higher atmospheric CO₂ levels as well as changes in surface energy and mass balances, which can lead to local and global climate changes (Longobardi et al., 2016). Deforestation causes desertification in Bangladesh by lowering groundwater levels, which causes soil to become dry, fragile, and highly erodible.

3.3 Carbon Emission

Carbon emissions (CE) are a key contributor to global warming and reducing emissions has become a challenge in recent decades. In truth, carbon emissions are a major contributor to global warming. Various industrial processes emit considerable amounts of carbon dioxide into the environment (Sinha and Chaturvedi, 2019). Energy production using fossil fuels leads to carbon emissions into the atmosphere, posing a serious threat to the global ecology (Sinha and Chaturvedi, 2019; Dakwale and Ralegaonkar, 2012). Global climate change, often known as the GHG impact, is potentially the most serious environmental issue related to energy utilization. GHG concentrations in the atmosphere such as CO₂, CH₄, CFCs, halons, N₂O, ozone, and peroxyacetyl nitrate are increasing for a variety of reasons.

These gases trap heat radiating from the earth's surface, elevating the earth's surface temperature. Such changes have the potential to have far-reaching consequences for human activity all around the planet. CO₂ is currently projected to generate approximately 50% of anthropogenic GHG emissions. For example, the construction industry provides infrastructure and buildings to society while consuming a substantial quantity of nonrenewable energy. As a result, this consumption results in significant CO₂ emissions (Huang et al., 2018).

4. IMPACT OF CLIMATE CHANGE ON SOIL AND WATER QUALITY

4.1 Salinity Intrusion

Climate change has a huge impact on onshore soil and water quality (Shamsuzzoha et al., 2023; Baral, et al., 2026). Salinity is one of the major problems in agriculture all over the world, including Bangladesh. Seawater intrusion leads to elevated soil- and water salinity levels in the coastal regions of Bangladesh during the dry season. It decreases soil productivity and increases food insecurity. Soil salinization is one of the major factors contributing to the loss of productivity of cultivated soils. This problem is increasing rapidly throughout the world. Researchers have estimated that more than 50% of the Earth's arable land could be salinized by 2050. According to an estimate of the FAO, over 6% of the world's land is affected by salinity and about 2000 ha of irrigated land per day is degraded by salts

(Islam et al., 2022). Both the magnitude and extent of soil salinity in Bangladesh are also increasing with time, being 0.83 Mha (million hectares) in 1973, 1.02 Mha in 2002, and 1.06 Mha in 2009, posing a serious threat to sustainable agricultural production (Islam et al., 2022). The continued melting of glaciers is raising the sea-level slowly that leads to saltwater intrusion (Nerem, et al., 2018). Saltwater intrusion is projected to worsen in low-lying coastal locations around the world as the climate changes (Dasgupta, et al., 2015). Research done by a group researcher shows that salinity and ocean intrusion are major concerns (Shammi et al., 2019). The list of difficulties is unavoidably long, including mortality in babies, high blood pressure in adults, and (pre)eclampsia in pregnant women, all of which result in millions of people suffering from heart disease.

The recorded sea level rise at various tidal water level stations in different periods are presented in Table 2 (Nishat and Mukherjee, 2013). The salinity problem in Bangladesh's coastal districts is worsening (Akib et al., 2020). Coastal rural communities have struggled to cope with rising soil and water salinity. The salinity of drinking water sources (STWs and pond) was comparable to that in the country's most salinity-affected southwestern region. Salinity concerns in coastal areas have been developing because of poor climatic circumstances (sea level rise, more frequent

storms, longer droughts), posing a serious threat to household water supplies. Salinity is a continually expanding threat to Bangladesh's coastal region, notably in the research locations where TDS, EC, and chloride concentration levels were found to be much higher than permissible limits (Tauhid Ur Rahman, et al., 2017). Several health-related issues are occurring because of saline water drinking in coastal areas. Despite their perceptions, comparable issues have been documented in Bangladesh's southwestern regions (Akib et al., 2020; Dasgupta, et al., 2016; Khan, et al., 2011).

The current saline concentration has already posed a danger to agricultural production, with a considerable yield loss during the dry season. In the changing scenario of sea level rise, it has been expected that increased saline concentrations will put more strain on farmers by reducing output, affecting livelihood, income generation, and food security (Baten et al., 2015). Water salinity causes soil salinity to rise, reducing agricultural production and putting a great strain on food security (Islam and Bhuiyan, 2016). Increased soil salinity inhibits standing crop growth and has an impact on overall crop productivity, as well as making the soil unsuitable for many prospective crops. Soil salinity has been identified as a serious barrier to food grain production in the country's coastal districts (Huq et al., 2015; Basar, 2012; Alam et al., 1999).

Table 2: Periodic examination of recorded sea level rise at various tidal water level stations (Nishat and Mukherjee, 2013)

Period of Analysis	Hiron Point	Moheshkhali	Cox's Bazar	Sandwip
1968-1977	-	207.10	-	-
1977-1986	177.35	214.35	199.87	279.31
1987-1996	182.76	214.97	213.68	337.75
1997-2002	186.20	-	206.54	291.29
Change in the Mean Sea Level (From Trend Line)	0.55cm/year	0.749cm/year	0.5055cm/year	0.7044cm/year

According to the IPCC's Fourth Assessment Report, sea-level rise caused by climate change would have an impact on marine and coastal ecosystems throughout South and Southeast Asia. The estimated amount of sea-level increase over the next century is between 0.2 and 0.6m. The increased saline concentration will put more strain on the population by diminishing yield and directly harming about 40 million people, and another 20 million are at risk (Habiba, et al., 2013).

Furthermore, it will endanger the livelihood, income production, and food security of coastal residents. The groundwater is contaminated with saline water and develops a variety of health issues, including high blood pressure, diarrhea, cholera, and other diseases, because of unsuitable groundwater intake (Mustari and Karim, 2014).

4.2 Shortage of Drinking Water

The root causes of the disruption of potable water supply in the coastal area were saline water intrusion, reduced upstream flow, sea level rise, disasters, polder, arsenic contamination, shrimp cultivation in brackish water, excessive use of underground water and a lack of appropriate aquifer found that climate change poses a significant risk to safe water supplies and health problems in the southwestern coastal areas of Bangladesh (Rahman and Islam, 2019; Abedin, et al., 2019). Climate variability harms both safe drinking water and freshwater resources, such as salinity intrusion, drought during the dry season, and floods during the wet season (Rahman, et al., 2024; Shamsuzzoha, et al., 2018). People in coastal Bangladesh rely heavily on groundwater for drinking purposes, which is a vital ecosystem service in the area (Al Nahian et al., 2018; Shamsuzzoha, et al., 2018). The salinity of drinking water has been linked to cardiovascular disease (CVD), diarrhea, and abdominal pain. If left unchecked, water salinity will continue to rise, resulting in a slew of serious health consequences and a huge load on the population soon (Lam et al., 2022; Chakraborty et al., 2019).

Raising awareness about its effects on everyday healthy lives and potential coping methods for obtaining freshwater may drive communities to adjust to safe water consumption habits and assist policymakers in developing effective mitigation policies to control drinking water salinity (Chakraborty et al., 2019).

4.3 Depleted Ground Water Level

The influence of climate change on groundwater in Bangladesh's coastal areas is a major concern. Rising sea levels and saline intrusion into freshwater aquifers have resulted in a dramatic decrease in groundwater quality and quantity. The problem has been compounded further by the

increased frequency and intensity of cyclones and storms, which are exacerbated by climate change. Groundwater is the principal source of fresh water in the coastal zone. There is also a substantial risk of salinity contamination due to pre-existing fresh and saline groundwater mixing increased by irrigation pumping and vertical infiltration of salt water from frequent storm surge floods (Zahid et al., 2018).

The agricultural sector is also suffering from climate change's impact on groundwater. Crop yields are declining due to saline intrusion, which may cut crop outputs by 15.6% (Chowdhury, et al., 2022; Myint Htun, et al., 2023; Shamsuzzoha, et al., 2022). Climate change is leading to less amount of annual rainfall. The season and time of rain are also changing due to climate change (Earman and Dettinger, 2011). This less rain factor is leading to draught and emphasizing groundwater level reduction (Kirby et al., 2016).

5. IMPACT ON SOIL QUALITY

5.1 Soil and Salinity

Climate change's possible impacts on coastal locations include progressive inundation from sea-level rise, greater storm damage, loss of wetlands, and increased salinity from saltwater intrusion (Dasgupta, et al., 2015). Climate change is not just changing weather patterns, but it is also hastening sea-level rise, resulting in greater flooding and soil saline contamination (Chen and Mueller, 2018). In a study stated that salt intrusion, along with other natural disasters like floods and cyclones, had a substantial impact on the livelihoods of nearby coastal people, and salt intrusion was identified as the primary natural driving force for land use change, which had a large impact on ecosystem services (Islam et al., 2023).

About one billion hectares of land worldwide are affected by several kinds of salinity and associated problems. Reduced cropping intensity with increasing salinity is a regular occurrence in this area, particularly during the Rabi season. As a result, saltwater intrusion not only destroys crop yield but also reduces total crop production on highly salinized soil (Miah et al., 2020). Soil salinity leads to health diseases as well. Salinity issues induced by periodic cyclones and consequent seawater inundations are likely (partly) driven by climate change and aggravated further by changes in upstream river flow and local land-use activities. Dietary (food) salt contributes significantly to the global burden of hypertension. Saline water contains high sodium which has similar impacts on blood pressure and cardiovascular diseases as sodium in meals. The influence of salt in drinking water on pregnant women's blood pressure. Increases in blood pressure in this group could have serious consequences for mother and

fetal health (Scheelbeek, et al., 2016). Dasgupta et al. provide projections of river salinity up to the year 2050 and provide the most comprehensive assessment of soil salinity influenced by seawater intrusion in Bangladesh (Table 3) (Dasgupta, et al., 2015). Soil salinity distributions bear resemblance to the river salinity distributions, particularly in central Khulna of Bangladesh where concentrations of river and soil salinity are high. However, there are instances in coastal areas of

Bangladesh where marked differences occur between river and soil salinity, such as in Barishal where soil salinity is higher than river salinity. The projected trend in soil salinity for the number of upazilas (sub-district of Bangladesh) falling into higher soil salinity classes (>4.01 dS m⁻¹) (Dasgupta, et al., 2018; Dasgupta, et al., 2016). This trend in rising soil salinity within Bangladesh's coastal areas will be accompanied by decreased rice yield.

Table 3: River salinity (parts per thousand, ppt) at its highest in coastal Bangladesh (Dasgupta, et al., 2015)

Location	River	Maximum measured Salinity (ppt)
Amtali	Burisuwar	0.9
Badurgasa	Darunmollik	22.9
Bamni/Char Elahi	Meghna	19.8
Bardia/Nabaganga	Nobogonga	9.8
Bashantapur	Ichamoti	22.6
Bhairab	Hospital Ghat/Fulbari Ghat	16.9
Biskhali DS	Biskhali	11
Burhanuddin	Tetulia	3.5
Chapail Ghat	Modhumoti	5.3
Chandpur	Meghna	0.1
Char Doani	Baleswar	8.5
Daulatkhan	Megna	6
Rangrail	Sundor Mahal	23.2
Habour Khali	Darunmollik Miega Ghat	9.9
Haridashpur	Madaripur Beel Route	2.1
Hilsha	Ganeshpura	4.6
Hiron Point	Pussur	27.3
Kaikhali	Modan Gauga	28.2
Khepupara Kolapara	Adhanmanik	19.8
[1] Khulna	[2] Rupsha	16.8
Kobadak	Kobadak	27.3
Madaripur	Arialkha	0.2
Madhupara	Andharmanik	13.9
Mohipur	Shibbaria Khal	22.8
Moju Chowdhury Hat	Meghna	1.5
Mongla	Pusur	20.7
Musapur	Little Feni	21.2
Nalian	Shibsha	23.4
Patgati	Modhumati	3.9
Pirojpur	Baleswar	0.6
Ramgati Jarirdona Regulator	Meghna	12.7
Shalta	Thanibuina	20.3
Sharankhola	Vola	5.3
Swarupkathi	Swarupkati	0.2

5.2 Decreasing Agricultural Land

Agriculture is the country's backbone, and it relates to food security. Agriculture is the single most productive sector of the economy, accounting for approximately 20.83% of the country's total GDP in 2007-08 (Hassan, 2017). Climate change has had a profound impact on the agricultural areas of Bangladesh. The severity of climate causes the inundation of cropland with saline water. These lands could not be readily converted back to agricultural usage (Huq, et al., 2015). The coastal agricultural areas are particularly vulnerable to the effects of climate change, especially for soil salinity. Inventorying and monitoring climate change impacts on salinity are critical for determining the scope of the problem, identifying trends, and developing irrigation and crop

management measures, implementing Phyto-desalination techniques that will preserve agricultural production in these areas (Corwin, 2021).

Climate change has increased the intensity and frequency of salinity, storms, drought, irregular rainfall, high temperatures, flash floods, and other events that are directly or indirectly related to agricultural output (Faroque, et al., 2013). A group researcher stated urbanization; another important factor for climate change affecting people from migrating from rural to urban areas (Muhsin, et al., 2018). The rapid rate of urbanization in emerging countries' medium and small cities is anticipated to continue over the next few decades. As a result, metropolitan areas are predicted to grow, resulting in the loss of agricultural land and the conversion of rural areas (Chaudhuri and Mishra, 2016).

5.3 Soil Erosion

Climate change has intensified the problem of soil erosion in Bangladesh's coastal areas. Rising sea levels, a rise in the frequency of extreme weather events, and shifting rainfall patterns have all contributed to the deterioration of critical coastal soil. As a result, the lush lands on which millions of people rely for a living are lost to encroaching floods. Not only are soil erosion and overall loss of soil fertility important challenges for developing countries but also reducing soil productivity and agricultural production (Khaleedian et al., 2017). Extreme weather events will contribute to soil erosion, diminishing the land quality, and making soil salinization (Corwin, 2021). Soil erosion and degradation continuously threaten and weaken agriculture's ability to increase or maintain agricultural production (Vanwallegem, et al., 2017).

The degeneration of riverbanks has a combination of direct and indirect implications on human life and the Bangladeshi economy. As riverbank erosion is one of the most dangerous disasters, developing different policies and programs for vulnerable areas may be beneficial in assisting the afflicted community (Bhuiyan et al., 2017). Shrimp farms have lately been built in coastal Bangladesh, causing increased saline water incursion inland.

Climate events such as tidal processes, storm surges, coastal erosion, and tropical cyclones are to blame (Huq, et al., 2015). It appears that deforestation on steep slopes accelerates soil erosion and landslides during monsoon precipitation. This, in turn, is thought to lead to disastrous floods in downstream areas such as Bangladesh (Kabir and Hossen, 2019). Soil loss due to water erosion endangers the environment and, in most cases, exceeds the period required for soil development and with proper management of usable land forestation can prevent soil degradation (Falcão, et al., 2020; Chowdhury et al., 2022).

6. IMPACT ON FOOD SAFETY AND NUTRITIONAL SECURITY

Food safety and nutritional security exist when all people have physical, social, and economic access to food that is sufficient in quantity and quality in terms of variety, diversity, nutrient content, and safety to meet their dietary needs and food preferences for an active and healthy life, in addition to a sanitary environment, adequate health, education, and care (Bilali, 2019; Binte Mostafiz, et al., 2021). It is a top priority for all developing countries, including Bangladesh which faces the significant challenge of food insecurity (Figure 2) due to climate change (Roy, et al., 2019).

6.1 Hampering Agricultural Production

Food and nutritional security are influenced by climate change in different ways. Climate change is multifaceted, encompassing growing greenhouse gas concentrations in the atmosphere, rising temperatures, shifting precipitation patterns, and an increase in the frequency of extreme weather events (Mohsenipour, et al., 2018). The atmospheric temperature is increasing due to the greenhouse effect. The mean world temperature is steadily rising and is projected to climb by 2 degrees Celsius by 2100, leading to significant crops and financial losses. Temperature rises related to global warming have influenced evapotranspiration and atmospheric water storage, changing precipitation patterns across the planet.

For this reason, increases in temperatures related to global warming have influenced evapotranspiration and atmospheric water storage, changing precipitation patterns; thus, seasonal pattern changes across the planet (Mohsenipour, et al., 2018). Rainfall has increased during the monsoon season while remaining practically constant during the other seasons (Rahman, et al., 2017). Due to this seasonal change, pest infestations pose a danger to crop growth in Bangladesh leading to crop production loss (Chowdhury, et al., 2018). To prevent crops from pest attacks, farmers are using more pesticides which eventually leads to less crop production, and the fewer crops are produced, the more food and nutritional security will be hampered (Shammi, et al., 2020; Popp, et al., 2013).

6.2 Heavy Metal Pollution in Soil and Water

Environmental pollution and food safety are two of today's most pressing challenges. Soil and water contamination have historically had an impact on food safety, posing a significant threat to human health (Lu, et al., 2015). Rapid growth in industrialization, urbanization, and other anthropological activities have also contributed to the widespread distribution of arsenic (As), cadmium (Cd), lead (Pb), mercury (Hg), and chromium (Cr) in the environment. Pb, Cd, and Cr contamination in soil, rivers, and crops harms human and natural life (Islam, et al., 2018). Heavy metal intrusion creates a great hamper on human health that leads to nutritional hazards (Kormoker, et al., 2022). For example, Hg is one of the most dangerous heavy metals, has entered the environment because of anthropogenic activities such as agriculture, municipal wastewater discharge, mining,

incineration, and industrial wastewater discharges causing various health hazards like pulmonary toxicity, blood pressure, nephrotoxicity, and neurological abnormalities (Jan, et al., 2015).

Chronic As exposure from drinking water and other food sources is a major public health concern that affects hundreds of millions of people globally (Rahman, et al., 2018). Exposure to high concentrations of As may have both carcinogenic and non-carcinogenic consequences. Chronic disorders such as vascular disease, liver disease, neurotoxicity, chronic cough, and diabetes mellitus are examples of non-carcinogenic consequences. High levels of As exposure can harm pregnancy outcomes and infant development.

High As exposure concentrations increase the likelihood of getting cancer in terms of carcinogenic effects (Yunus, et al., 2016). Arsenic was actively transferred to the developing fetus and caused developmental damage. Birth abnormalities are increased by exposure to soil and water (Mohammed Abdul, et al., 2015). These heavy metals enter and contaminate the food chain and cause food and nutritional insecurity.

7. EXTREME CLIMATIC EVENTS BECAUSE OF CLIMATE CHANGE

Bangladesh's location in the Bay of Bengal has historically made it vulnerable to extreme climatic events. Severe tropical cyclonic storms frequently hit the nation, causing terrible destruction to livelihoods and infrastructure as well as the untimely death toll. Some recent cyclone phenomenon and their losses are described in Table 1. Throughout time, different cyclones have impacted local lives and influenced climate change in coastal areas of Bangladesh (Haque and Jahan, 2016). A group researcher found that cyclone SIDR created the highest loss in the agricultural sector (Shamsuzzoha and Al-Maruf, 2012). The Aila destroyed more than 700 km of coastal embankments and the displacement of around 2 million people, razing 77,000 acres of agricultural land (Islam and Hasan, 2016; Saha 2015). 1.4 million people were affected due to Amphan, and total damages were around 5.4 million (Medha; et al., 2023).

8. DISCUSSION AND FUTURE DIRECTION

Due to rapid growth of industrialization and urbanization, the temperature in the atmosphere is increasing day by day. Greenhouse effect, excessive CO₂ emission, deforestation, heavy use of agricultural land etc. accelerate the pace of temperature rise. Because of increasing temperature, problems like river and soil erosion, glacier melting, sea-level rise are increasing which also create many adverse effects specially in coastal areas. Sea-level rise leads to a high risk of life loss to people who are living near sea by natural disasters like tropical cyclones, floods, coastal erosions and many more. Sea level rise also is increasing salinity level in ground/drinkable water sources (Baral, et al., 2026). Due to this, the agriculture sector in coastal area is getting affected adversely. Not only in the agricultural sector surface water sources are also getting contaminated because of the effects of climate change. Usable and agricultural land is also decreasing day by day because of rapid urbanization.

To maintain crop fertility, farmers are now using chemical fertilizers and pesticides. Overuse of chemical fertilizers and pesticides contaminates groundwater and food sources by inputting heavy metal materials which are later consumed by humans and other animals. Due to these impacts, food and nutritional security in coastal area of Bangladesh is getting adversely affected (Muna, et al., 2025). Nature-based and climate-resilient solutions can be introduced to get rid of this situation. Like, phytoremediation of heavy metals, phyto-desalination of saline water and soil using different living plant species can be a good option to reduce heavy metals and salinity-induced stress on crop production and fresh safe water reservation (Islam et al., 2022; Islam et al., 2019; Islam et al., 2017; Islam et al., 2015; Islam et al., 2013). Plant-based herbicides were successfully trailed by on selected weeds to control them (Islam et al., 2021). Some other agricultural activities like mulching, alternate wetting, and drying (AWD), zero tillage, integrated pest management (IPM), integrated nutrient management system (INMS), climate resilient crop variety development, rainwater harvesting, vertical cropping, floating bed, sorjan technique etc will be a suitable option to mitigate the climate change impact on agricultural production and ensure the food and nutritional security to the most affected coastal people to achieve sustainable development goals. Addressing soil-water quality, food, and nutritional security in the coastal areas of Bangladesh, especially within the context of the United Nations Sustainable Development Goals (SDGs), requires a multi-faceted approach due to the unique challenges faced by these regions.

Bangladesh's coastal regions are susceptible to cyclones, floods, saline intrusion, and increasing sea levels, all of which have an immediate effect on access to clean water, food systems, and agriculture. Some possible

approaches and solutions based on the SDGs are listed below, particularly those related to zero hunger (SDG 2), good health and well-being (SDG 3), clean water and sanitation (SDG 6), climate action (SDG 13), life on land (SDG 15), responsible consumption and production (SDG 12), and Partnerships for the Goals (SDG 17):

8.1 Enhancing Food Security (SDG 2: Zero Hunger)

Climate-resilient farming methods that maximize resource utilization while lowering the risk of extreme weather events are promoted by Climate-smart Agriculture (CSA). Among these is agroecology, which introduces sustainable agricultural methods that boost soil health and resilience to climate shocks by integrating crops, animals, and trees into a harmonic system. Its varied farming methods promote multi-cropping (rice, fish, and vegetables, for example) and agroforestry to guarantee food diversification and lessen reliance on a single crop, increasing farmers' resilience to changes in the market and climate. Shrimp farming and integrated rice-fish farming systems are examples of sustainable aquaculture practices that must be expanded to improve coastal food security offer alternate sources of income and help alleviate the climate problem in Bangladesh. As part of SDG-2's objective to improve food security, community-based Seed Banks have established local seed banks to preserve and disperse crop types resistant to salinity and drought, giving vulnerable farmers in Bangladesh's coastal regions access to high-quality seeds.

8.2 Promoting Nutritional Security (SDG 3: Good Health and Well-being)

It is recommended that nutrition-sensitive agriculture be used to create policies and initiatives that guarantee food systems also support nutrition security by encouraging a range of nutrient-dense crops, including fish, fruits, vegetables, and legumes. Diversified diets and education can be used to raise knowledge of nutrition through community outreach initiatives that use locally sourced food to teach people the value of a balanced diet. To alleviate prevalent deficiencies in the coastal population, it is recommended that rice, flour, and other staples be fortified with micronutrients. Local farmers, non-governmental organizations, and the business sector collaborate to manufacture and sell reasonably priced, nutrient-dense foods like fish and fortified rice through public-private partnerships.

8.3 Research, Innovation, and Capacity Building (SDG 4: Quality Education)

Creating platforms for farmers, scientists, and policymakers to share knowledge on climate-smart agriculture, nutrition-sensitive farming, and best practices for soil and water management requires high-quality education-based knowledge-sharing platforms. Training programs on climate change adaptation, water management, and sustainable farming methods are offered to local communities through capacity building and training, with a focus on women and young people. Lastly, policy support and advocacy encourage the adoption of creative and sustainable techniques by integrating soil and water management into agriculture and food security strategies.

8.4 Improving Soil and Water Quality (SDG 6: Clean Water and Sanitation)

In Bangladesh's coastal areas, managing salinity is crucial to enhancing the quality of the soil and water. The quality of the soil and water has been deteriorated by the incursion of salt brought on by sea level rise (Baral, et al., 2026; Muna, et al., 2025; Islam et al., 2022). Among the solutions are to help farmers deal with rising salt, saline-tolerant crop types can be developed and promoted. Examples of these include rice, vegetables, and fruits. In the meantime, to improve soil structure and lower saline levels in coastal soils, soil amendment also requires applicants to add organic elements like gypsum and compost. Reliance on saline groundwater is lessened via rainfall gathering, collection, and storage for irrigation during the dry season. Using devices such as pond sand filters (PSFs) to remove salt and produce safe drinking water is known as integrated water management.

8.5 Disaster Preparedness, Emergency Management and Climate Adaptation (SDG 13: Climate Action)

First, to shield land from saline water incursion and lower the risk of floods, coastal protection infrastructure constructs and maintains physical infrastructure such embankments, coastal forests (mangroves), and storm surge barriers. Second, early warning systems help communities better prepare and react to extreme weather events like floods, cyclones, and other natural disasters by increasing awareness and warning systems. Planning for climate resilience can put into practice community-based adaptation techniques that boost resilience, like crop rotation, better

irrigation, and saltwater-resistant crops.

8.6 Sustainable Resource Management and Livelihoods (SDG 12: Responsible Consumption and Production, SDG 15: Life on Land)

Mangrove ecosystems near the coast can be preserved and restored through Mangrove Restoration and Conservation. These ecosystems support biodiversity, serve as natural storm barriers, and offer sustainable sources of fuel and food (such as fish and prawns). Regulation of fishing to avoid overfishing and maintain fish populations in coastal seas is one example of how sustainable fisheries management can assist sustainable fisheries practices. To lessen reliance on agriculture alone, Alternative Livelihoods encourages alternative livelihoods like ecotourism, sustainable aquaculture, and handcraft production (Muna, et al., 2025).

8.7 Collaboration and Partnerships (SDG 17: Partnerships for the Goals)

Government agencies, non-governmental organizations (NGOs), local communities, and the commercial sector work together more effectively when multi-stakeholder partnerships are in place to execute integrated solutions that improve the security of food, water, soil, and nutrition. International collaboration works with donors and international organizations to provide financial assistance and technical know-how to address Bangladesh's particular problems along the coast.

9. CONCLUSION

The information from the examined publications portrays a bleak picture of the short- and long-term consequences of these environmental alterations. Due to climate change, due to the rising sea level, Salinity intrusion in groundwater contaminates drinkable and usable water resources. Climate change also affects the groundwater level. Reduced groundwater levels are creating a shortage of drinkable and usable water. Soil salinity intrusion undermines conventional farming practices and threatens staple crops while worsening water quality endangers the local population's health.

As urbanization is increasing, usable agricultural land is also decreasing. Agricultural land reduction plays affect crop production as well. Rapid urbanization, deforestation, loss of agricultural land, river and soil erosion, carbon emission, everything leads to adverse effects of climate change that hampers soil, water, food, and nutrition security in coastal areas. The conclusions of this analysis underscore the critical importance of tackling climate change and its effects on coastal places such as Bangladesh.

Collaboration between governments, non-governmental organizations, and local communities is essential for developing and implementing solutions to ensure food and nutritional security in the face of these problems. Furthermore, continual study and monitoring will be required to adapt and modify solutions as the situation in this dynamic and fragile coastal environment evolves.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Prattaya Chakraborty (1st Author): Research inquiry, literature review, materials and methods, compilation report, and original draft writing; **Md. Shamsuzzoha (Equal contribution as 1st author):** Research inquiry, literature review, materials and methods, data curation, analysis, result interpretation, GIS and RS-based maps, compilation report, and original draft writing; **Md. Shariful Islam (Corresponding author):** Conceptualization, materials and methods, data extraction and curation, result interpretation, review, editing, and supervision of research; **Md. Sujahangir Kabir Sarkar:** Conceptualization, review, and editing of research; **Md. Anwarul Abedin:** Conceptualization, review, and editing of research; **Mst Moriom Khatun:** Conceptualization, review, and editing of research; **Rajib Shaw:** Conceptualization, review, editing of research and supervision of research.

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Data Availability Statement

Upon a reasonable request, the corresponding author will make the dataset created and analyzed for this study public; however, there are limitations on the data's repeatability for reuse and commercially reliable details.

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Conflicts of Interest

With relation to the research, the authors disclose no conflicts of interest.

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