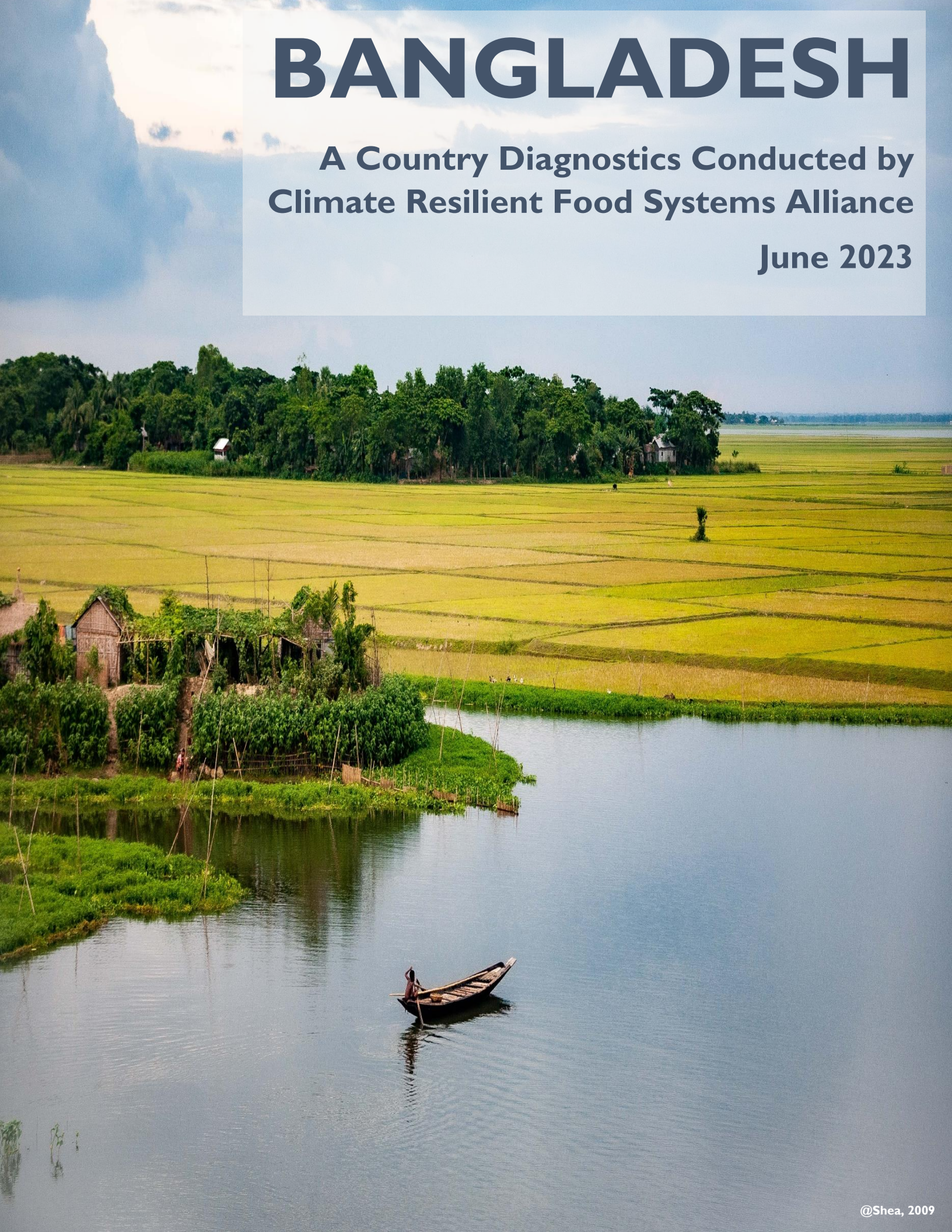
BANGLADESH

A Country Diagnostics Conducted by Climate Resilient Food Systems Alliance

June 2023



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1. Geography and Economy

Bangladesh is a low-lying deltaic country from South Asia with a total area of 147,570 square kilometers (56977 square miles) extending from 20.34° N to 26.34° N latitude and 88.01° E to 92.41° E longitude. The states of West Bengal, Meghalaya, Assam, Tripura, and Manipur of India border Bangladesh from West, North, and East respectively. Besides, the country also shares a border of 271 kilometers with Myanmar on the South Eastern front. In the South, the country is exposed to the Bay of Bengal with a coastline of around 720 kilometers.

Country Profile

Name: People's Republic of Bangladesh

Location: South Asia

Population: 16,98,28,911 *(BBS, 2022)*

Land Area: 147,570 square kilometers

Economy: As of 2019-20, 13.35% of the country's total GDP comes from the Agricultural sector.

Food System Priority Areas: Sustainable intensification, diversification, emissions reduction, and increasing resilience of production, through the adoption of agroecological practices and agri-food system modernization including the use of nanotechnology, and the development of ocean and blue economy.

In terms of its land area, Bangladesh is relatively a small country with a considerable topographic diversity. Being situated in the world's third largest river basin system (the Ganges-Brahmaputra-Meghna basin), 79% of Bangladesh's total land area is formed of alluvial flood plain. The rest 12% and 9% of the land mass are occupied by hilly areas (North East and South East) and terrace soil (Central and North West) respectively (Hossain, 2018). On average, most of the country is less than 12 meters (39 feet) above sea level, and the elevation of plains declines in the coastal South ranging within 1-3 meters (Lázár, 2020).

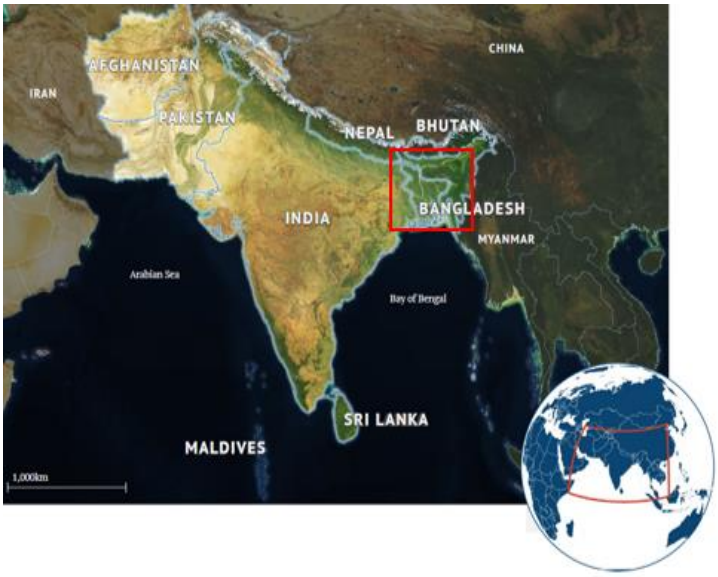
Bangladesh is a riverine country with as many as 800 rivers, tributaries, and distributaries that spread like a web all over the land creating a complex river system. The major rivers of the country the Padma, the Jamuna, the Brahmaputra, the Meghna, the Surma, and the Karnafuli hold more than 230 tributaries with a length of about 24,140 kilometers (BBS, 2022).

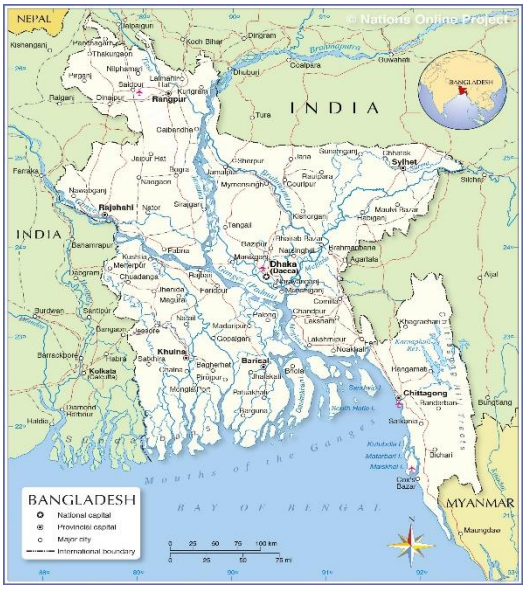
Straddling the Tropic of Cancer, Bangladesh has a tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures, and high humidity. Historically, the average temperature of the country remains around 26°C ranging from 15°C to 34°C throughout the year (WorldBank, 2021). Generally, there are three distinct seasons (i) Pre-monsoon hot season (March–May), (ii) Rainy season (June – October), and (iii) Cool dry winter season (November – February) in the country. However, traditionally these three seasons are divided into six seasons Grisma (summer), Barsa (rainy), Sarat (autumn), Hemanta (late autumn), Shhit (winter), and Basanta (spring). Each season comprises two months, but some seasons flow into other seasons, while others are short. Each of these seasons influences the agricultural production and practices of the country.

Bangladesh receives ample rainfall with an average of 2,200 millimeters (mm) per year. Most of the region of the country receives 1,500 mm of rainfall on average, while the North Eastern border regions receive 5,000 mm of rainfall per year (WorldBank, 2021). The rainfall heads from South-West (the Westerlies) and carries enough moisture from the Bay of Bengal and the Indian Ocean during the pre-monsoon seasons. Depending on the rainfall pattern, rice which is the main crop of the country is cultivated throughout the year in three distinct seasons: Aush (generally

cultivated in December – January), Boro (generally cultivated in March–May), and Aus (generally cultivated in July – August). However, in recent times due to the erratic rainfall pattern, the cultivation timeline of rice and other cereal crops has been altered.

Figures: (1) Bangladesh in South Asia (Source: Carbon Brief), (2) Map of Bangladesh (Source: Online)





In Bangladesh, the rural population encompasses 60% of the total country's population. But over the year there has been a strong urbanization trend, and the current rural-urban rate of change is approximately 3% annually (WorldBank, 2023). Urbanization has supported the rapid development of Bangladesh's economy, which has grown at ~6% per year since 2008 (WorldBank, 2023). In line with this rapid economic growth, Bangladesh has made remarkable improvements in its Human Development Index (HDI) which are evident through the country's reduction in poverty from 48% of the population in 2000 to only 24% in 2016 (WorldBank, 2018). The development of the industry as a result of urbanization has also shifted the country away from its past economic reliance on agriculture.

Bangladesh is now among the fastest-growing countries in the World and the second-largest economy in South Asia. Currently, the country ranks 35th among the largest economies of the world and is expected to become the 20th largest economy by 2037 out of 191 countries (CEBR, 2022). In 2021, Bangladesh was the number 32 economy in the world as per GDP, 56th in total exports, 48th in total imports, 133rd economy in terms of GDP per capita, and 101st most complex economy according to the Economic Complexity Index (ECI). The top export of Bangladesh is RMG (readymade garments) products, Jute and jute products, fish, shrimps and prawns, leather, home textile, and agro-products, exported mostly in the US, Germany, Spain, the UK, the EU, Russia, China, and Japan. The top imports of the country are refined petroleum, raw cotton, non-retail pure cotton yarn, wheat, and light rubberized knitted fabrics, imported mostly from China, India, Singapore, Indonesia, and the US (OEC, 2022; UNB, 2023).

Following the trend of achieving economic growth, the growth of Bangladesh exceeded 6.0 percent in FY 2010-11, 7.0 percent in FY 2015-16, and 8.0 percent in FY2018-19 (WorldBank, 2023). Although the economic situation of the country was normal in the first eight months of

FY2019-20, the COVID-19 pandemic has had a negative impact on the economy of Bangladesh since March 2020. Economic growth slowed to 5.24 percent in FY2019-20 (July 2019 to June 2020), according to the provisional estimates of BBS, which is the lowest since FY 2008-09 (Islam, 2020). In addition, rapid growth in per capita GDP along with the continued generous inflow of remittances helped a progressive increase in per capita gross national income (GNI). Major sectors currently contributing to GDP include services (~56%), industry (~29%), and agriculture (~14%) (MoF, 2022). Even though the agricultural sector is no longer the dominant sector in terms of GDP, 45.33% of the country's workforce and 59.7% of all employed women in the country are directly and indirectly associated with the sector (Byron, 2023; Ahmed, 2022). Such numbers indicate that the country is continuing to be an agrarian society, despite rapid urbanization. Furthermore, rural communities, which are disproportionately affected by poverty, still rely on agriculture as a primary livelihood.

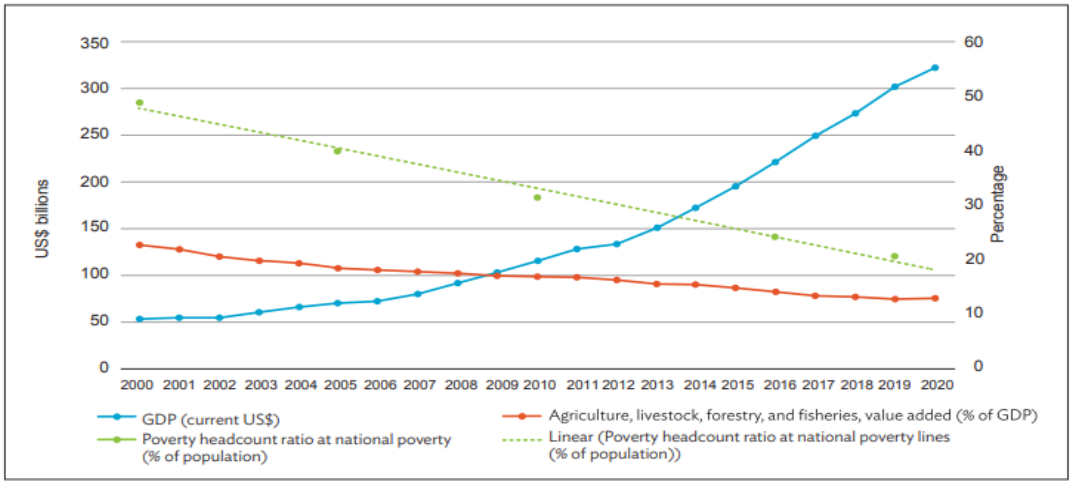
Nevertheless, the impacts of climate change and extreme weather events have dire consequences on the fragile food system and agricultural production of the country. It is estimated that there might be a loss of USD 7.7 billion per annum in the agricultural sector due to climate change and the average rice production might decline to 33% within the next two decades in the BAU scenario (Chowdhury, 2022). The rising temperature and weather anomalies have been creating adverse conditions for agricultural production as each crop requires a different temperature range for optimal vegetative and reproductive growth. When temperatures fluctuate and either fall below the range or exceed the upper limit, crop production is hampered.

Despite the challenges of population pressure, rapid urbanization, and climate change impacts the agricultural sector of Bangladesh succeeds in ensuring food security and stability. The introduction of 30 Agroecological Zones (AEZ) has also helped the process of crop growth, providing a way of including seasonality in land resource appraisal. The government of Bangladesh is committed to achieving 'Food and Nutrition Security' (FNS) for all citizens, at all times, and ensuring an active and healthy life. The government also pledged to end poverty (SDG-1), eradicate hunger and food insecurity, and achieve improved nutrition (SDG-2) by 2030 (FPMU, 2021).

2. Bangladesh's Food System

Bangladesh's agriculture has transformed from a preliminary agrarian and low-productive agriculture to a food-self-sufficient economy since its independence in 1971. In Bangladesh, the agri-food system happens to be a complicated network of actions, processes, and institutions that work together to grow, process, distribute, and consume food. The agricultural sector supports the country's GDP and secures the employment of almost half of the population directly and indirectly. The agricultural sector also plays a vital role in poverty elevation and economic growth of the country. Therefore, it becomes important to ensure a profitable, sustainable, and environment-friendly agricultural system to ensure food security and nutrition (MoF, 2017).

Figure 3: Bangladesh's Gross Domestic Product, Agriculture, and Poverty, 2000–2020



GDP = gross domestic product, US = United States.

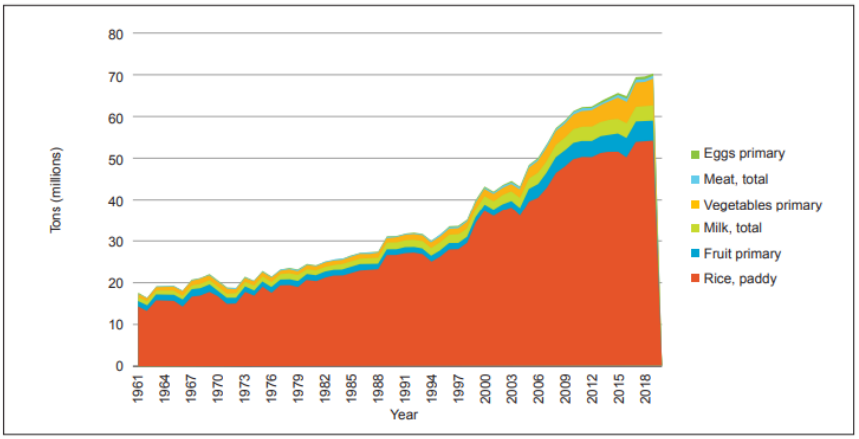
Sources: 2020 value for poverty headcount ratio at national poverty is from Asian Development Bank, 2021; other values World Bank Data Bank, World Development Indicators, 2021. (accessed 21 April 2021).

2.1 Production

Recently, Bangladesh has been ranked among the top ten countries in the production of 22 agricultural products, including rice, lentils, potatoes, onions, tea, and various fruits (Milad, 2023). Besides, the country also holds the 10th position in terms of food production (SRDI, 2020).

Rice being the staple food of the country, holds a high demand and grows abundantly all over the country. Wheat and Maize are the other two major cereal crops. Besides, a variety of oilseeds, legumes, fruits, and vegetables are also produced here. Both fisheries and aquaculture provide major contributions to the country's overall protein supply along with livestock farming, which includes cattle, goats, sheep, and poultry, offering meat, milk, and other dairy products.

Figure 4: Crop and Livestock Production from 1961-2019



Source: Food and Agriculture Organization of the United Nations (FAO). 2021. FAOSTAT–Production. Crops and Livestock Products DatasetLPD (accessed 14 April 2021).

(A) Cereal Crops: Rice, Wheat, and Maize

A1. Rice: Bangladesh ranks third in global rice production. Since independence, the country reached 38.2 million tonnes of production in 2022 from 10.59 tonnes in 1971 (DailySun, 2022). The rice sector provides nearly 48% of rural employment, about two-thirds of the total calorie supply, and about one-half of the total protein intake of an average person in the country. Besides, the sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (BRKB, 2023).

Figure 5: Total Rice Production of Bangladesh. Source: (Nasim et al., 2021)

Rice production covers approximately 78% of the country's total cultivated area. With a population of around 169.04 million people, Bangladesh has achieved self-sufficiency in rice production by cultivating approximately 11.55 million hectares of gross cultivated area (Mamun et al., 2021). Thus, ensuring rice security almost means securing the food security of Bangladesh.

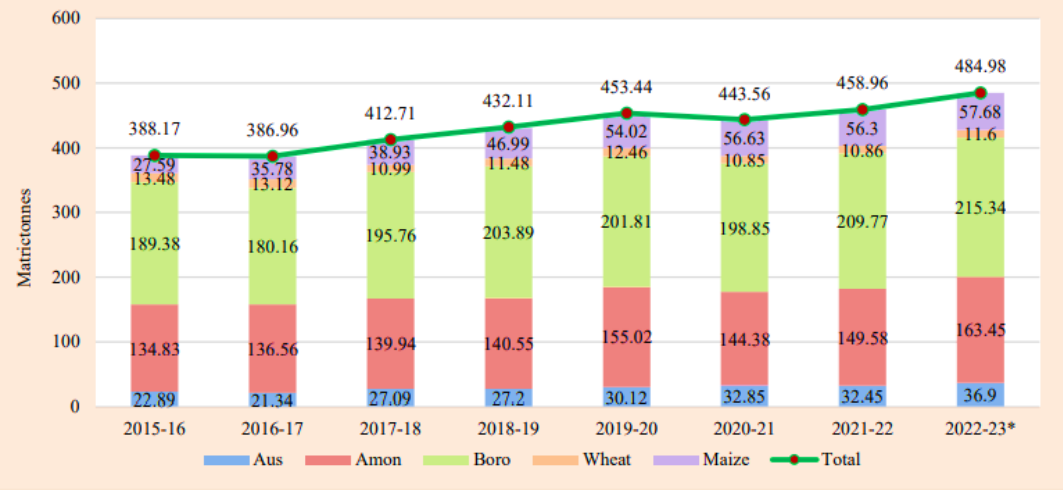
Rice is cultivated in three seasons annually: Aus, Aman, and Boro. Significant increases in rice production in Bangladesh occurred after 1990-1991, especially during 1996-1997 and 2000-01, as well as from 2009-10 to 2013-14. This progress can be attributed to improved loan distribution policies, well-organized fertilizer supplies, availability of high-quality seeds from both public and commercial sectors, and technical interventions such as genetic improvements of varieties suitable for favorable and unfavorable ecosystems (Mamun et al., 2021).

A.2 Wheat: The introduction of wheat in Bangladesh was a winter crop, that has now become one of the important cereal crops due to changing diets and preferences. The demand for wheat increasing as a desirable food supplement to rice. According to the combined estimate of BBS, and the Ministry of Agriculture and Department of Agriculture Extension

(DAE), the volume of wheat production was 10.86 lakh MT in 2021-22 FY and the target for FY 2022-23 is 11.60 lakh MT approximately (DAE, 2023).

A.3 Maize: Maize holds a significant position as a cereal crop in Bangladesh, following rice and wheat. Maize production from the FY 2021-22 was 56.30 lakh Mt and the target for 2022-23 FY is 57.68 lakh Mt (DAE, 2023). The consumption of maize is expected to increase in all segments, including human food, livestock, and poultry feed, in the future.

Figure 6: Food Grain Production of Bangladesh (2015-2022). Source: (DAE, 2023)



(B) Oil Seed: Oil seeds include mustard, canola-rapeseed soybean sesame, and groundnut. In 2022, oil seed was produced in 0.48 million hectares which was 0.38 million hectares in 2021. Higher demand from edible oil mills and animal feed mills increases the oil-seed demand in the country. In 2021-22, the total production of oil seed was 1499 Mt., and the industry of cattle, poultry, and fish feeds was 5.5-6 million tonnes with demand rising by 6-8% per annum (Wardad, 2022; DAE, 2023).

(C) Vegetables and Fruits: Bangladesh ranks third in vegetable cultivation globally and the loamy fertile soil of the country supports around 142 types of vegetable growth. In 2022, the vegetable was cultivated in 10.34 lakh hectares of land and the total production was 216lahkslakh Mt. During summer and monsoon season 30% of the total vegetables are produced, amounting a to million tones and a total market value of around 12,500 crores BDT (DAE, 2023; Pandit, 2022).

(D) Livestock and Dairies: Livestock species of Bangladesh include cows, cattle, buffalo, goats, sheep, chickens, and ducks. In FY 2021-2022, the sector contributed 1.90% of the national GDP and 16.52% of the agricultural sector. The sector also ensures the protein demands of the nation the livestock sub-sector also plays a vital role in securing employment and livelihood opportunities, particularly for the rural poor communities (DAE, 2023). In addition, livestock also contributes 95% of draft power, 50% of rural transport, and 25% of fuel for cooking in the country (Hamid, 2020).

Table 1: Number of Livestock and Poultry Population in Bangladesh. Source: (DAE, 2023)

(Number in Lakh)

Livestock/ Poultry	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Cattle	234.88	236.36	237.85	239.35	240.86	242.38	243.91	245.50
Buffalo	14.57	14.64	14.71	14.78	14.85	14.92	14.93	15.01
Goat	254.39	256.02	257.66	259.31	261.00	262.67	264.35	266.00
Sheep	32.06	32.70	33.35	34.01	34.68	35.37	36.07	36.80
Total livestock	**535.90**	**539.72**	**543.57**	**647.45**	**551.39**	**555.34**	**559.26**	**563.30**
Chicken	2553.11	2617.70	2683.93	2751.83	2821.45	2892.83	2966.02	3041.10
Duck	488.61	505.22	522.40	540.16	558.53	577.52	597.16	617.50
Total Poultry	**3041.72**	**3122.93**	**3206.33**	**3292.00**	**3379.98**	**3470.35**	**3563.18**	**3658.50**

Source: DLS, MoFL.

Table 2: Production of Milk, Meat, and Fish. Source: (DAE, 2023)

Product	Unit	Production							
		2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22*
Milk	Lakh MT	69.69	72.75	92.83	94.06	99.23	106.80	119.85	94.62
Meat	Lakh MT	58.62	61.52	71.54	72.60	75.14	76.74	84.40	70.99
Eggs	crore	1099.52	1191.24	1493.31	1552.00	1711.00	1736.00	2057.64	1578.67

Source: Department of Livestock Services, ministry of Livestock and Fisheries, *Up to February 2022.

Note: 10 lakhs = 1 million

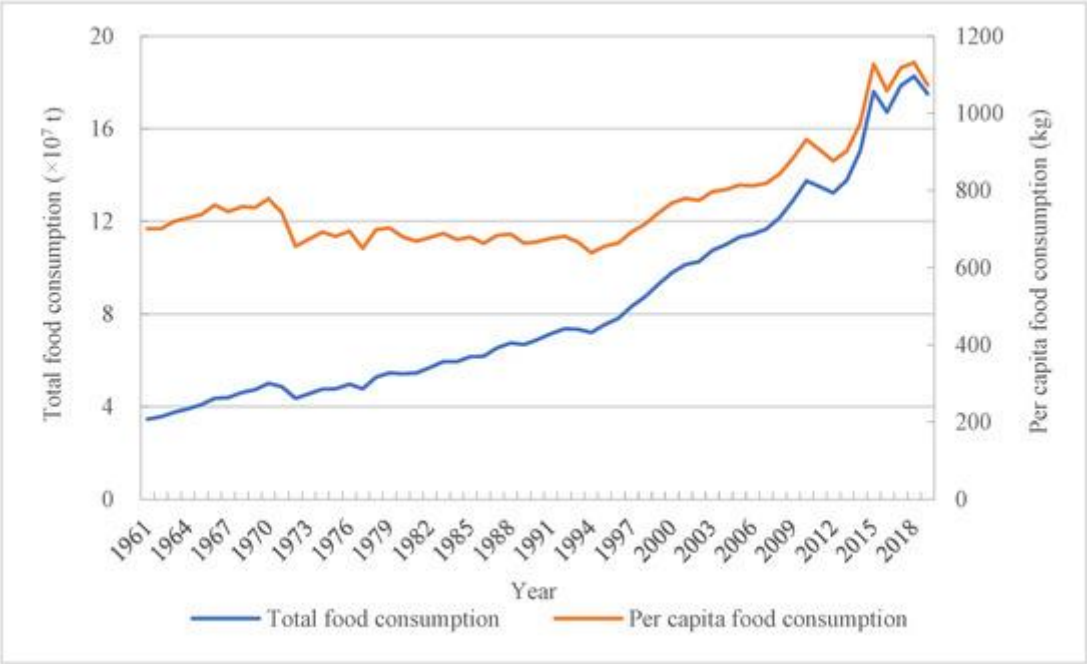
2.2 Consumption

As per the Household Income and Expenditure (HIES) survey conducted in 2022 by the Bangladesh Bureau of Statistics (BBS), there has been a decline in people's reliance on rice as a staple food in Bangladesh. On the contrary, the consumption of nutritious foods such as fish, meat, milk, vegetables, and fruits has increased. The study also reveals that the daily per capita consumption of major foods like pulses, vegetables, fish, meat, milk, and fruits increased from 734.7 grams in 2016 to 820.8 grams in 2022. However, the consumption of rice declined by an average of 38.3 grams per day, while wheat consumption slightly increased from 19.8 grams to 22.9 grams. The study also revealed that the daily per capita consumption of fish, and fruits has increased, along with the calorie intake (risen by 8.26% over six years) (HIES, 2022). The consumption of eggs has declined, while the consumption of fish, milk products, and fruits has increased. Meanwhile, the per capita family expenditure on food has also increased significantly (HIES, 2022). These changes can be attributed to increased production, availability, price levels, and income.

A recent study also claimed that food consumption in Bangladesh showed an increasing trend overall, but there were some fluctuating declines in the process. With the effect of sustained population growth, per capita food consumption experienced significant fluctuation. Additionally, food consumption and structure changes were affected by a series of factors including social, economic, and ecological aspects. However, not every factor had a positive correlation with food consumption, such as arable land. The study also found that, for total food consumption in Bangladesh from 1961 to 2020 the least and biggest were 3.46×10^7 t and 19.02×10^7 ton. In specific divided periods such as the first period (1961-1971), and the average food consumption reached to25×10^7 tons. In the second period (1971-1998), the average food consumption achieved some increase of 44.16%, which reached 6.13×10^7 tons. During the third period (1998-

2020) the average food consumption reached 13.29 × 10^7 tons, which had a growth rate of 116.70% compared to the second period's average food consumption (Jai et al., 2023).

Figure 7: Changes in Total and Per Capita Food Consumption in Bangladesh. Source: (Jai et al., 2023)



2.3 Distribution

In Bangladesh, the Food Value Chain (FVC) distribution and marketing are mainly informal with the associated challenges of inadequate infrastructure (NFNSP, 2020). Though, the PFDS (Public Food Distribution System) arrangement led by the Ministry of Food supports the food distribution process. Till 2014 the PFDS was operated through nine distribution channels. Four of these channels: Open market sales (OMS), Essential Priorities (EP), and Other Priorities (OP) were monetized, and the rest of the five channels: Food for Work (FfW), Vulnerable Group Development (VGD), Vulnerable Group Feeding (VGF), Test Relief (TR), and Gratuitous Relief (GR) remained non-monetized. However, from 2014 onwards the Work for Money (WfM) program has been included in PFDS. The PFDS was established to ensure the supply of food grains to food-based social assistance programs, providing price incentives to farmers to encourage production; maintaining a buffer food stock in case of emergencies; and stabilizing market prices in the face of price volatility (PFDS, 2022). In FY 2020-21, the government had a revised budget of 24.53 lakh MT of food grains for distribution and the actual distribution was 22.89 lakh MT (monetized 15.60 lakh MT and nonmonetized lakh 7.29 MT) through the PFDS. In FY 2021-22, the budget was revised and set at 32.38 lakh MT. Against this budget, up to February 2023, the total actual distribution was 19.05 lakh MT, where 13.46 lakh MT was through monetized channels and 5.59 lakh MT through non-monetized channels of the PFDS (DAE, 2023).

2.4 Key Challenges for the Food System

An extensive literature review identifies three broad challenges that influence the overall food system growth and development within the country. The challenges are:

Population Growth	Rapid Urbanization	Extreme Weather Events and Climate Change
Creating pressure on limited natural resources	Conversation of agricultural and arable lands	Slow-on set events such as drought, sea level rise, and salinity intrusion
Nutritious food insecurity and malnutrition	Migration and changes in occupation	Erratic and extensive rainfall
Land fragmentation	Decrease in the agricultural labor force	Temperature rises and heat waves
Water resource degradation and unsustainable consumption	High wage rates	Cyclones, floods, flash floods, tidal surges

Besides, the **UNFSS National Pathway Document** identifies several associated challenges which are as follows:

- Inadequate mechanization in the agricultural sector
- Scarcity of quality fodder and feed for livestock
- Lack of farmers' capacity to use nature-based solutions for agricultural and animal husbandry practices
- Weakness in backward and forward packages to ensure local product accessibility in wider markets
- Limited contribution of private investment in inputs, processing, storage, packaging, transportation, and marketing of agri-food products and services
- Environmental Monitoring System and water-saving technologies
- Limited access to extension services and aggregation models
- Limited access to support services: financial, technical, and investment on Smallholder farmers and the Cottage, Micro, Small, and Medium Enterprises (CMSMEs)
- Limited market facilities, storage, transport, and communication infrastructure
- Lack of formalization of informal sector workers and providing vocational training
- Lack of institutional strengthening at the national and sub-national level
- Substantial food and nutritional loss along the agri-food value chain arising from harvest and postharvest losses due to inadequate infrastructure and lack of updated technologies
- Prevalence of micronutrient deficiencies and adequate nutrition especially for pregnant women, infants, and children's
- Ensuring nutritious and healthy diets
- Limited coordination and collaboration among different ministries and agencies
- Integrated disaster risk management and EWS
- Humanitarian crisis response: Rohingya influx

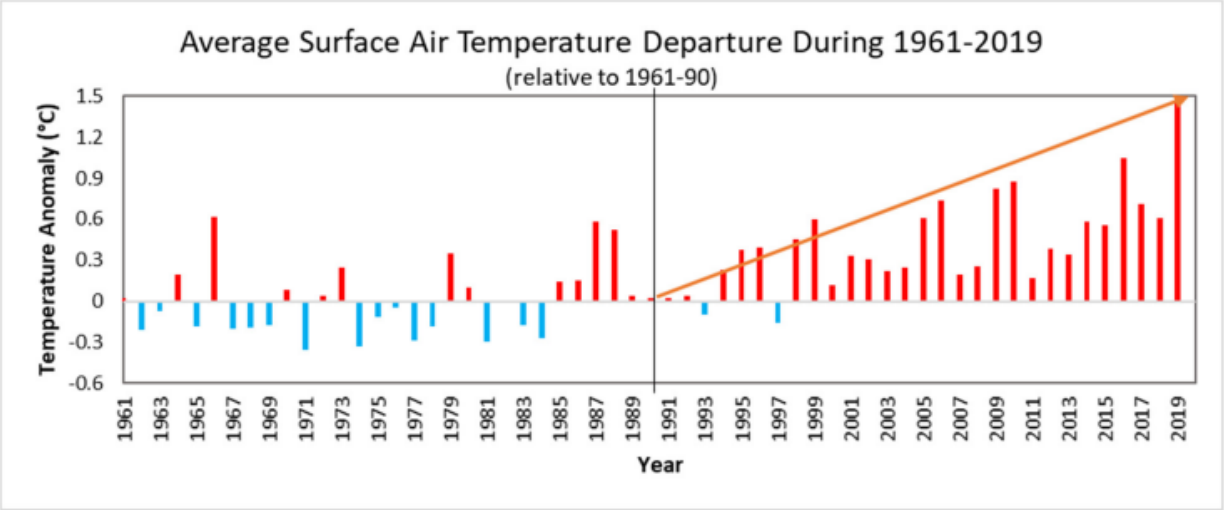
3. Risk Analysis

3.1 Climate Risk and Vulnerability

The unique geographical setting with low elevation and dominance of floodplains, high population density, along with low economic, infrastructural, and technological capacity makes Bangladesh one of the most climate-vulnerable nations of the world (Towrin et al., 2022). According to the Global Risk Index 2021, the country ranks as the 7th most vulnerable country to climate change impacts considering both slow onset and rapid climatic occurrences (Eckstein et al., 2022). Since 1990, climate-related events accounted for almost 95% of all major disasters in Bangladesh, which intend to be more frequent and intense (Roy, 2020). The higher frequency and intensity of such natural occurrences are the result of increased temperature that influences the precipitation pattern and oceanic temperature in the region.

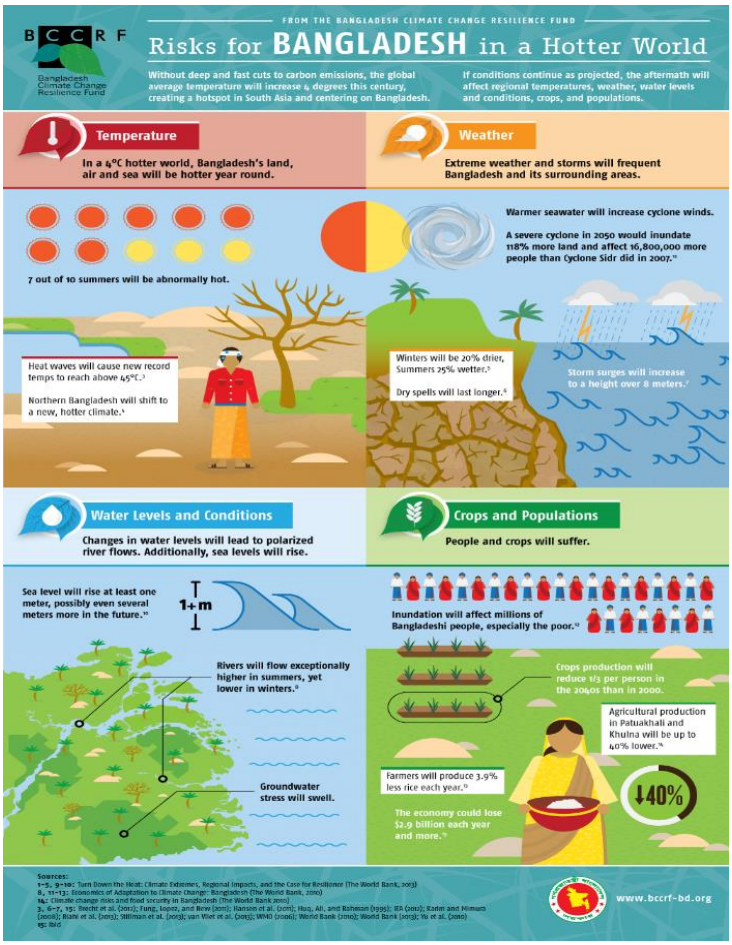
Temperature Rise: As per a report by the World Bank, the average temperature of Bangladesh has increased by 0.5° C in the last four decades. The report also includes that the summer season is prolonged and hotter, whilst the winters are also warmer. By the end of 2050, it is projected that the average temperature of the country will rise to 1.4°C (WorldBank, 2021). A similar projection has also been made by the meteorological department of the country. A data analysis deriving from the 35 meteorological stations of the country for the years 1948-2010 revealed a significant rise in both maximum and minimum temperature (monthly) at the rate of 0.5°C and 1.40°C respectively. The study also observed an increase in temperature predominantly in the last 21 years from 1990 to 2010 than the last 63 years from 1948 to 2010 (Hasan et al., 2013).

Figure 8: Departure of Average Surface Air Temperature From 1961 to 2019 (Source: NAP, 2022)



Cyclones: The significant temperature rise also influences the precipitation pattern and ocean temperature. The depth and the peaking oceanic temperature (minimum of 26°C) create an ideal zone for tropical cyclone formation in the Bay and Bengal, while the funnel-shaped triangular coast of Bangladesh invites deadly cyclones to make landfalls almost every year (Haque et al., 2012; Irfanullah, 2023). The Ministry of Disaster Management and Relief states that Bangladesh is one of the worst sufferers of cyclones in terms of causalities. Since 1965, 12 major cyclones hit the coast leaving 479, 490 people dead (DhakaTribune, 2017). In 1970 the great Bhola cyclone

hit the southern coast of Bangladesh claiming over 3,00,000 – 500,000 (approximate) lives with a total damage of 86.4 million US$ (1970 USD), remarking the event as one of the deadliest cyclones ever recorded in history. This catastrophic event laid the foundation of the WMO tropical cyclone program (WMO, 2022). Later in 1991, the Gorky cyclone hit the South Eastern coast of Bangladesh claiming 1,40,000 lives (approximately) and making ten million people displaced (Irfanullah, 2023). It also reported that since the last two decades (2000-2020) seven deadly cyclones made landfall or impacted the coast of Bangladesh: cyclone Sidr (2207), cyclone Aila (2009), cyclone Mahasen (2013), cyclone Roanu (2016), Cyclone Fani (2016), cyclone Bulbul (2019), and cyclone Amphan (2020) (DhakaTribune, 2021). These frequent and intensive cyclones possess a grave impact on the coastal communities of the country affecting more than 35 million people, representing 21% of the total country's population (IFRC, 2021).

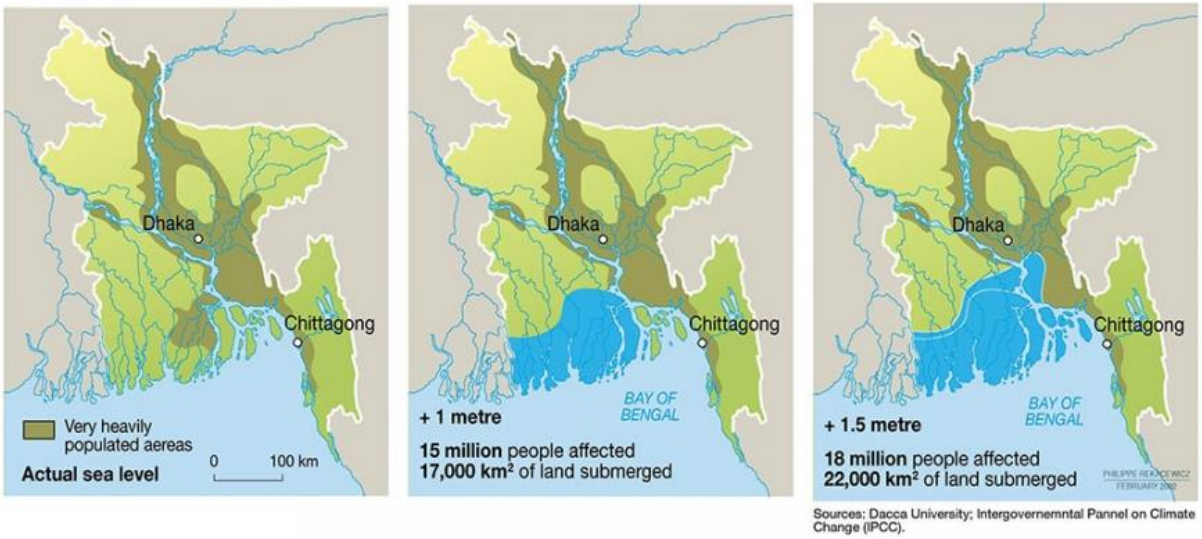


Source: [Climate Change Resilience Fund]

Sea Level Rise (SLR) and Salinity Intrusion: Sea level rise is most likely to intensify coastal floods and subsequent saltwater intrusion, particularly in low-lying countries like Bangladesh where almost 60% of the landmass is around and less than 6 meters above the average sea level (Hossain et al., 2020). The southwestern region, comprising a population density of 743 km, is only 1-2 meters above sea level. According to a report published by the Soil Resources Development Institute 2010, an annual average increase in the salinity level is around 0.74%.

Between 1973 and 2009, the soil salinity increased from 0.833 million hectares to 1.056 million hectares, equivalent to 3.5% of coastal land. Interior coastal districts had been salinized to 3.76mha in 2007 from 2.96mha in 2000 (SRDI, 2010). The increasing sea level rise and salinity intrusion especially on the South Western coast of the country not only hamper agricultural production but also impacts the livelihood, health, and well-being of the communities. Besides, these rising seas now threaten to inundate the Sundarbans, the largest indiscrete mangrove forest of the world located in the southern-western region of the country. This coastal forest not only supports and sustains biodiversity and livelihoods but also acts as a natural shield and minimizes the impacts of devastating cyclones.

Figure 9: SLR Scenario for Bangladesh (Source: Centre for Science and Education)



Internal Migration: The impacts of climate change also trigger the rate of internal migration within the country and it is estimated that by 2050, one in every seven people in Bangladesh will be displaced by the changing climate. Specifically, with a projected 19.6-inch (50-centimeter) rise in sea level, Bangladesh may lose approximately 11% of its land by 2050, and up to 18 million people will be forced to migrate because of sea-level rise alone (CRP, 2022).

Erratic and Extensive Precipitation: Since the last five decades the annual rainfall of Bangladesh has significantly increased at the rate of +5.53 mm/year (Shahid, 2013). The IPCC's AR6 fact sheet report on South Asia also projects the rise of both annual and summer monsoon precipitation during the 21st century, with enhanced interannual variability in the region (IPCC, 2023). However, the distribution of rainfall has been uneven and complex bringing in diverse climate risks all over the country. For instance, northwestern Bangladesh is prone to drought due to receiving less rainfall, whereas the northeastern freshwater wetland often faces delayed rainfall or early flash flooding. The central floodplains experience massive floods and riverbank erosion during monsoon. On the contrary, the hilly areas in the South East receive substantial rainfall that often leads to landslides. Due to extensive rainfall, the urban areas in Bangladesh are plagued by rainwater drainage and waterlogging (WorldBank, 2019). It is also reported that due to climate change, the frequency and intensity of heavy and extensive rainfall has been increased, and also shifting the pre-monsoon weeks earlier than usual particularly in the North Eastern hills of the

country (Ahmed, 2021). Such shifts in the precipitation pattern and extensive rainfall have contributed to flood and flash flood events in the country (Haque et al., 2018).

Floods, Flash Floods, and Erosion: Being situated in downstream of the great GBM Basin, and also consisting at a low altitude compared to the mean sea level the extensive rainfall upstream and within the country often results in devastating floods and flash floods. It was reported that from the 1990s till 2021, 90 floods happened in the country where riverine floods dominated the flooding events by 50%. Each of these floods inundated 30-70% of the total land area of the country. The massive floods of 1998, 2003, 2004, 2007, and 2012 claimed 6,279 lives, affecting 152 million (approximately) people, and resulting in net economic damage of 136 million USD (Hossen, 2022). During the 1987 flood, 40% of the country's total landmass was inundated, displacing 5 million people and accounting for a total damage of 1 billion USD. The following year the country witnessed another massive and extensive (for 90 days) flood event that led to total economic damage of 450 million USD (Towrin et al., 2022; Hossen, 2022). The riverine floods are also accompanied by massive erosion and a study conducted by the Water Ministry found that 28 square kilometers of landmass eroded only in 2021 due to the extensive rainfall and flood (Molla, 2021). Besides, the riverine flood the recent flashfloods (more common in the North Eastern region) from 1998, 2004, 2006, 2007, 2010, 2015, 2017, and 2020 also had a devastating impact inundating up to 25% of the total landmass of the country (Towrin et al., 2022). River bank erosion is considered a prime threat to livelihoods and vulnerable communities, as it leaves people homeless and landless, and also triggers displacement rate.

Droughts and Arid Conditions: Droughts in Bangladesh are mostly seasonal and depend much on the precipitation pattern. It is a common natural phenomenon in the North Western region of the country as the precipitation rate in the region is comparatively less than in the other parts of the country. The North Western region of the country receives a total rainfall of 1,971 mm (approximate) annually which is less than the average rainfall of the country. It is stated that the country suffers from a severe drought once every decade and previously severe drought was observed in 1972, 1979, and 1994 affecting almost 39% area of the country and half of the population (Icddrb, 2022). However, due to the temperature rise and scarcity of adequate rainfall in the region, the elongation of the dry season and drought-like conditions might become a regular phenomenon.

3.1.1 Climate Risk and Vulnerability in Food System

Climate change happens to be one of the major threats to food security and agricultural production decline in Bangladesh. Around 70% of the landmass of the country is devoted to agriculture and the impacts of climate-induced disasters in the forms of sudden and slow onset events affect agricultural production, livelihoods, and overall well-being of the most vulnerable communities (FAO, 2023). For instance, a record flooding in 2017 resulted in decreased food production across the country. The event significantly impacted the livelihoods of rural communities that depend on agriculture by increasing the costs of staple foods such as rice and wheat.

It is also reported that the agricultural sector might lose around 7.7 billion USD/annum due to climate change impacts and the annual rice production, the staple food of the country might fall by 33% within two decades (Chowdhury, 2022).

In Bangladesh there are two distinct cropping seasons: (a) Rabi (mid-November to mid-March) and (b) Kharif (mid-March to mid-November). The Kharif season is again subdivided into two categories (b.1) Kharif-I (mid-March to mid-July) and (b.2) Kharif-II (mid-July to mid-November). These cropping seasons are determined by the climatic and hydrometeorological conditions. Therefore, a minimal change in the overall condition influences the entire cycle; delaying and affecting the production of different crops, cereals, fruits, and vegetables.

The anticipated and gradual rise of temperature affects the growth of sensitive crops, whilst extending the warm summer season and reducing the duration of winter. This hampers the productivity of Rabi (winter-sown) crops. Studies reveal that an increase of 1–2°C, combined with lower solar radiation, causes sterility in rice spikelet, reducing the yield of HYV of Aus (July–August), Aman (December– January, and Boro (March–May) rice (Chowhan, 2016). Rapid changes in temperature, humidity, and radiation will also encourage pest infestation, disease outbreaks, and growth of microorganisms, and have a negative effect on soil organic matter (Alison, 2020; Anik et al., 2012). An increase of 4°C in temperature would also have a severe impact on overall food production in Bangladesh, resulting in a 28% reduction in rice and a 68% reduction in wheat (Rezvi et al., 2018).

Due to the temperature rise **intense heatwaves, and prolonged arid and drought-like conditions** will become more frequent. A study reports that every year 0.45 million hectares of land are affected by drought during the Rabi season, and 0.40 million hectares and 0.34 million hectares are being affected during the pre-kharif and kharif seasons, respectively (Habiba et al., 2011). Since the last few decades there, has been a reduction in rainfall in the North Western region of the country, which is also considered as an important agricultural hub of the country (Khan et al., 2019). This makes the region highly dependent on groundwater extraction. However due to the lower precipitation, groundwater resources are also diminishing, creating a threat to the agricultural yield. On the contrary, other parts of the country receive sufficient rainfall all over the year, which can also possess a great threat.

The extensive precipitation results in severe floods leading to crop damage. From 1988 to 2007, several floods were recorded, inundating 70% of the total land area of the country. These floods destroyed some 485 600 hectares of cropland, and during the flood of 1988, the national crop production was reduced by 45% (Karim et al., 1996). The Ministry of Agriculture (MoA) estimated that the recent extensive floods submerged 1,59,000 hectares of agricultural land, damaging crops with a net worth of over 13 billion BDT (151.672 million USD) (Mamun, 2020).

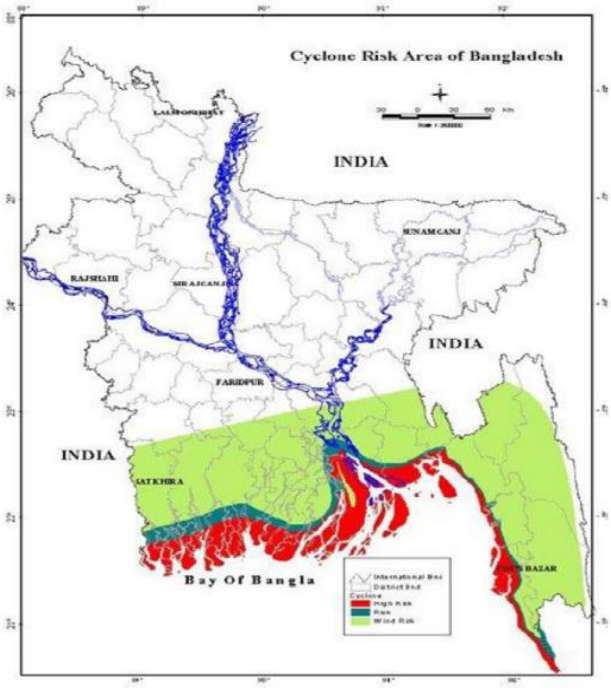


Figure 10: [Cyclone and SLR Risk Areas]

Floods and flash floods impact the rural livelihood of Bangladesh, as the majority of the people in the rural sites depend much on agriculture. Similarly, on the coast, **tropical cyclone accompanied by tidal flooding impacts overall agriculture production.** From 1960 to 2010, some 52 severe cyclonic storms hit the country, causing grave impacts on the agriculture and livelihoods of the coastal population.

The 1991 cyclone destroyed 2,10,000, 36,000, and 3,500 tons of Boro, Aus, and other food crops (potatoes, vegetables), respectively (Farukh et al., 2019). Also, 95% of the crops in the coastal region crashed during the devastating cyclone Sidr in 2007 (Mahmud, 2017). The Ministry of Agriculture estimates that the recent cyclone Amphan affected crops on 176, 007 hector with a total crop loss of 6.72 billion USD in the 17 coastal districts (Shovon, 2020; Wardad, 2020).

Rising sea level increases the salinity intrusion in the coastal areas, resulting in a hostile environment for plants, reducing crop productivity, and reducing sources of fresh drinking water. According to the Soil Resources Development Institute, between 1973 and 2000, the amount of salinity-affected land increased from 83 million hector to 102 million hectors, with an expansion of 26% in the last 35 years into formerly non-saline areas (Haider, 2019). Salinization is expected to advance 8 km further north in the country by 2030, further reducing land availability for farming. While the infusion of salt water into the rivers and canals remains a challenge for crop production, it also brings opportunities for salt-water shrimp production (CIAT & WorldBank, 2017). The excessive salinity on the coast has encouraged the local farmers to practice shrimp cultivation. Due to such intervention, rice production in Satkhira (one of the most vulnerable coastal districts of Bangladesh in terms of climate change) reduced by 69% compared to 1985 (Ali, 2006). Shrimp farming has been a profitable income generation source in the South Western region; however, the initiative has been criticized as it gradually changes the surrounding natural environment, leading to social problems by displacing tenant farmers and seasonal agricultural practitioners.

Besides, the SLR and salinity intrusion also led to **fodder shortages for cattle and livestock.** Livestock rearing involves more than 10 million people in the country, contributing 1.6% shares to the GDP and 14.31% in the agricultural GDP for 2016-2017. The impacts of climate change will affect livestock production through alerted feed quality and quantity (SLR and salinity intrusion, flood), water scarcity (drought), heat stress (temperature rise), enhancing body metabolism but reducing feed intake, the spread of pathogens, injuries and casualty (cyclone, storm, floods, etc.). It is claimed that climate-related natural disasters will be responsible for an economic loss of <1-35 million USD, and 1-11.8 million USD in the livestock and poultry sectors from location to location across the country (Biswas et al., 2019).

Figure 11: Impacts of Climate Change in the Agricultural Sector. Source: (NAP, 2022)

Climate signals and hazards	Potential impacts
Excessive rainfall	• Crop damage • Cultivation becomes less suitable due to waterlogged conditions • Loss of cultivable lands • Changed cropping patterns
Extreme heat	• Crop yield change/reduction • Pest infestations and disease outbreaks • Changes in flowering patterns and phenological changes
Cold spells	• Crop damages • Phenological changes • Pest and diseases
Frequent river floods	• Crop damages • Loss of fisheries and livestock production • Loss of livelihoods
Early or frequent flash floods	• Dry season (Boro) crop damages • Harvesting and storage problems • Changed cropping patterns • Seasonal migration • Shifting occupations
Severe droughts/water scarcity	• Irrigation water crisis • Less yield • Food crisis • Pest and diseases
Frequent lightning	• Death of farmers
Increased salinity	• Crop damages among traditional varieties • Low yields • Less suitable irrigation water • Cropping pattern change • Limited scope for agricultural production • Loss of livelihoods • Internal displacement
Frequent cyclone/ tornado and storm surges	• Crop damages • Loss of livelihoods • Human death • Food and medicine crisis
Sea-level rise	• Less availability of cultivable lands • Low crop yields • Hampered food security

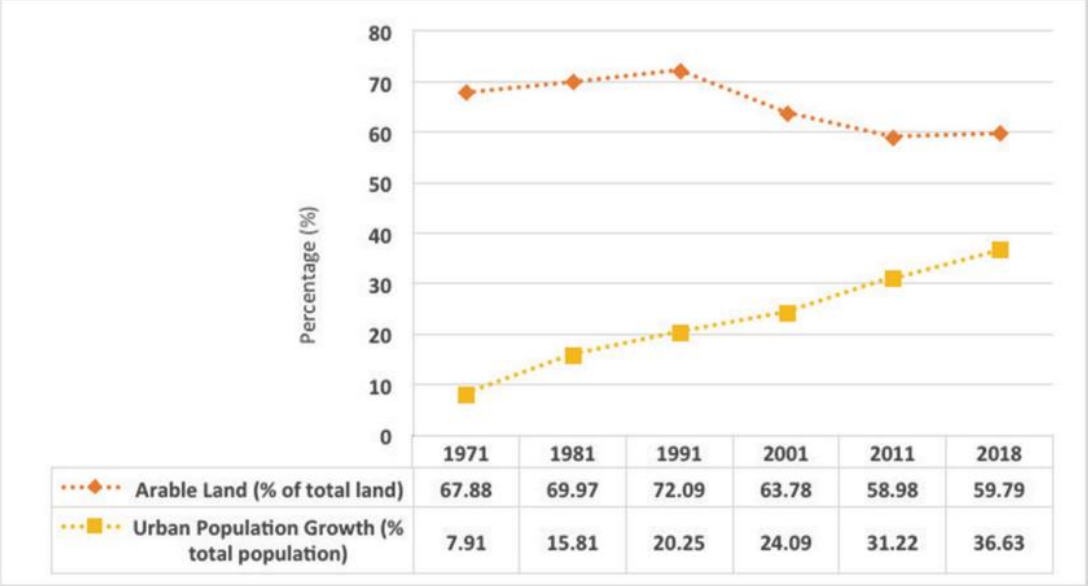
3.2 Other Factors and Stressors

Besides climate change, two other major factors that influence the food production and security of the country are population growth and rapid urbanization.

Population Growth: Bangladesh ranks 8th as the most popular country in the world in terms, of where 1,265 people live per square kilometer area (Worldometer, 2023). This humongous population creates pressure on the limited land mass and it is reported that rapid population growth has decreased the per-capita agricultural land by 0.11, 0.09, 0.07, and 0.06 hector/person in 1981, 1991, 2001, and 2011, respectively (Rai et al., 2017). Besides, the increase in nuclear families and the division of land among family members, especially in the rural settlements of the country, is leading to agricultural land fragmentation, affecting total crop production (Islam, 2014). The United Nations Population Fund projects, that the population of Bangladesh may reach 201 million (under a low fertility rate scenario) or 245 million (under a high fertility rate scenario) by 2051 (BBS, 2015). Consequently, the country would need to produce and manage food for an additional 35 million people (under the low fertility scenario) within 30 years. Therefore, maintaining and preserving significant amounts of agricultural land is crucial to ensure food security, economic growth, and the livelihood of the people (Rozario et al., 2021).

Rapid Urbanization: The agricultural land cover and land use (LULC) is also being affected by the rapid rate of urbanization, as more people are moving to urban areas, and cultivated lands are being converted and used for non-agricultural purposes. The current rate of urbanization in Bangladesh is 3.3%. It is estimated that the country is losing fertile agricultural land at a rate of approximately 80,000 hectares annually due to rapid urbanization including the construction of new infrastructure such as roads and housing, and implementation of other development projects (Ahmed, 2011). A study reported that, from 1976 and 2010, total agricultural land – including cropland, forest, mangrove, river, lake, beel (lake-like stagnant water body), haor (bowl-shaped shallow depression), aquaculture, tea estates, and saltpans – decreased by 1.12 million hectors (Hasan et al., 2013). During the same period, there has been an increase in non-agricultural land of 1.22 million hectors (Rai et al., 2017).

Figure 12: The Increase of Urban Population Along with the Decrease of Available Arable Land Based on World Bank, 2020 Data. Source: (Rozario et al., 2021)



	1971	1981	1991	2001	2011	2018
Arable Land (% of total land)	67.88	69.97	72.09	63.78	58.98	59.79
Urban Population Growth (% total population)	7.91	15.81	20.25	24.09	31.22	36.63

4. Climate, Agriculture, and Food System Policies and Practices

4.1 Vision, Goals, and Objectives

To meet the future needs of the growing population and to build sustainable, safe, and profitable agricultural systems to ensure food security the government of Bangladesh is working diligently to make efforts for the overall development of the agriculture sector. The sector also played a vital role in reducing Bangladesh's poverty from 48.9% in 2000 to 31.5% by 2010 (WorldBank, 2016). Such a remarkable story of poverty reduction and gradual development helped Bangladesh to receive the lower middle-income country status in 2015. Now the country aims to graduate from the UN's Least Developed Country (LDC) status by 2026 (WorldBanK, 2023).

The government of Bangladesh is devoted to achieving food and nutrition security at all times. The country also pledges to fulfill the SDG's of ending poverty (SDG-1), eradicating hunger and food insecurity, and achieving improved nutrition (SDG-2) by 2030. To do so, the government has adopted several policies, strategies, and short, medium, and long-term action plans to meet the future needs of the growing population, based on the agriculture sector's achievements in various emergencies, including the impact of COVID-19.

As a part of the process, the **National Food and Nutrition Security Policy (NFNSP) 2021-2030** was approved by the government of Bangladesh (GoB) in August 2020 that aims to ensure the country's food and nutrition security aligns with the SDG's and other national and international commitment by 2023 (NFNSP, 2020).

The goal of NFNSP 2021-2030: Improve FNS status to the level needed to achieve the FNS-relevant SDG target and fulfill related national and international commitments by 2030 (NFNSP, 2020).

Objectives of the NFNSP 2021-2030:

1. Ensure the availability of safe and nutritious food for healthy diets.
2. Improve access to safe and nutritious food at an affordable price.
3. Enhance the consumption of healthy and diversified diets for achieving nutrition improvements.
4. Improve access to nutrition-sensitive social protection and safety nets across the life cycle with a focus on vulnerable groups and regions.
5. Strengthen cross-sectoral FSN governance, coordination, capacity building, and partnership for effective policy implementation.

The NFNSP 2021-2030 also takes into account the increasing role of the private sector in food production, processing, and marketing, the importance of partnerships, multisectoral convergence, and the enabling role of policymakers. Incentives, legislations, and regulations represent the main policy instruments to encourage welfare, food safety, healthy diets, and nutrition improvements and changes in the economic decisions of food value chain actors – i.e., farmers, processors, marketers, and consumers. The NFNSP 2021-2030 recognizes the relevant direct role of the public sector in areas such as procurement and management of public food stock for price stabilization and social security, hygiene and sanitation, behavior change communication, and in partnership with the private sector on investment in agricultural infrastructure, nutrient-dense product development, food fortification/biofortification and other specific initiatives of agricultural research and development (NFNSP, 2020).

The following section includes major policies, action plans, and strategies of Bangladesh that relates to climate-resilient food systems.

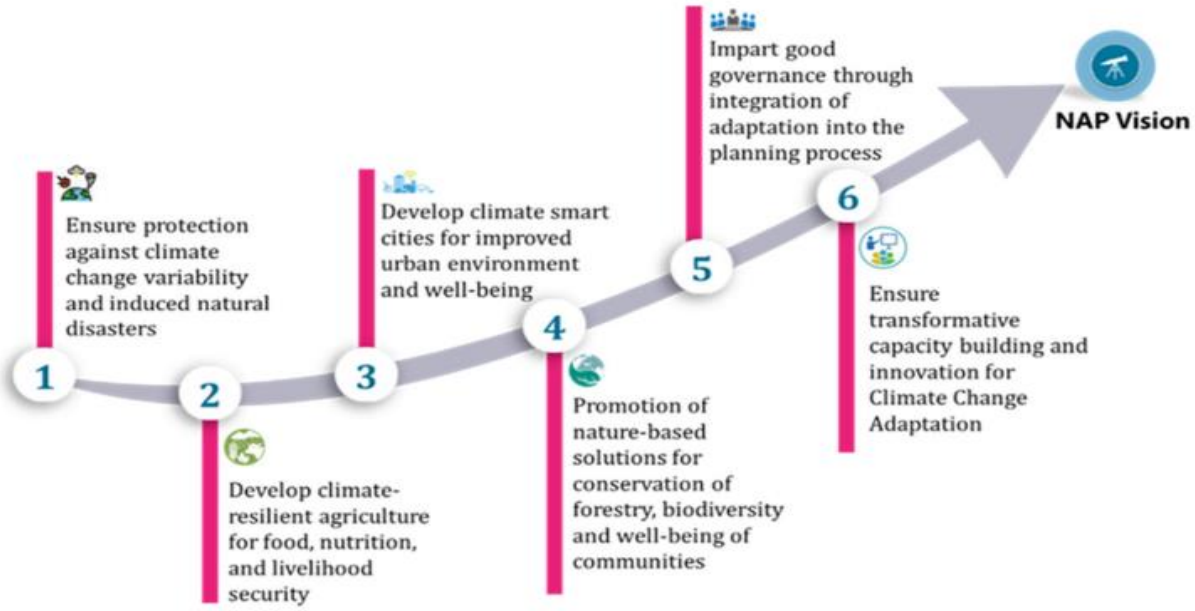
4.2 National Policies

4.2.1 National Adaptation Plan (NAP) 2023-2050

Acknowledging that effective medium- and long-term adaptation strategies are crucial to reducing the negative impacts of climate change and promoting sustainable planning for future development routes, the Government of Bangladesh initiated the formulation of its NAP under the Ministry of Environment, Forest and Climate Change (MoEFCC) in 2022, aiming for a viable path to climate-resilient development and reduced climate risks and vulnerabilities. The NAP primarily encompasses eight distinct sectors: water resources; disaster, social safety, and security; agriculture; fisheries, aquaculture, and livestock; urban areas; ecosystems, wetlands, and biodiversity; policies and institutions; and capacity development, research, and innovation. Besides, the NAP also includes six goals to support the vision.

NAP Vision: Building a climate-resilient nation through effective adaptation strategies to foster a robust society and ecosystems and stimulate sustainable economic growth (NAP, 2022).

Figure13: NAP Goals (Source: NAP 2023-2050)



Goal Two: The second goal of the NAP incorporates developing climate-resilient agriculture for food, nutrition, and livelihood security. This goal aims to reduce the risks and vulnerabilities of climate change in agriculture by incorporating climate-resilient and smart agriculture (CRSA) in efforts to protect food, nutrition, and livelihood security. This will be achieved through developing climate-smart agriculture, fisheries, aquaculture, and livestock, and managing a sustainable value chain for agro-inputs in climate-vulnerable regions. Research and innovation for climate-resilient crops and smart agricultural practices can be strengthened (NAP, 2022).

4.2.2 Nationally Determined Contribution (NDC)

The INDC of Bangladesh was submitted to UNFCCC on 25 September 2015, for three sectors (Power, Industry, and Transport). Subsequently, Bangladesh prepared the NDC Implementation Roadmap and Action Plan in 2018. Considering 2011 to be the base year, a 5% (12 million tons) unconditional reduction of GHG emission from the BAU scenario by 2030 and a further 10% (24 million tons) conditional reduction of GHG emission with the support of the international community has been proposed in the INDC. On 26 August 2021, Bangladesh submitted the first NDC to UNFCCC as a part of the global initiative considering 2012 to be the base year for the BAU scenario. The updated NDC incorporates sub-sectors of energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and other Land use (AFOLU), and Waste. The updated NDC also aims to reduce and limit in-country GHG emissions by undertaking significant mitigation actions supporting the global goals and also shifting to a low-carbon, and climate-resilient economy. As mentioned, the updated NDC of Bangladesh included Agriculture, Forestry, and Other Land Use (AFLOU) as a sub-sector which comes with specific targets and actions (NDC, 2021).

Table 3: AFLOU Sub-sector Details. Source: (NDC, 2021).

Sub Sector	Baseline Year (2012) Emission (MTe CO_2)	Business as Usual (BAU) Scenario 2030 (MTe CO_2)	Unconditional Reduction (MTe CO_2) By 2030	Conditional Reduction (MTe CO_2) By 2030	Potential Action Area
Agriculture, Forestry, and Other Land Use (AFLOU)	46.24	55.1	0.64	0.4	Enhance solar energy in agriculture and reduction of emissions from rice fields, fertilizer users, enteric fermentation, and manure management.

Note: No mitigation scenario analysis was carried out for Other Land Use.

4.3 Other Relevant National Strategies/Policies on Food Systems, Agriculture, and Climate Change (2006-2023)

Name of Policy	Year	Ministry	Focus on Food Security Agriculture, and Climate Change
Mujib Climate Prosperity Plan	2021	Ministry of Environment, Food, and Climate Change (MoEFCC)	MCPP incorporates both climate change and agriculture and food security aspects inclusively. It includes an action plan to make food production sustainable by addressing all issues concerning producers, production process, supply chain, and adverse effects of climate change, fisheries, and supply chain.
National Pathway Document for the UN Food Systems Summit	2021	Ministry of Food (MoF)	The Plan of Action (2021-2030) of the pathway includes sustainable intensification, diversification, emissions reduction, and increasing resilience of production, through the adoption of agroecological practices and agri-food system. Modernization including the use of nanotechnology, the development of the ocean, and the blue economy, will be prioritized, in line with targets

			under SDGs 6, 13, 14, and 15 (clean water and sanitation, climate action, life below water, and life on land).
National Food and Nutrition Security Policy and Action Plan (2021-2030)	2021	Ministry of Food (MoF)	The action plan includes action agenda that relates to agricultural credit service, incentives for clean, efficient, and sustainable technologies, the promotion of the blue economy, the establishment of an agro-information market system, and other aspects of agro-food security. Climate-smart agricultural technology such as vertical farming, aquaponics, and hydroponics and practices are mentioned here. Besides, there are several action plans highlighted in the draft that directly and indirectly supports agro-food security and climate actions.
The Eight Five Year Plan (8FYP)	2020	Ministry of Planning (MoP)	The Bangladesh Planning Commission has framed the 8th Five Year Plan aligning with different social and economic targets envisaged in the country's second perspective plan 2021-2041. The 8FYP titled "Promoting Prosperity and Fostering Inclusiveness", focuses on a pro-poor growth strategy. This strategy includes seven themes. One of these includes agricultural diversification. To enhance agricultural production and ensure food security, the 8FYP targets to assure the country, and ensuring credit for the small farmers should be the ideal targets for the country for the next five years.
National Plan for Disaster Management (2021-2025)	2020	Ministry of Disaster Management and Relief (MoDMR)	The plan has a direct connection with Upgrading existing Disaster Management (DM) programs and policies, DM governance, Investments for building resilience against chronic disasters, social protection, Inclusive development, private sector engagement, resilient post-disaster response and recovery, and emerging risks. NPDM 2021-2025 is the GoB's 'white paper' document and abides by national DRM institutional and policy regimes. It embodies both rapid and slow-onset disasters and it also includes recurrent, anticipated, and climate-induced disasters.
Perspective Plan of Bangladesh 2021-2041	2020	Ministry of Planning (MoP)	The policy has a direct connection with sustainable agriculture for food security and rural, macroeconomic farmwork for accelerated inclusive growth and sustainable power and energy. The vision document consists of twelve chapters- including topics ranging from governance, human development, industry and trade, agriculture, power, and energy to ICT and climate change and environment.
Bangladesh Climate Fiscal Framework	2020	Ministry of Finance (MoFin)	The policy focuses on establishing greater national ownership of climate finance, promoting government–NGO-private sector partnership, enhancing results management, increasing mutual accountability, and broadening the opportunity for resilient development and green growth in Bangladesh. Climate Fiscal Framework (CFF) provides principles and tools for climate fiscal policy-making, helping to identify the demand and supply sides of climate funds and to ensure that climate fiscal policies are transparent and sustainable in the longer term.

Bangladesh Food Safety Authority	2019	Ministry of Food (MoF)	The policy has a direct connection with regulating and monitoring the activities related to the manufacture, import, processing, storage, distribution, and sale of food to ensure access to safe food through the exercise of appropriate scientific methods, and to coordinate the activities of all organizations concerned with food safety management.
Bangladesh Delta Plan 2100	2018	Ministry of Planning (MoP)	The Bangladesh Delta Plan (BDP) 2100 is a long-term integrated techno-economic mega plan that integrates all delta-related sector plans and policies, enveloping a Delta Vision and strategies that make it possible to secure the future of water resources and mitigate the likely effects of climate change and natural disasters, and to present actionable interventions with a roadmap for realization. Agriculture, Food Security, and Livelihood are identified as one of the cross-cutting issues. The plan proposes strategies for supporting agricultural activities and livelihoods based on the six climatic hotspots that the country's delta has been divided into.
National Seed Policy	2018	Ministry of Agriculture (MoA)	The overall purpose of this policy is to make the best quality seed of improved varieties of crops conveniently and efficiently available to farmers to increase crop production, farmer productivity, per capita farm income, and export earnings.
Roadmap and Action Plan for Implementing Bangladesh NDC	2018	Ministry of Environment, Food, and Climate Change (MoEFCC)	The policy has a direct connection with low carbon growth in Bangladesh and meets a wider draft of objectives and priorities, including energy access, economic growth, productivity, poverty reduction, and improved quality of life. The road map includes the agriculture and food security sector as one of the critical and vulnerable sectors to the adverse impacts of climate change.
National Agriculture Policy	2018	Ministry of Agriculture (MoA)	Several sections, and subsections of the policy address the food security issue with climate change impacts and also include adaptation solutions. Strengthen research and initiatives in determining climate change impacts on different crops and natural resources and introducing low greenhouse gas emission crop technology.
Second National Plan of Action for Nutrition (2016-2025)	2018	Ministry of Health and Family Welfare (MoHFW)	The second thematic area (Agriculture and diet diversification and locally adapted recipes) of the plan relates food insecurity with climate-related shocks. Growing foods through environmentally friendly technology, and also ensuring availability, affordability, and accessibility of nutritious food. Promotion of diversified, integrated food production systems to enable resilience to climate and price shocks, seasonal food and income fluctuations, and support more gender-equitable income generation.
The Climate Change Trust Act 2010 ACT No. LVII of 2010	2016	Ministry of Environment, Food, and Climate Change (MoEFCC)	The act has a direct connection with making necessary action plans for capacity building for adjustment of the people or groups of people of the affected and risky areas resulting from climate change, upgrading their life and livelihood and facing the long-term risk, and taking measures for implementation thereof and to take measures for adaptation, mitigation, technology

			development and transfer, capacity building and funds for facing the adverse effect of climate change on man, biodiversity and the nature.
National Social Security Strategy (NSS)	2015	Ministry of Planning (MoP)	The strategy considered food security issues and climate change impacts in silos; however, the strategy mentions specific funding for climate change and food safety net programs. Funds allocated for different schemes related to climate change and food security are as follows: Climate change 1.7%, school feeding program 2.0%, one household, one farm initiative 2.3%, vulnerable groups feeding 5.2%, Food for work 6.5% for FY13. A total fund of 4000 million has been dedicated to the climate change crisis.
Seventh Five-Year Plan (2016-2020)	2015	Ministry of Planning (MoP)	The plan has dedicated chapters both for Agriculture (Chapter 4), and Environment and Climate Change (Chapter 8). The 7FYP strategy aims to achieve productivity gains, diversification, value addition, and agro-processing commensurate with national environmental protection and climate change adaptation measures.
National Nutrition Policy	2015	Ministry of Housing and Family Welfare (MoHFW)	The goal of the National Nutrition Policy is to improve the nutritional status of the people, especially disadvantaged groups, including mothers, adolescent girls, and children; to prevent and control malnutrition, and to accelerate national development by raising the standard of living. Objectives: 1. Improve the nutritional status of all citizens, including children, adolescent girls, pregnant women, and lactating mothers. 2. Ensure availability of adequate, diversified, and quality safe food and promote healthy feeding practices. 3. Strengthen nutrition-specific or direct nutrition, interventions. 4. Strengthen nutrition-sensitive or indirect nutrition, interventions 5. Strengthen multisectoral programs and increase coordination among sectors to ensure improved nutrition.
The National Climate Change and Gender Action Plan for Bangladesh (ccGAP)	2013	Ministry of Environment, Food, and Climate Change (MoEFCC)	The policy has a direct connection with mainstream gender concerns in climate change-related policies, strategies, and interventions ensuring access to, participation in, contributions towards, and benefits for the diverse group of stakeholders for the sustainable and equitable development of Bangladesh.
Food Safety Act 2013	2013	Ministry of Food (MoF)	A legal framework for the establishment of an efficient and effective authority and for regulating, through coordination, the activities relating to food production, import, processing, stock, supply, marketing, and sales, to ensure the rights toward access to safe food through appropriate application of scientific process, upon repealing and reenacting the existing laws connected thereto.
National Livestock Extension Policy	2013	Ministry of Fisheries and	The policy reflects the impacts of climate stressors on animal agriculture. The uncertainty of climate change and

(Draft)		Livestock (MoFL)	how change will influence animal production on a global as well as regional scale is largely unspecified. In Bangladesh, by contrast, the bulk of livestock have no protective structures and they graze off the land. There is every reason to expect that livestock in Bangladesh will be sensitive to climate change. Early warning systems and response measures to protect livestock and the environment during natural calamities, technologies adaptable to climate tempted vulnerabilities, and long-term resilient strategies.
Master Plan of Agricultural Development in the Southern Region	2013	Ministry of Agriculture (MoA)	Chapter 5 of the master plan includes the aspects of climate change and chapter 6 includes the present scenario of the agricultural sector in the southern region. Developing climate-resilient infrastructure and improving surface water irrigation systems is a major part of the master plan.
National Aquaculture Development Strategy and Action Plan of Bangladesh 2013–2020	2013	Ministry of Fisheries and Livestock (MoFL)	The strategy action plan recognizes climate change impacts on aquaculture and fish production (Rationale). Owing to climate change, the acidification of the sea would be a deterrent to shrimp aquaculture; it might be an opportunity to introduce other species such as salt-tolerant tilapia, mullet, and other marine fish.
Bangladesh Water Act 2013	2013	Ministry of Water Resource (MoWR)	The act involves nodal ministries such as MoA, MoF, and MoFL The act emphasizes water resource management; which is a major component of agricultural production and also relates to climate change impacts.
National Agricultural Extension Policy (Draft)	2012	Ministry of Agriculture (MoA)	Out of the nine key principles of the policy, principle seven states the adoption of climate change and the development of specialized extension services for climatically distressed areas. Besides, one of the five key objectives of the policy includes improving longer-term sustainability of the use and conservation of Natural Resources including mitigation of climate change-induced vulnerabilities.
Bangladesh Country Investment Plan	2011	Ministry of Food (MoF)	The policy has a direct connection with investment programs to improve food and nutrition security in an integrated way, enhance access and improve nutrition and food security-related Government investments. One of the programs of the plan includes integrated research and extension to develop and propagate sustainable responses to climate change to ensure food availability at all scales. Another area of investment is the research and development of agricultural practices and farming systems aiming to adapt to and mitigate climate change.
National Adaptation Program of Action (NAPA)	2009	Ministry of Environment, Food, and Climate Change (MoEFCC)	The key document of the goal is to establish coping mechanisms and adaptation measures should be to reduce adverse effects of climate change including variability and extreme events and to promote sustainable development. The policy includes agriculture, fisheries, livestock, food security, land use, forestry, and climate change aspects.
Bangladesh Climate Change Strategy and Action Plan (BCCSAP)	2009	Ministry of Environment, Food, and Climate Change (MoEFCC)	Out of the, 6 pillars of the plan the first pilar addresses food security, social protection, and health The policy has a direct connection with food security, social protection & health, comprehensive disaster management, Infrastructure, Research and Knowledge management,

			mitigation and low carbon development and capacity building and institutionalization. Under the six pillars of the plan, there are 44 programs listed that directly or indirectly address climate change issues. Of the 44 programs, 19 programs directly address food security and carbon mitigation issues.
National Livestock Development Policy	2007	Ministry of Fisheries and Livestock (MoFL)	One of the objectives of the policy is to promote sustained improvements in income, nutrition, and employment for the landless, small, and marginal in the aspects of food security.
National Food Policy Plan of Action (2008-2015)	2008	Ministry of Food (MoF)	The plan of action states climate change poses an additional burden on food security, especially in areas where agriculture and water resources are already under stress due to adverse meteorological conditions. provides strategic guidance on the way to address the key challenges facing Bangladesh in achieving food security in all its dimensions, including food supply and availability, physical, social, and economic access to food, as well as nutrition/utilization of food, as embedded in its three core objectives, namely: 1. Adequate and stable supply of safe and nutritious food NFP 2. Increased purchasing power and access to food for the people NFP 3. Adequate nutrition for all individuals, especially women and children
National Food Policy	2006	Ministry of Food (MoF)	The goal of the food policy is to ensure a dependable food security system for all people of the country at all times. The objectives of the food policy are: 1. Ensure adequate and stable supply of safe and nutritious food; 2. Enhance the purchasing power of the people for increased food accessibility; and 3. Ensure adequate nutrition for all (especially women and children).

5. Institutional Arrangement and Coordination

5.1 National Coordination

The Ministry of Agriculture (MoA), the Ministry of Fisheries and Livestock (MoFL), and the Ministry of Food (MoF) are the three core ministries of the government of Bangladesh working closely to ensure the food production and security of the country with the support of other relevant ministries and departments. Some other significant ministries supporting the process are the Ministry of Planning (MoP), the Ministry of Finance (MoF), and the Ministry of Water Resources (MoWR).

Figure 14: Institutional Arrangement and Coordination in Bangladesh's Agricultural Sector (Policy Development, Coordination, Production, and Consumption) (Source: Author, 2023)

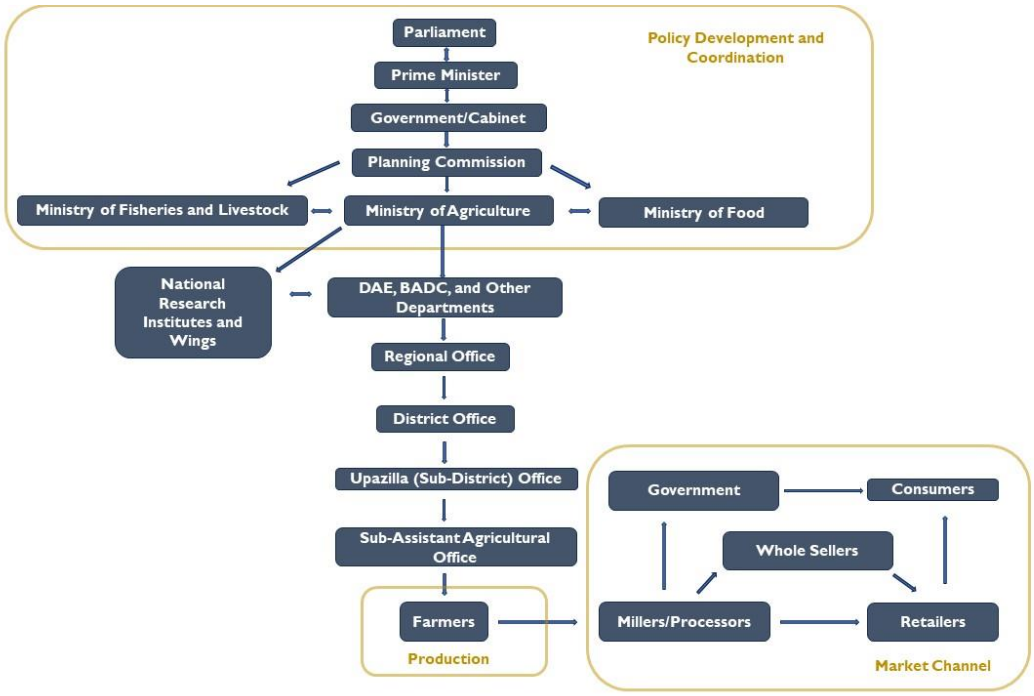
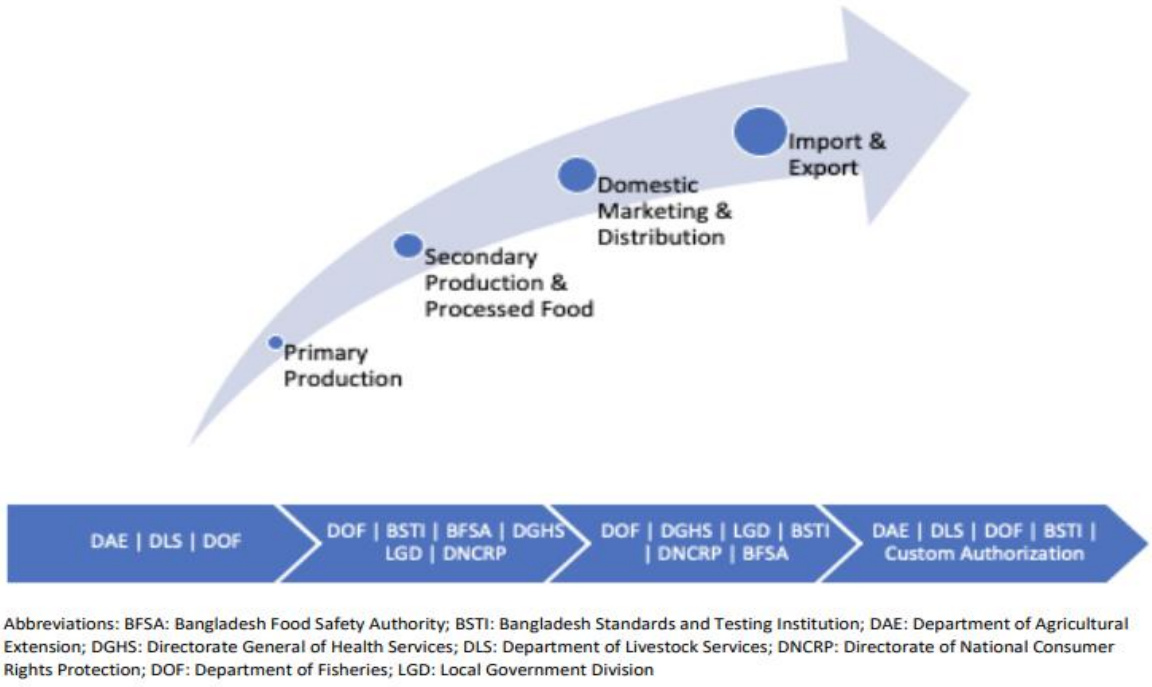


Figure 15: Food Safety Enforcement and Regulatory Bodies in Bangladesh. Source: (Suman et al., 2021)



Abbreviations: BFSA: Bangladesh Food Safety Authority; BSTI: Bangladesh Standards and Testing Institution; DAE: Department of Agricultural Extension; DGHS: Directorate General of Health Services; DLS: Department of Livestock Services; DNCRP: Directorate of National Consumer Rights Protection; DOF: Department of Fisheries; LGD: Local Government Division

5.2 Key Stakeholders Working in Food Safety and Resilience

Government	
Autonomous	
NGOs and CSOs	
UN and INGO's	
UN Agencies	
Development Partners	

Agricultural Universities	
Research, Capacity Building, and Learning Institute	
Private Sector	

(*) List subjected to change

6. Ongoing Projects, Programs, and Initiatives Geared Toward Climate-Resilient Food Systems

Over the years, Bangladesh has made significant improvements in the food security and nutritional status of its population. At present, the growth rate of food production exceeds that of the population. Rising per capita incomes and declining incidence of poverty indicate that access to food has also improved over time. In addition, the prevalence of undernourishment or "hunger" has declined from 20.8% in 1999-2001 to 13% in 2017-2019. However, the country yet faces intimidating challenges for ensuring FNS of its current population of more than 160 million which is projected to reach over 186 million by 2030. Besides, the challenges of climate change on food productivity also become a barrier to ending hunger, achieving food security and improved nutrition, and achieving the SDGs (NFNSP, 2020). Consequently, the government of Bangladesh introduced a long list of climate-sensitive interventions by modes of contemporary and effective policies, programs, and projects. The initiatives are undertaken to cope with the threats to food security resulting from climate change impacts and also promote community-level adaptation and agricultural technological extension.

The study considered the climate-adaptive agricultural projects of Bangladesh from 2007-2022 under six different categories: (a) Climate Risk Management and DRR, (b) Water Management and Technologies, (c) Agriculture, Land Use, and Fertility, (d) Climate Smart Technologies, (e) Research and Knowledge Generation, and (f) Capacity Enhancement and Social Protection [Table 4].

Table 4: Categories of Project. (Source: Author, 2023)

Categories	Activities	Benefits	Challenges
Climate Risk Management and DRR	• Early Warning and Weather Information • Food Information System • Pest and Diseases Monitoring and Control	• Enhanced Farmers, Preparedness and Response to Disasters • Reduce Yield Loss • Access to Information • Improve Income	• Data Availability • Limitations to Data Accessibility by the Farmers
Water Management and Technologies	• Rain Water Harvesting • Solar Irrigation • Excavate Reservoirs (Ponds, Ditches) • Construction of Embankments • Alternative Wetting and Drying Method (AWD)	• Availability of Water • Improved Yields, Income, and Ensure Food Security • Reduce Runoff • Efficient Water Usage	• Expensive for Marginal Framers • Evaluation of Efficacy • Installation and Monitoring
Agriculture, Land Use, and Fertility	• Develop a Land Use Database • Nutrition-Sensitive Agriculture • Seed Banks • Enhance Food Storage Capacity • Crop Rotation, Agroforestry, Homestead Gardening • Zero-tillage, Priming, Mulching, and Relay Cropping • Encourage Green Manure Usage • Integrated Farming	• Access to Information and Planning • Improve Soil Fertility and Productivity • Reduce Crop Damage • Alternative Income Opportunities • Ensure Food Security • Carbon Sequestration • Emission Reduction	• Accessibility to Information and Resources • Lack of Proper Documentation and Scaling up the Initiatives
Climate Smart Technologies	• Floating Garden, Cage Culture, Sarjon Method • Solar Irrigation	• Alternative Income Generation • Increase Crop Yields • Emission Reduction	• Lack of Support and Resources • Small Scale Initiative
Research and Knowledge Generation	• Stress Tolerant Verity Crops • Farmer's Training Program • Agriculture Technology Transfer Programs	• Reduce Crop Damage and Improve Yield • Peer to Peer Learning	• Lack of Scaling up the Initiatives • Technological and Financial Support and Assistance
Capacity Enhancement and Social Protection	• Social Safety Net • Stimulus Packages and Subsidy • Farmers Scheme Programs	• Reduce Poverty • Food and Nutrition Security	• Coordination and Evaluation

6.1 Climate Risk Management and Disaster Risk Reduction (DRR)

- **Bangladesh Weather and Climate Services Regional Project (BWCSRP):** helps to strengthen the weather, water, disaster risk, and climate information services in Bangladesh. The project introduces a complete package of weather forecasts to improve accuracy and lead time for weather forecasts and multi-hazard early warning, increased sharing of data and information for extreme regional events, increase in a number of end users satisfied by hydro-meteorological services and farmers satisfied with agro-meteorological services. The main objective of the proposed project is to strengthen the capacity of the Bangladesh Government in delivering weather and climate information in priority sectors and to prepare for and respond to climate variability and hydrometeorological disasters. Proper implementation and the right communication with stakeholders will reduce damage due to climate change and will play a major role in increasing the GDP of the country. One of the intentions of the project is to set up an Agrometeorological Information System portal, agromet information in 487 Upazilas, and agromet display boards at 4,051 Unions. This will enable more than 30,000 farmer households to gain access to weather and water-related information and enable them to make better planning and decisions to deal with climate uncertainties (WorldBank, 2017).

- **Bangladesh Agro-Meteorological Information Systems Development Project (BAMIS):** The project was developed to fulfill component C of the BWCSRP to strengthen the capacity of the Government of Bangladesh to deliver reliable weather, water, and climate information services and improve access to such services by priority sectors and communities. Besides, the specific objective of the project was to (a) disseminate Agro-Meteorological services to farmers to increase agricultural productivity and assist farmers in coping with weather and climate extremes, (b) provide support to establish a science-based Agro-Meteorological information system to develop appropriate information and products, (c) deliver Agro-Meteorological information through several dissemination mechanisms that will provide the agricultural sector with a decision support information system to mitigate climate-related agricultural production risks, and (d) strengthening of capacity at different levels to enable the development and effective delivery of climate information services to the agricultural sector (DAE, 2019).

- **Agricultural Information Services (AIS):** Agriculture Information Service (AIS) is a government organization under the Ministry of Agriculture (MoA), Government of Bangladesh. The main target of this organization is to carry modern agricultural information and technologies to the farmers' doorstep at the grass root level through mass media. It was incepted in 1961 as Agriculture Information Agency which was turned into Agriculture Information Service in 1985. Information services are being rendered through Headquarters in Dhaka and 11 regional offices across the country. AIS acts as a media focal point of the Ministry of Agriculture for mass media-related campaigning on agricultural development. AIS proudly takes the responsibility for producing and disseminating demand-driven print and video materials for MoA and its agencies (AIS, 2022).

- **Strengthen Logistics in Disasters:** In 2019, Bangladesh started mapping national logistics capacities and stakeholders, and assessing logistics gaps in partnership with the Global Logistics Cluster of the Inter-Agency Standing Committee. The purpose was to

define a Logistic Preparedness Action Plan and to make operational a Preparedness and Response Platform that combines mapping, imagery, early warning, crowd-sourced information, and logistics. This process will be developed and incorporated into the national disaster management system (Cluster, 2019).

- **Integrated Flood Resilience Program (IFRP):** The project focused on scaling up the community resilience capacity of disaster-vulnerable households through the Bangladesh Red Crescent Societies via a community-led approach. The Project was planned to be implemented in 4 communities of Lalmonirhat and Nilphamari districts. The objective of the project was to build the capacity of the community to reduce the loss of life, livelihood, and well-being in recurrent disaster and climate change risks through a Community-Based Approach (IFRC, 2018).

- **Climate Adaptation and Livelihood Protection (CALIP) project:** Climate Adaptation and Livelihood Protection (CALIP) project supported by IFAD was a supplementary project of Haor Infrastructure and Livelihoods Improvement Project (HILIP). CALIP was built on existing HILIP activities and tested various adaptation technologies and approaches, and scale-up those that prove to be effective. The CALIP project has four components: a) Component A: Village Protection and Enhancement; b) Component B: Livelihoods Protection and Diversification; c) Component C: Building Resilience to Climate Change; and d) Component D: Project Management. Under Component C, one critical activity is 'Capacity building in weather and flash flood warning'. These descriptions of services referred to the development of a low-cost and effective weather and flash flood early warning system (FEWS) involving four national institutions (FFWC, BMD, IWFM, and IWM) and various communities in the HILIP project areas (BWDB, 2019).

- **Digital Warning System for Wheat Production:** The digital early warning led by CIMMYT integrates mathematical models combined with weather forecasts, and can simulate disease growth and risks to provide an advanced warning about potential wheat blast outbreaks. With three years of data already recorded, the system was originally piloted in Brazil, where the wheat blast originated in 1985. Later, it has been rolled out across Bangladesh to deliver real-time disease updates to extension workers and smallholder farmers via SMS and voice message (CIMMYT, 2019).

- **The Coastal Embankment Improvement Project (CEIP):** The project helps Bangladesh to mitigate some of the large impacts of cyclones and flooding and improved emergency response in the coastal region. It also supports the rehabilitation and upgrading of protection polders to protect the areas from tidal flooding and frequent storm surges and includes as well improvements in agricultural production by reducing saline water intrusion in selected polders. Further, the project aims to enhance the Government of Bangladesh's capacity to respond more efficiently and effectively to natural disasters (WorldBank, 2018).

- **Improved Weather and Flood Information System for Community Based Risk and Resource Management (Shouhardo III):** The initiative led by CARE Bangladesh built the capacity of the poor and extremely poor participants to apply appropriate strategies in the reduction of negative impacts from, and response to, disasters. The

program supported the development of household and community contingency plans and the use of early warning information. In the community groups, there are elected Disaster Risk Reduction (DRR) leaders who facilitate the review of the contingency plan at the community level. The program provided capacity-building training to Upazila Disaster Management Committee (UzDMC), and Union Disaster Management Committee (UDMC) on disasters preparedness, rescue, and response, and Union Disaster Volunteers (UDVs) on the collection of early warning information and dissemination, engage in rescue at the local level and help UDMCs in response activities. The program closely works with its technical partner Regional Integrated Multi-Hazard Early Warning System (RIMES) to enhance community resilience by reducing risks from extreme natural events and going beyond "what the weather will be" to "what the farmers will do." RIMES has developed a 15-day streamflow forecasting system that has been automated and this has been integrated into Flood Forecasting and Warning Center (FFWC)'s operational forecasting system (CARE, 2023).

- **Enhancement of the Food Security and Early Warning Information System:** The Food Planning and Monitoring Unit (FPMU) of the Ministry of Food and Disaster Management (MoFDM), installed software in MIS-DG Food and DAM to facilitate data exchange among government agencies. This represents a further step in strengthening the food security information management capacity at the national level and in establishing a food security and early warning information system in collaboration with other relevant institutions (Bangladesh Meteorological Department, Comprehensive Disaster Management Program under MoFDM, Disaster Management Bureau under the MoFDM, the Local Government Engineering Department, Institute of Public Health and Nutrition, Institute of Water Modelling and Space Research and Remote Sensing Organization) (FPMU, 2023).

- **Pesticide Risk Reduction in Bangladesh:** Funded by the GEF trust fund and implemented by FAO the overall project objective is to reduce risk to human and animal health and the environment from Stockpiles of POPs and other obsolete pesticides and from ongoing excessive use of new POPs and other Highly Hazardous Pesticides (HHP) in Bangladesh (GEF, 2019).

6.2 Water Management and Technologies

- **Enhancing Adaptive Capacities of Coastal Communities, especially Women, to Cope with Climate Change-induced Salinity in Bangladesh:** Lead by the Bangladesh Ministry of Women and Children Affairs, this project focuses on strengthening the adaptive capacities of coastal communities, especially women and adolescent girls, to cope with impacts of climate change-induced salinity on their livelihoods and water security. The 6-year project (2018-2024) focuses on the Southwestern coastal districts of Khulna and Satkhira, both of which frequently experience cyclones and tidal flooding, and experience severe drinking water scarcity due to salinity. Under the project, communities will be empowered as 'change agents' to plan, implement, and manage resilient livelihoods and drinking water solutions. The project will promote a paradigm shift away from a focus on short-term responses and technology-led interventions towards community-centric

solutions that build ownership and capacities across multiple stakeholders, to sustain and scale up adaptive responses to safeguard livelihoods and water security (UNDP, 2023).

- **SAFAL Project:** SaFal was implemented during 2012 – 2016, with the overall objective to enhance the food and nutrition security of small farmers and landless workers in Southwest Bangladesh towards developing resilient livelihoods through promoting sustainable agricultural production and market chain development. A new phase of the project has been launched with IWR that aims to recharge 80 micro-watersheds at the sub-catchment level in the districts of Jashore, Narail, Satkhira, Khulna, and Bagerhat of southwest Bangladesh. This will be done by promoting community-based water management models through interventions like water-efficient, climate-smart, and regenerative agriculture practices, as well as watershed protection management (Solidaridad, 2022).

- **Project on Ground Water Conservation and Improving Efficiency and Productivity of Agricultural Systems in Bangladesh:** The objectives of the project are: (a) facilitate policy formulation in creating the necessary economic incentives to transition from efficient, less productive, and wastewater through management, (b) Increase efficiency and productivity of irrigation water in deep tube well areas of BMDA and BADC through proposed water management based on five components (water quality based irrigation charge, smart card, AWD technology, water supply efficiency, community-based water management), and (c) conducting surveys on irrigation water markets (DAE, 2023).

- **Irrigation Management Improvement Project (IMIP):** Supported by the ADB the IMIP is designed to realize the full production potential of large-scale irrigation schemes in Bangladesh. It will address the recurrent lack of sustainable management, operation, and maintenance (MOM) and increase water productivity by transferring MOM schemes to private operators and introducing innovative infrastructure modernization. The project will focus on modernizing the Muhuri Irrigation Project (MIP) in the Chittagong division. It will also finance a feasibility study and detailed design for modernizing the Ganges-Kobadak Irrigation Project in the Khulna division and the Teesta Irrigation Project in the Rangpur division (IMIP, 2021).

- **Re-excavation of small rivers, canals, and reservoirs in 64 districts**: The project aims to increase agricultural production by supporting irrigation facilities in about 150,000 hectares of land. Besides, the risk of floods and waterlogging will be reduced by conserving biodiversity, and increasing the drainage capacity of small rivers, canals, and reservoirs in an area of approximately six lakh hectares. Re-excavation will also revitalize small rivers, canals, and reservoirs, increase navigability and ensure easy communication of about 2,000 kilometers of navigation. Fisheries will be promoted by increasing and prolonging the water-holding capacity of small rivers, canals, and reservoirs (Islam, 2021).

- **Blue Gold Program:** The six-year-long program aimed to reduce poverty for 150,000 households living in a 160,000 ha area of selected coastal polders by creating a healthy living environment and a sustainable socio-economic development. Blue Gold has rehabilitated and improved the main water infrastructure in 22 coastal polders in south-

west Bangladesh and empowered Water Management Groups (WMGs) and Water Management Associations (WMAs) to be the drivers of economic development in the polders using the improved water infrastructure. Blue Gold has assisted these water management organizations with arrangements and procedures for water management, and advice on how to optimize profitability through the adoption of modern crop technologies, crop selection and intensification, and the collective purchase of inputs and sales of produce. Blue Gold's differentiated approach ensured that benefits reached not only households with access to land but also the many landless households, as well as men and women farmers (BWDB, 2022).

- **Action Research Project on Integrated Water Management (IWM):** The ADP-funded project covered 75 sites in total with objectives to (a) ensure integrated use of surface and sub-surface water for irrigation, potable water supply, fisheries, nursery development, beef fattening, poultry rearing, horticulture, and homestead gardening, etc. and non-farm activities, (b) ensure highest agricultural production through efficient (90%) and economic use of water resources as well as training and credit support, (c) generate additional employment/income through better access in integrated water resources management, and (d) introduce community-based bio-gas for better waste management and organic manure production as well as for hygiene promotion and changing the lifestyle of the project beneficiaries (CIWM, 2016).

- **The Small-Scale Water Resources Development Sector Project:** The project started in 1996 and was funded by the ADB with an additional contribution for TA by The Netherlands. It was the first donor-funded project implemented through the Local Government Engineering Department (LGED) that addressed water resources constraints imposed by inadequate flood protection, waterlogging, and limited irrigation in a participatory manner. The purpose of the project was to support the Government's poverty reduction effort by increasing sustainable agriculture and fish production through the development of sustainable stakeholder-driven, small-scale water resource management systems with special attention to the poorer section of the population (BWDB, 2020).

- **Integrated Planning for Sustainable Water Management (IPSWAM) (2002-2011):** The objective of IPSWAM was to strengthen the capacity of water sector organizations, including local-level water management organizations (WMOs), the different offices of the BWDB (headquarters and regional/local level) and to a limited extent local government institutions, to assume their roles as specified in the NWPo and the Guidelines for Participatory Water Management (GPWM). IPSWAM tried to achieve this by developing local-level water management capability, stimulating the transfer of responsibilities for operation and maintenance to local-level water management organizations, and enhancing the planning capacity of BWDB (BWDB, 2020).

6.3 Agriculture, Land Use, and Fertility

- **National Agricultural Technology Program Phase II Project:** The NATP-2 Project is anticipated to bring about changes in the traditional scenario of Bangladesh agriculture towards a modern agricultural system based on the application of information

and communication technology tools and renewable energy technologies including mobile technology. NATP-2 has an important segment for creating a market access network through value and supply chain activities for the farmer holder's community. The overall objective of NATP is to support GOB's strategy to improve national agricultural productivity and firm income, with a particular focus on small and marginal farmers covering 35% female farmers as well within the NATP-2 project target area (NATP-2, 2023).

- **The Smallholder Agricultural Competitiveness Project (SACP):** Supported by IFAD the SACP aims to significantly increase incomes and food and nutrition security by helping smallholder farmers be more responsive and competitive in producing diverse, high-value crops and marketing fresh and processed agricultural products. The project will provide technical training and access to finance. The project will reach 250,000 rural households in southern Bangladesh, where the highest percentage of rural poor resides. Women, youth, and disadvantaged households will be specifically targeted (IFAD, 2023).
- **Farm Mechanization through Integrated Management Project:** The project aims to reduce crop wastage by 10% to 15% which is about 5 million tons. The project will help farmers to save time in crop cultivation by 50% and money by 20% (DAE, 2023).
- **Production Storage and Distribution of Quality Seeds of Rice Wheat and Jute at Farmers' Level Through Modern Technology Project:** The government (DAE) has undertaken the project to (a) ensure the increase of crop productivity by making good quality rice, wheat, and jute seeds of right variety at right price and at right time, (b) improve the socio-economic status of farmers through production and marketing, (c) rapid expansion if area wise new cultivars at farmer level by strengthening linkages between farmers, DEA and research related institutes (DAE, 2023).
- **Accelerating Economic and Social Inclusion of Smallholder Farmers in Climatic Hotspots through Strong Producers' Organizations (ACCESS) Project: Implemented by FAO the project aims to** improve the livelihoods of smallholder farmers in climatic hotspots so that they are more resilient to public health and climate-induced crises (FAO, 2021).
- **Community-based Climate Resilient Fisheries and Aquaculture Development in Bangladesh**: The key objective of the project is to build the climate change (CC) adaptive capacity of vulnerable fisheries and aquaculture communities in Bangladesh (GEF, 2023).
- **The Diversified Resilient Agriculture for Improved Food and Nutrition Security (RAINS) Project:** Supervised by IFAD and implemented by MoA the four-year-long project will work in 14 districts in the coastal region of Bangladesh in the drought-prone region, and the northern Char region, supporting communities to build resilience to environmental and economic shocks. RAINS aims to work with the most vulnerable households to the impacts of climate change and improve the income and nutrition of 420,000 women and men. Some of the activities of the project include enabling farmers to adopt climate-smart and nutrition-sensitive technologies, achieved through integrated farming approaches, collaborating with the farmers' groups and production

clusters to encourage on-farm diversification by mapping needs and disseminating integrated farming business models, and tailoring the specific needs of women and youth living in poverty and vulnerability. Further, the project will promote innovative climate-smart water management by providing solar irrigation pump sets, drip irrigation systems, and rainwater harvesting facilities, enhancing water availability for irrigation and drinking purposes (DhakaTribune, 2023).

6.4 Climate-Smart Technologies

- **Crop Production Enhancement Project through Extension of Solar Energy and Water-Efficient Modern Technologies:** The objectives of the project are: (a) Save 95-100% fuel oil/electricity using solar energy for irrigation, (b) Improve irrigation efficiency through water management technology, (c) Increase the efficacy of irrigation by using the minimal subsurface water, (d) Protecting the natural balance and reducing irrigation costs by encouraging the use of surface water and reducing the dependency of groundwater (DAE, 2023).

- **Research, Extension, and Popularization of vegetables and Species Cultivation on Floating Bed Project:** The objectives of the initiative are: (a) Promote floating agricultural technology for increasing agricultural production to ensure food security, (b) Disseminate and popularize the advance and applicable technologies of floating agriculture invented by BARI, (c) Propagation of modern varieties of vegetables and spice crops developed by BARI and other institutions through floating agriculture, (d) Intensification and diversification of submerged crop production and encourage small farmers in floating cultivation of vegetables and spice, (e) Women empowerment and engagement in agricultural activities, (f) Ensure the appropriate use of Kachuripana (Water hyacinths) as means of crop production in water-logged lands where cultivable lands are scarce (DAE, 2023).

Figure 16: Floating Bed Practices (Source: Future Planet)

- **Climate Smart Agriculture and Water Development Project:** The CSAWMP focuses primarily on (a) rehabilitating and improving the quality of FCD and FCDI infrastructure for climate-resilient water resources management; (b) improving the management and sustainability prospects of FCD and FCDI infrastructure by supporting local communities to play an expanded role at all stages of scheme management (including contributing to Operation and Maintenance-O&M); (c) promoting the more efficient use of water resources through improved storage, on-farm water use efficiency, and water productivity in the drought season; (d) supporting the dissemination and adoption of CSA practices both in crop and aquaculture production; and (e) improving the marketing of agricultural products by the beneficiaries. The four components of the project are (1) Improved Climate Resilience of Flood Control, Drainage, and Irrigation Infrastructure System, (2) Climate-Smart Agricultural Production and Marketing, (3) Project Management Support, and (4) Contingency Emergency Response (WorldBank, 2018).

6.5 Research and Knowledge Generation

- **Stress-Tolerant Variety Crops:** The Government of Bangladesh (GoB) has researched the development of drought, cold, waterlog, diseases, pest, and salt-tolerant crop varieties to cope with the changing climate which are listed below:
  - **Early Harvest Short Duration Rice Varieties:** BRRI dhan 62 (100 days), 66, 71 (113 days); BINA dhan 7, 11, 16, 17, 19-22 (100-120 days); traditional varieties require 140-150 days.
  - **Drought Tolerant Early Varieties:** BRRI dhan 42, 43 (100 days), 57 (100-105 days), 66 and 71 (also short duration); BINA dhan-17, 19, 21.
  - **Salt Tolerant Rice Varieties:** BRRI dhan 23, 40, 41, 55, 67, 73 (8 ds/m); BRRI dhan 53, 54, 61, (6 ds/m); BRRI dhan 47 (8-12 ds/m), 97(8-14 ds/m), 99 (8-10 ds/m); BINA dhan 8, 10, 23.
  - **Flooding Tolerant Varieties:** BRRI dhan51, BRRI dhan52, BRRI dhan79; BINA dhan 11, 12, 23.
  - **Stress Tolerant other Crop Varieties:** BARI Gom 22, 23, 24 (heat tolerant); BARI Gom 25, 26, 30, 31 (early maturing heat tolerant); BINA Gom 1 & BARI Hybrid Maize 16 (salt tolerant); BINA mung-8, 9, 10, BINA Masur 8, 10 and BARI Hybrid Maize 12, 13 (drought tolerant).

Source: (MoEFCC, 2021)

- **Farmer Training Project for Technology Transfer at Upazilla Level:** The project included the development of physical infrastructure to provide institutional training to farmers. Besides, the project also aimed to change the attitude of farmers by imparting planned, practical, and hands-on training in modern agricultural management. Reducing the yield gaps between agricultural research results and field-level results by improving the technical skills of extension workers was another objective of the initiative (DAE, 2023).
- **BARI Technology Transfer Program:** To transfer the invented crop varieties and other technologies at the field level to the end users, thus the concept of the BARI technology village emerged. BARI Technology Village (BARI-TV) program was initiated in 2002-03 to transfer BARI-developed technologies directly to the farmers. The activities

include both establishment of a Crop Museum and the demonstration of matured technologies in farmers' fields through existing BARI set-ups in technology village activities. BARI technology village concept paid attention to making research more demand-driven and scientists' farmers participatory (BARI, 2016).

6.6 Capacity Enhancement and Social Protection

- **Smart Agricultural Card and Digital Agriculture (Pilot) Project:** The objective of the initiative is to provide location-specific need-based agricultural services to every farmer by using smart agricultural cards as a digital identity of the farmers and their farm through the sharing of digitally analyzed and managed agricultural information (DAE, 2023).
- **Family Nutrition Plantation Project on Uncultivated Fallen Lands and Backyard Courses (IFNAP) Project:** The key objective of the project is to bring uncultivated and unused homesteads under cultivation for increasing agriculture production (DAE, 2023).
- **Promoting Agricultural Commercialization and Enterprises (PACE) Project:** Led by PKSF the goal of the project is to enhance livelihoods (higher income from self-employment, business profit and wage employment, and food security) of the moderate and extremely poor project participants (men and women) sustainably (PKSF, 2015).
- **Ekti Bari Ekti Khamar:** Ektee Bari Ektee Khamar i.e. One House One Farm is a poverty alleviation project through family farming by the government of Bangladesh. The goal of the project is poverty alleviation through financial inclusion followed by family farming livelihood and income generation for the underprivileged and poor of the country (GoB, 2020).
- **Food for Work, Work for Money, and Test Relief:** In the lean periods ahead of harvest, twice a year, when food shortages are most significant, the rural labor force has fewer employment and income-generating opportunities. Many agricultural workers find it extremely hard to survive these seasonal lean periods and until recent years, were affected by seasonal famine called 'Monga'. The Government of Bangladesh has been operating two public works schemes, Food for Work (FFW) and Test Relief (TR), to address the shortage of both food and work opportunities. As the food security of the country improves and transaction costs associated with food payment lower the program efficiency, the food-to-cash transitions are taking place for wages with the introduction of a complementary program: Work for Money (WFM) (WorldBank, 2019).
- **Government Subsidy:** In FY 2021-22, the government allocated a total of Tk 9,500 crore as a subsidy for the agricultural sector. However due to the rise in the price of fertilizer in the international market, the actual subsidy of the government till April 2022 stood at around Tk 13,332 crore. However, it is estimated that the subsidy could exceed Tk 25,000 crore in the current fiscal year (UNB, 2022).

7. Priority Actions in Climate and Food Systems

7.1 Priority Actions in Climate and Food Systems

Priority actions from the NAP (2023-2050), and the Food System National Pathways of Bangladesh, relevant to climate-resilient food systems have been considered for the case study.

Priority Actions Areas from NAP: The NAP has 23 adaptation strategies, with 113 interventions under 8 sectors to reinforce implementation, all towards achieving its vision and 6 goals. The strategies aim to address adaptation needs for short (2030s), medium (2041) and long-term (2050s) planning horizons. Of these 23 adaptation strategies, 8 adaptation strategies align well with the CRFS.

- **Combat Cyclonic Storm Surges, Sea-level Rise, and Salinity Intrusion:** The particular strategy encompasses the enhancement of the adaptive capacity of human, natural, and economic systems to reduce risks and vulnerabilities and ensure protection against climate change-induced disasters in coastal areas.
- **Manage Floods, Erosion, and Drought Risks:** The strategy aims to increase the adaptive capacity of human, natural, and economic systems to reduce risks and vulnerabilities and ensure protection against climate change-induced disasters in floodplain or drought areas.
- **Protect Life, Livelihoods, Infrastructures, and Ecosystems Against Slow-onset and Other Climate Extremities:** The strategy aims to enhance adaptive capacity and protection of life, livelihoods, and ecosystems against slow-onset and other extreme events of climate change.
- **Promote Extension of Climate-smart Agriculture:** Increase agricultural productivity and resilience, and reduced emissions from the adoption of climate-smart agriculture (CSA) practices.
- **Develop Climate-resilient Fisheries, Aquaculture, and Livestock:** Enhance climate resilience in aquaculture, fisheries, and livestock.
- **Manage Sustainable Agro-inputs and Transformative Value Chains:** The strategy ensures the abundance of quality inputs for agriculture, fisheries, and livestock, and transformed value chains.
- **Strengthen Extension Services for Agriculture, Fisheries, and Livestock:** Improved extension services related to agriculture, fisheries, and livestock.
- **Advanced Research on Climate Change Impacts on Ecosystems and Application of Ecosystem-based Adaptation:** The strategy includes the development of tools and methodologies, and increased capacities of actors to improve research and extension services related to agriculture, fisheries, and livestock.

The key action areas highlighted in the National Pathway Document of GoB for sustainable food system include:

- Research and development on integrated food systems, strengthening institutional collaborations, linkages across cross-sectoral and cross-administrations, including informal sectors, and strengthening harmonization of policies and regulations to anticipate, prevent and adapt to shocks and evolving risk scenarios.

- Strengthening multi-risk Early Warning Systems (EWS) and coordinated approaches linked to contingency planning, anticipatory action, and rapid emergency response including shock-responsive social protection.
- Strengthening innovation in climate change adaptation with a focus on coastal areas, to implement innovative solutions that enable empowering vulnerable groups to make them more resilient.

7.2 Implementing Strategies

The eight implementation strategies highlighted in the NAP of GoB are as follows:

- Integrating policies and regulations, and coordination of institutional arrangements
- Engaging the private sectors
- NAP Financing Strategies: Mobilizing international, national, bilateral, and private sector funding
- Mainstreaming Guidelines: The climate change policy regime highlighted in the NAP will provide guidelines and directives for mainstreaming tools and integrating the CCA into different sectoral policies, plans, and guidelines under the policy mandate.
- Enhancing transformative capacity and technology transfer
- Steer implementation of strategic data and knowledge management
- NAP communication
- Gender, disability, youth, and social inclusion.

Sector:	Agriculture
CSA1	Extension of climate-smart technologies for increasing irrigation water use efficiency
CSA2	Augmentation of surface water for irrigation and multipurpose use
CSA3	Extension of stress-tolerant, pest and disease-resistant rice and non-rice crops
CSA4	Introduction and scaling up of innovative and indigenous agriculture
CSA5	Crop diversification/intensification for natural resources optimization and reduction of climate stress
CSA6	Farm modernization/mechanization to reduce climate vulnerability
CSA7	Increased fertilizer use efficiency for enhancing production
CSA8	Extension of good agricultural practices, modern agricultural technology and sloping agricultural land technology (SALT)
CSA9	Strengthening and development of impact-based early warning systems and data management for agriculture
CSA10	Improvement of storage or post-harvest facilities, transport, communications and e-commerce-based market facilities for agricultural products
CSA11	Development of agrofood processing industries based on climate-sensitive crop zoning
CSA12	Development of e-commerce and engagement of women, people with disabilities and youth in e-commerce-based entrepreneurship

Figure 17: Agriculture-related Interventions Highlighted in the NAP of GoB. Source: (NAP, 2022)

Sector	Fisheries, aquaculture and livestock
CFL1	Extension of climate-resilient technology for combating climate-related stresses in aquaculture
CFL2	Development of climate-ready open water fisheries management
CFL3	Development and management of coastal and marine fisheries to foster blue economy
CFL4	Validation and extension of indigenous knowledge-based adaptation techniques to combat climatic effects on fisheries
CFL5	Monitoring, evaluation and enforcement to ensure the conservation of fish biodiversity and habitat
CFL6	Development of shrimp culture planning and zoning
CFL7	Improvement of post-harvest facilities and e-commerce-based market facilities for fisheries and aquaculture
CFL8	Development of fish industries based on climate-sensitive crop zones
CFL9	Extension of climate-stress-tolerant livestock and poultry breeds, farms, feed and fodder
CFL10	Development of a national livestock and poultry database and information
CFL11	Extension of indigenous and advanced livestock and poultry farming practices
CFL12	Climate-resilient infrastructure development for the safety of livestock and poultry during disasters
CFL13	Development of livestock product processing industries and transportation systems

Figure 18: Fisheries, Aquaculture, and Livestock-related interventions Highlighted in the NAP of GoB. Source: (NAP, 2022)

Sector:	Capacity development, research and innovation
CDR1	Transformative capacity development and knowledge management for integrating CCA into planning processes and climate financing
CDR6	Research on the impact of climate change on land and water resources
CDR7	Action research and field demonstrations on climate-smart agriculture
CDR8	Research and innovation related to climate-resilient fisheries and aquaculture
CDR9	Research and innovation related to climate-smart livestock and poultry
CDR13	Research and popularize climate-stress-tolerant plant species

Figure 19: Capacity Development, Research, and Innovation-related Interventions Highlighted in the NAP of GoB. Source: (NAP, 2022)

The implementation strategies highlighted in the National Pathway Document are as follows:

- Enhanced research and technology support will focus on improving input use efficiency and productivity.
- Prioritizing sustainable intensification, diversification, emissions reduction, and increasing resilience of production, through the adoption of agroecological practices and agri-food system modernization including the use of nanotechnology, and the development of the ocean and blue economy.
- Strengthen backward and forward linkages to ensure accessibility of local products in wider markets.
- Promotion of private investment in inputs, processing, storage, packaging, transportation, and marketing of agri-food products and services especially in remote areas.
- Enhance access to extension services to boost on-farm productivity.
- Regulate environmental monitoring, and water-saving technologies to protect against water shortages and harmful pollution that threaten to undermine gains in food production and food security.
- Reduction of GHG emission from crop and livestock sub-sectors, in line with the latest Nationally Determined Contributions (NDCs).
- Capacity building of women, inclusive and gender-sensitive financing arrangements, and institutional reforms to tackle gender-based inequalities and discrimination.

- Tailored vocational skill training, including literacy skills will be promoted to facilitate entrepreneurship and enterprise development, motivating youth to be the agents of poverty reduction.
- Increase investment to equip small farmers, and cottage, micro, small, and medium enterprises with relevant skills, and technical and financial support.
- Introduction of specialized markets to reduce intermediaries and improve the profitability of smallholder producers.
- Enhancing financial services, including mobile financing, risk coverage, and quality compliance will help enhance the productivity of small producers.
- Promote coordinated governance through an integrated multistakeholder, multi-sectoral, and multi-level approach.
- Nurture a progressive and inclusive system through more efficient and effective delivery of SSN following a lifecycle approach and prioritizing the poorest and most vulnerable sections.
- Introduction of a National Food Loss and Waste (FLW) strategy to reduce substantial food and nutritional loss along the agri-food value chain.
- Adoption of best food safety practices by the private sector, and enforcement of regulatory and oversight systems for food safety to enhance off-farm value addition and commercialization of food and food products.
- Coordination and collaboration under the One Health approach between different ministries, divisions, and agencies, responsible for safeguarding human and animal health and the environment.

7.3 Synergies and Tradeoffs

Promotion of agricultural practices should be prudent, sustainable, context and region-specific to avoid maladaptation practices. For instance, in most cases, shrimp farming in the coastal zones of the country has proved to be a profitable investment until it hampers the agricultural production in the surrounding areas in the long run due to high salinity risk. Besides, the use of excessive fertilizer and pesticides to influence the growth and productivity of crops can threaten human health and the environment.

8. Needs and Gap for Implementation

The government of Bangladesh is working dedicatedly to ensure national food security and sustainability, despite various challenges of population growth, diminution of agricultural land due to rapid urbanization, and impacts of frequent climate-induced disasters. The NAP of Bangladesh clearly states several strategy action plans in terms of improving climate resiliency for the agricultural sector. With the support from the UN corporations, INGO, and NGO the government of Bangladesh has already implemented several of these strategies. Also, the government acknowledges the threat of climate change on food security and is committed to improving the agricultural sector through extensive research, collaboration, multi-stakeholder engagement, and cooperation.

Based on an extensive and systematic literature review of national documents (policies, plans, and strategies), and relevant scientific literature some of the existing challenges related to the national food and agricultural system are discussed below.

8.1 Gaps Identified by Study

- **Gradual Loss of Arable Land:** The trend of population and rapid urbanization has been rapid in Bangladesh over the last few decades which has resulted in the gradual loss of arable land. From 2010 to 2020 cropland or arable land decreased from 65.05% to 58.19%. with an average annual loss of 0.685%. On the contrary, the area under homesteads, rivers, urban, etc., has increased from 30.13% to 36.93% over the years (SRDI, 2020).
- **Higher Dependency on Rice and Need for Diversification:** Rice happens to be the staple and the most crucial cereal crop of the country to ensure the food and energy security of the country. In terms of per capita rice consumption Bangladesh ranks as the top nation in the world, with an annual rate of 268.5 Kg. The share of rice in the regular dietary energy is nearly 69% making the energy security of the country highly rice-dependent (Ali, 2020). In Bangladesh the demand for rice is mainly population-driven, indicating an exponential relation between the growth of the population and the demand for rice cultivation. Therefore, to meet the high demand rice cultivation tends to be the major cultivation practice in the country other than diversification of crops. Such a predominant focus on rice production also creates the risk of malnutrition due to the lack of diversification in farming households (CIAT & WorldBank, 2017).
- **Excessive Use of Fertilizer and Decline of Soil Fertility:** To meet the rice demand intensive cropping practices have been observed in limited arable lands over the years. This monocultural practice hampered soil fertility and productivity and resulted in gradual organic matter and nutrition deficiencies, and physical and chemical degradations of soil salinity and acidity (Bayes, 2016). Moreover, the government subsidy on chemical fertilizers led to a spectacular rise in fertilizer use from 0.36 kg/ha in 1995 to 298 kg/ha in 2007. Such measures helped the country to achieve rice self-sufficiency but also degraded the soil organic matter (SRDI, 2020).
- **Out-migration Trends and Labor Shortage in Rural Areas:** Since the last few decades, Bangladesh's high population growth led to a stark decline in per capita agricultural land availability. The situation is exacerbating as more agricultural land is being transformed for non-agricultural usage and rapid urbanization. Limited availability of farmland and on-farm livelihood opportunities is driving the rural labor force to seek employment in urban and suburban areas, causing a labor shortage in rural areas (CIAT & WorldBank, 2017).
- **Urbanization and Nutritious Food Intake:** It has been observed that rapid urbanization has brought a transformative change in the food system and nutrition food intake. Especially in the urban areas a pattern of higher fast food and processed food intake has been observed, concerning the nutritious and balanced diets of the urban dwellers (NFNSP, 2020).
- **Weather and Climatic Data Management, Early Warning System, and Dissemination:** Despite undertaking several initiatives to generate weather data to help the farmers, in most cases there remains a question on the reliability of the data and effective dissemination process. Both NAP and the Country Investment Plan II (CIP-II) of GoB highlight the need and importance of developing early warning systems and vulnerability risk assessment in terms of agricultural production and food security. The CIP-II emphasizes strengthening the Integrated Food Security Phase Classification (IPC),

and Vulnerability Analysis and Mapping (VAM) information, with beneficiary awareness building, and ensuring necessary institutional arrangements (MoF, 2021). Whilst, the NAP underlines the need for ICT-based early warning dissemination systems to engage communities with readily understandable warning advisory services in local languages to reduce losses and damages from sudden disasters, minimize disaster risks, and achieve SDG targets (NAP, 2022). Therefore, there is an urgent need to introduce "Climate Services" at the farmer's level to disseminate the weekly forecasting comprehensibly considering the local context (NFNSP, 2020).

- **Taking Technologies to Small-scale Farmers and Need of Investment:** In Bangladesh, the small-scale farmers (owning less than 0.60 hectors of land) dominate the agricultural sector and are considered the most vulnerable group in terms of natural disasters, and accessibility to resources and services. Besides, their lack of social and financial resources, education, land insecurity, and limited access to agricultural schemes amplify their sufferings (Rozario et al., 2021). The NFNSP also highlights the need for investments for smallholder farmers as they are the important change agents for the improved food system and nutrition (NFNSP, 2020). Therefore, further training, capacity building, skills sharing, financial and technological support, and investment are required to change and optimize their condition and potential.

  Extension of supporting and advisory services, market links and proper monitoring of supply chains, expanding e-commerce, and integrated pest and diseases management can be some key measures to consider (NAP, 2022; MoF, 2021).

- **Need for Training and Inclusion:** The small-scale farmers need to be skilled and technologically sound to mitigate the impacts of climate change on agricultural and food systems sustainability. Introducing the 'Framer School' is a good initiative by the GoB in this regard; however, the program should be expanded especially in the climate-vulnerable regions. The establishment of local information networks, and better access to market information, climate services, training in understanding the disaster risk and impact can also be scaled up to support the farmers. Strengthening of integrated homestead food production with emphasis on indigenous, underutilized, and nutritious varieties/species/breeds can also be promoted.
  There is also an urgent need to promote women's leadership in the agricultural and food system and support them as per their requirement (NAP, 2022; NFNSP, 2020).

- **Mainstream and Scaling Up Climate Smart Technologies:** To reduce production losses likely to result from the high frequency of extreme weather patterns induced by climate change, climate-smart technologies are required. Such technologies are also needed to increase the availability of micronutrient-dense fruits and vegetables and improve breeds of livestock, poultry, and fish that are high in good-quality protein and bioavailable micronutrients. To improve the productivity of grains and receive maximum yield from minimal resources CST can play an important role (NAP, 2022; CIAT & WorldBank, 2017).

- **Ensuring Effective Irrigation and Water Resource Management:** The agricultural practices in Bangladesh massively depend on surface and groundwater irrigation, and precipitation. However, in recent times many places especially in the North Western region is facing water scarcity due to the lack of precipitation and groundwater recharge

which is impacting the crop yield significantly. On the contrary, the South Western coastal belt suffers from salinity intrusion, hampering crop production (NAP, 2022). Therefore, there is a need to improve the current irrigation distribution networks, invest in increasing the capacity of the water reservoirs, create mass awareness of efficient use of water resources, promote community-based water management technologies, integrate community-based practices with scientific approaches, and most importantly establish good governance and enhance institutional capacity in water resource management (Roy, 2020).

- **Measuring Food Losses and Strengthening Post-harvest Handling:** There is a need of improving the method of measuring food losses, especially at the farm level, and also strengthen the capacity in post-harvest handling technology and infrastructures (Transport, Packaging, and Storage) (MoF, 2021).

  Extensive research can also be practiced to identify the stages of the value chain where nutrients are being lost due to inadequate practices or infrastructure and, or where they can be enhanced (NFNSP, 2020).
- **Data Management and Market Monitoring Mechanism:** Introducing an effective big data analytics ecosystem for the food system is required. This would help to develop adequate responses to climate change variability, environmental impacts of food production (footprint), and food safety, and also help to analyze and forecast the overall FNS situation, including with regards to food markets in terms of production, supply, demand and prices (MoF, 2021).

  Also, the market should be strictly monitored regularly to ensure the smooth distribution of food products and price stability. Such measures would also discourage syndicated market systems and reduce food adulteration (Huda, 2023).
- **Extensive Research in Making the Livestock Sector Climate Resilient:** The livestock sector meets the protein demand of the country, and also contributes to the national GDP significantly. Even though the sector has been flourishing over the last few decades, there are several scopes of improvement to make the sector more resilient to the impacts of climate change. To do so, extensive research on climate-resilient technology and system is required. This includes developing good farming practices, ensuring farm bio-security and herd health management, developing vaccines to combat endemic and emerging diseases, designing sheds considering the heat impacts and animal comfort, conserving and developing local breeds, developing saline and drought tolerant fodder verities, introducing modern feeding management practices, linking climate data to animal diseases surveillance, and enhancing the multistakeholder collaboration to study the real-time impacts of climate change on the livestock's (Ali et al., 2020). The inadequate availability of quality fodder and feed for the livestock also remains a great challenge for the sector (CIAT & WorldBank, 2017).
- **Execution of Policy and Interventions:** The national documents (policies, action plans, investment plans, and strategies) related to agriculture and food includes several objectives and activities to ensure the sustainability of both the agricultural and food system. The NAP also acknowledges the threats of climate change on food security and proposes several interventions. All these measures, need to be executed and implemented promptly.

- **Need for Private Sector Involvement and Investment:** The climate change adaptation measures in Bangladesh are mostly centralized and donor-driven and the participation of the private sector is insignificant. Especially, in terms of agriculture and food production, manufacturing, and export the private sector can play a vital role. The sector can also invest in research, capacity building, and providing technological support. For instance, improve the stress-tolerant variety of seeds, develop climate-friendly construction material, dissemination of weather and climatic information at the root level, improve cold storage facility, expand aquaculture and agricultural value chain, promote green and renewable energy sources, invest in agro-forestry, water resource management, and resilient infrastructure can be some of the sectors of investment by Private-Public Partnership (NAP, 2022).
- **Ensuring Sufficient Agricultural Credits, and Insurance Schemes to Support the Farmers:** To address the adverse effect of climate change and the SDGs fulfillment, inclusive agricultural finance is a must. Timely increased access to credit is essential to ensure that small-scale producers have the liquidity to both timely operate and to take up the risk of changing their current practices in favor of adopting climate-smart technology and diversification. However, the credit disbursement is uneven across the country: farmers in the char (sand bars), haor (bowl shape shallow depression) and less developed areas received less than 1% of the total beneficiaries, and the amount of disbursement compared to other regions of the country. Similarly, crop sector agricultural credit receives 60% of the total disbursement, and fisheries and livestock sector receive only 10% each, and the rest is by other rural activities. Moreover, the average size of loans disbursed is small and barely meets farmers' needs. Small farmers unable to borrow loans from the formal financial sector borrow loans from microfinance institutions (MFIs). In many cases, they face several challenges including high interest rates, credit overlapping, unfavorable repayment periods, and credit ceilings. Therefore, suitable institutional reforms are necessary for ensuring the availability and access to agricultural credit in an inclusive and timely manner (NFNSP, 2020).
  There is also a need to facilitate the development of insurance schemes via public–private–NGO cooperation for losses due to disasters and climate change by supporting needs assessments and providing technical assistance to the farmers. Even though, agricultural insurance is intended to minimize farmers' risk, in Bangladesh most crop insurance products are offered for "Less Risky" crops (Bakhtiar et al., 2023).
- **Financial Deficit to Fulfill SDG 2:** The National Pathway Document highlighted that an additional amount of 16.21 USD billion (at 2015-16 prices) would be needed to achieve the target for SDG 2 by 2030. The cumulative budget of the second country investment plan (CIP-II) on nutrition-sensitive food systems (2016-20) had a gap of 3.5 billion USD in the cumulative budget of 19.2 billion USD for the por eriod indicating a deficit in the budget for nutrition interventions (GoB, 2021).
- **Enhance Coordination and Expand Cooperation:** The impacts of climate change on the agricultural sector are a national concern that can threaten food security and hinder overall development. To mitigate the challenge, cooperation within the ministries and associate agencies needs to be strengthened. For instance, there should be a collaborative approach in linking the food system with the health system to track the progress on food and nutrition security. Thus, inter-ministerial cooperation, convergence,

partnerships, coordination, and multistakeholder engagements are the key to achieving resiliency in the agriculture and food system (NAP, 2022; FPMU, 2021; GoB, 2021).

- **International Commitments and Fulfillment**: Food systems transformation can become more appropriate and effective by fulfilling the commitment and investment from developed countries. Under the SDG 2030 Agenda and the Addis Ababa Action Agenda (2015) on financing for development, developed countries are to provide official development assistance (ODA) equivalent to 0.7% of their gross national income, including 0.2% allocated to the support of LDCs. Besides, COP21 (2015) restated the commitment of developed countries to mobilize an additional 100 billion USD/ year by 2020 to address the needs of developing countries through the Green Climate Fund (GCF). As of June 2021, however, the initial resource mobilization and first replenishment amounts together amounted to only 20.3 billion USD (GoB, 2021).

9. Entry Points for the Climate Resilient Food System Alliances

The Climate Resilience Food System Alliance (CRFSA) is a consortium of both UN and non-UN agencies that possess the capacity to support the alliance members in ensuring the resiliency of the food system through a multi-stakeholder collaborative approach. In a densely populated, and climate-vulnerable country like Bangladesh; the resilience of the food system remains a big challenge. However, Bangladesh has been committed to achieving the SDGs and other national priorities and welcomes regional and global collaboration to accelerate learning and support in meeting the country's development needs. In addition, Bangladesh also envisions the emergence of Coalitions for Action under the United Nations Food Systems Summit (UNFSS) as an important step in line with SDG 17 (GoB, 2021).

As the CRFSA includes different actors and holds a wealth of knowledge and expertise, it could certainly extend support to Bangladesh in mitigating the existing gaps and challenges through:

- Strengthening the collaboration and integration within the appropriate ministries and relevant stakeholders, and creating a platform for mutual peer-to-peer exchanges and interventions.
- Strengthening the network and developing interventions within the national, regional, and international stakeholders to improve bilateral, and multi-lateral cooperation to achieve food system resiliency. For instance, the SAARC (South Asian Association for Regional Collaboration) network.
- Helping the government to identify appropriate solutions towards climate-resilient food systems and support to achieve national and international goals.
- Support the government by introducing climate-smart technology, methods, tools, and skills which is appropriate (considering the local context), acceptable, feasible, and sustainable.
- Generating evidence: In what works well? Why? And Why Not?
- Supporting the government in agricultural and livestock research and knowledge generation, capacity building of the different stakeholders (From Producers to Consumers), and enhancing institutional capacity considering the NAP priorities.

- Ensuring the proper dissemination of knowledge and information regarding climate change, Disaster Risk Reduction (DRR), and Early Warning System (EWS) at the lowest appropriate level, and accelerating women's participation in the overall decision-making process.
- Supporting the government to sensitize the private sector, and promote public-private partnerships to achieve food system resiliency.
- Identifying scopes and providing support to the government for undertaking agricultural development measures in rural areas to limit internal migration.
- Supporting the government to identify potential funding sources and opportunities for collaboration.
- Increasing institutional and interdisciplinary coordination amongst local and national governments, farmers, businesses, academicians, INGOs, NGOs, agroecologists, sociologists, journalists, etc. to conduct True Cost of Accounting (TCA) and assess the costs and benefits of the food system.
- Establishing adequate market mechanisms and monitoring bodies at local, divisional and national levels to avoid price distortions, food loss, and enhance transparency to the smallholder farmers.

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Annex

CRFSA Organization	Project and Activities (Links)
FAO	https://www.fao.org/bangladesh/programmes-and-projects/project-list/en/
IFAD	https://www.ifad.org/en/web/operations/w/country/bangladesh#anchor-projects_and_programmes
CGAIR	https://ccafs.cgiar.org/regions/south-asia/projects
WFP	https://www.wfp.org/countries/bangladesh
World Bank	https://projects.worldbank.org/en/projects-operations/projects-list?countrycode_exact=BD&os=0
IRRI	https://www.irri.org/where-we-work/countries/bangladesh
CIMMYT	https://www.cimmyt.org/location/asia/bangladesh/?category=0&theme=0&research=0&year=0&order=0&orderby=date
BRAC	https://www.brac.net/