



**EFFECTS OF CLIMATE CHANGE ON LIVELIHOODS IN DROUGHT-PRONE REGIONS  
OF BANGLADESH: AN IN-DEPTH ANALYSIS**

**Md Mahedi<sup>1</sup>, Shabrin Jahan Shaili<sup>1\*</sup>, Md Nurnobi<sup>1</sup>, Arafatur Rahman Shihab<sup>2</sup>, A Rahman Sakil<sup>3</sup>**

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## EFFECTS OF CLIMATE CHANGE ON LIVELIHOODS IN DROUGHT-PRONE REGIONS OF BANGLADESH: AN IN-DEPTH ANALYSIS

Md Mahedi<sup>1</sup>, Shabrin Jahan Shaili<sup>1\*</sup>, Md Nurnobi<sup>1</sup>, Arafatur Rahman Shihab<sup>2</sup>, A Rahman Sakil<sup>3</sup>

<sup>1</sup>Dept. of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi-6205, Bangladesh.

<sup>2</sup>Dept. of Physics, Tejgaon College, Dhaka 1215, Bangladesh.

<sup>3</sup>Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh.

\*Corresponding author: Shabrin Jahan Shaili, Email: [s2012066151@ru.ac.bd](mailto:s2012066151@ru.ac.bd)

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### ABSTRACT

Bangladesh is one of the nations most at risk from climate change. Drought is becoming more severe in the northern and southern parts of the country, putting the country at even greater risk. This analysis provides a comprehensive synthesis of the numerous impacts of climate change, particularly through extended and recurring droughts, on rural livelihoods in Bangladesh. Utilizing empirical data, published literature, and policy evaluations, this study rigorously analyzes the socio-economic and environmental ramifications of drought, encompassing diminished agricultural productivity, groundwater depletion, income instability, food insecurity, gendered vulnerability, and health challenges. The results indicate that rural livelihoods in drought-prone regions are ensnared in a self-perpetuating cycle of vulnerability, exacerbated by diminishing natural resource availability, entrenched poverty, and institutional deficiencies. Traditional coping mechanisms, such as crop diversification, seasonal migration, and indigenous wisdom, have helped in the past, but they are no longer effective as the weather worsens. Governmental and NGO-led initiatives have achieved some success in certain areas. Still, they are generally limited by poor execution, elite capture, and unsustainable resource utilization, particularly in the overuse of groundwater. The assessment emphasizes the need for a fundamental change in adaptation tactics. Some of the essential suggestions include using climate-resilient agricultural technology on a broad scale, implementing water governance that involves everyone, establishing social protection systems that are prepared for any eventuality, implementing early warning systems led by communities, and implementing programs that help people diversify their livelihoods, especially those who are most vulnerable. The research suggests that mitigating the effects of drought in Bangladesh requires not only environmental interventions but also comprehensive socio-political and economic changes to ensure equitable, inclusive, and sustainable

resilience-building. This review enhances the knowledge of the interplay between climate and livelihood by pinpointing research deficiencies and policy inadequacies. It is a key piece of information for planning future actions in one of South Asia's most environmentally and economically strained areas.

## 1. INTRODUCTION

Climate change is one of the most significant problems of the 21st century (Kabir et al., 2023). It threatens natural systems, food security, water availability, and people's jobs in a big way. Increasing temperatures, unpredictable rainfall patterns, longer dry periods, and more frequent severe weather events are all causing problems for the environment and the economy worldwide (Dharmarathne et al., 2024). These effects are particularly pronounced in the Global South, where many people rely on natural resources for their livelihoods and economic development. South Asia is one of the areas most affected by climate change (Habib-ur-Rahman et al., 2022). It is already seeing serious effects, such as more frequent droughts, later monsoons, and alterations in agroecological patterns.

Droughts are one of the most severe climate-related disasters, as they occur gradually and have long-lasting consequences for many areas. Climate change has an immediate impact on livelihoods in areas prone to drought, where water is scarce and rain-fed agriculture is prevalent (Roy et al., 2022). This is especially true for smallholder farmers, landless workers, and rural populations who are already marginalized. To ensure that rural development is sustainable, it is crucial to understand how droughts impact income patterns, agricultural output, migratory behavior, and social vulnerability. The effects on people's livelihoods are numerous, including impacts on food security, employment, health, education, and social cohesion (Mahedi et al., 2024). To develop effective policy and intervention frameworks, we must examine all these factors in detail for each area.

Bangladesh is known across the world as one of the nations most at risk from climate change because of its location, high population density, low elevation, and reliance on industries that are susceptible to climate change (Khan et al., 2021). People often discuss the hazards of cyclones and saline intrusion in Bangladesh's coastal areas, while its northern and southwestern regions are experiencing increasingly chronic and severe droughts. These places experience little rainfall, limited groundwater, significant evaporation, and inadequate irrigation infrastructure. Because these areas rely heavily on farming and have limited resources, they are particularly vulnerable to climate shocks. People residing in areas prone to drought are witnessing a decline in their agricultural yields, incomes, and food security, as well as an increase in climate-induced migration and pressures on livelihood diversification (Hamza et al., 2024). The combination of socio-economic stress and climatic unpredictability makes these regions even more vulnerable to losing their livelihoods.

Although a growing body of research on climate change and livelihood adaptation exists worldwide, a significant deficiency remains in thorough evaluations that specifically address the consequences of drought-induced livelihood impacts within the context of Bangladesh (Ahmad et al., 2022; Mahedi, Pervez, et al., 2025). Current research primarily focuses on either the physical aspects of drought or broad adaptation strategies, often missing a cohesive perspective that links climate change, local

vulnerability, and the intricate dynamics of rural livelihoods. This analysis aims to integrate disparate findings and provide a comprehensive understanding of how climate change, particularly through increased drought stress, is transforming livelihoods in Bangladesh. This paper enhances climate resilience by integrating existing information and pinpointing research and policy deficiencies, therefore directing targeted adaptation measures for drought-prone regions. The following objectives direct this review: a) To look at what climate change, particularly droughts, does to rural life in Bangladesh; b) To find out what the main livelihood risks are and how drought-prone people adjust to them; c) To evaluate the efficacy and constraints of existing policies and actions; d) To point out research gaps and recommend new areas for study.

This review's main research questions are:

**RQ1:** What are the main effects of climate change, especially drought, on the lives of people living in rural areas of Bangladesh?

**RQ2:** Which groups of people and ways of making a living are most likely to be affected by stress caused by drought?

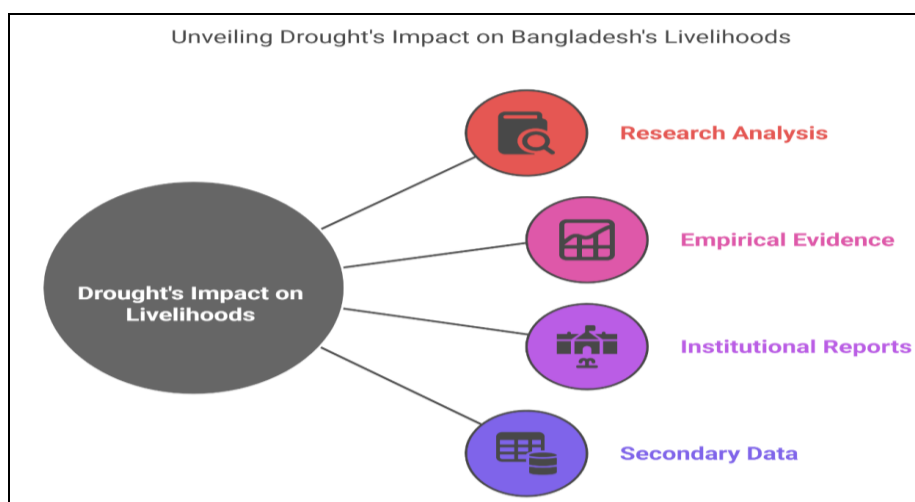
**RQ3:** What strategies do communities in places prone to drought use to deal with it?

**RQ4:** How well do current policies and institutions deal with these problems?

**RQ5:** What are the main gaps in the present research, and what areas need further study?

## 2. METHODOLOGY

This paper presents a narrative and integrative analysis of current research, empirical evidence, institutional reports, and secondary data on the effects of climate change, specifically drought, on livelihoods in Bangladesh's drought-prone areas. This research employed a theme synthesis technique rather than adhering to a strict review process, with a focus on relevance, credibility, and contextual application. Data was collected from a diverse array of published journal articles, governmental reports, NGO publications, policy briefs, and statistical yearbooks pertinent to climate change, rural livelihoods, drought vulnerability, and adaptation strategies in the northwestern and southwestern regions of Bangladesh. Particular emphasis was placed on reports and statistics generated by national entities, including the Bangladesh Bureau of Statistics (BBS), the Department of Agricultural Extension (DAE), the Bangladesh Agricultural Development Corporation (BADC), and the Department of Livestock Services (DLS), among others. This method facilitated the integration of multiple forms of information to provide a comprehensive and contextually relevant understanding of how climate-induced drought is impacting rural livelihoods in Bangladesh. This technique, albeit not systematic, prioritizes depth, contextual relevance, and policy importance in integrating current information and pinpointing gaps for future study.



**Figure 1.** Unveiling Drought's Impact on Bangladesh's Livelihoods

### 3. CLIMATE CHANGE AND DROUGHT DYNAMICS IN BANGLADESH

Bangladesh is one of the most climate-vulnerable nations in the world, as it is situated at the intersection of three major river systems. People often discuss floods and storms, but drought has become a long-term, slow-onset threat, particularly in the northern part of the country. Recent weather data shows that temperatures are rising quickly. The Bangladesh Meteorological Department (BMD) reports that the average temperature in the northwestern regions has increased by approximately 1.3°C from 1976 to 2019 (Rashid et al., 2022). At the same time, rainfall patterns have grown more unpredictable. For example, in the 1980s, Rajshahi, prone to drought, received 1,400 mm of rain per year, but in recent years, it has only had around 1,100 mm, significantly less than the national average of about 2,200 mm.

The historical record of droughts is long and scary. Bangladesh had severe droughts in 1975, 1979, 1981, 1989, 1994, 2000, 2006, and 2010. The 1994 drought affected approximately 5.5 million people and failed many crops. In the Barind Tract, droughts often occur when insufficient rainfall and a prolonged period of heat waves precede the monsoon. The Intergovernmental Panel on Climate Change (IPCC) and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) both indicate that the northwestern region could experience up to a 20% reduction in rainfall during the dry season by 2050, assuming the RCP 8.5 scenarios are accurate. This would result in more extreme dry days and prolonged droughts.

The Barind Tract, which includes the districts of Rajshahi, Naogaon, and Chapainawabganj, is the most vulnerable area to drought (Sujan et al., 2023). This is because it gets the least rain each year and has coarse-textured soils that don't hold water well. The region's terrain, characterized by high terraces, makes it difficult for surface water to remain in one place. At the same time, groundwater tables have been progressively declining because people rely too heavily on deep tube wells. For instance, the average groundwater level in Rajshahi has plummeted by more than 1 meter per year over the last 20 years. This has put numerous upazilas in "critical" water stress zones, according to the Bangladesh Water Development Board (BWDB).

Several factors increase the likelihood of drought susceptibility. In terms of ecology, deforestation, topsoil erosion, and the rapid decline of wetland ecosystems have all made it harder for nature to cope

with dry spells. More than 60% of the people in these areas depend on farming for their income. Many of them grow just one crop and require a significant amount of water, such as Boro rice, making them highly vulnerable to insufficient rainfall and the inability to use irrigation. Social vulnerabilities exacerbate the situation. More than 35% of families in these areas live below the poverty line, and access to climate-resilient infrastructure, financial services, and institutional safety nets is still restricted. The absence of cohesive drought monitoring systems and localized early warning mechanisms hinders preparation and response efforts.

**Table 1.** Climate Trends, Drought Statistics, and Regional Vulnerabilities in Northwestern Bangladesh  
**Source:** Bangladesh Meteorological Department (BMD)

| Features                                | Impact                                                                        |
|-----------------------------------------|-------------------------------------------------------------------------------|
| Temperature Rise                        | ↑ 1.3°C in northwestern Bangladesh (1976–2019)                                |
| Rainfall Decline                        | ↓ From 1,400 mm in the 1980s to 1,100 mm (Rajshahi, Naogaon, Chapainawabganj) |
| National Average Rainfall               | ≈ 2,200 mm/year                                                               |
| Major Drought Years                     | 1975, 1979, 1981, 1989, 1994, 2000, 2006, 2010                                |
| Population Affected by the 1994 Drought | ≈ 5.5 million                                                                 |
| Projected Dry Season Rainfall (2050)    | ↓ Up to 20% under the RCP 8.5 scenario                                        |
| Groundwater Depletion (Rajshahi)        | ↓ >1 meter/year (Average drop in water table over two decades)                |
| Agricultural Dependence                 | > 60% of the population in drought-prone districts depend on agriculture      |
| Poverty Rate (Regional)                 | > 35% of households below the poverty line (Barind region)                    |
| Drought-Prone Districts                 | Rajshahi, Naogaon, Chapainawabganj (Barind Tract)                             |
| Soil Characteristics                    | Coarse-textured, low water retention, high evapotranspiration                 |
| Key Climatic Drivers                    | Rising temperature, erratic rainfall, weak monsoon, and declining groundwater |
| Socioeconomic Drivers                   | Poverty, mono-cropping, weak institutions, and low adaptive capacity          |

#### 4. LIVELIHOOD SYSTEMS IN DROUGHT-PRONE AREAS

The Barind Tract in northwestern Bangladesh is a very vulnerable agro-ecological zone. Climate change is causing rainfall to vary and temperatures to rise, which is increasing the frequency and severity of droughts. This poses a significant threat to complex livelihood systems that rely on a deteriorating natural resource base. Most people make a living by farming in the rain, which relies primarily on the Transplanted Aman (T-Aman) rice that grows during the monsoon season and the Rabi season crops (such as wheat, legumes, potatoes, chili, and mango) that are watered by groundwater and are becoming less stable (Ali & Hossain, 2016). The fact that pre-monsoon (Chaitali/Khowai) and post-monsoon (Rabi) rains fail so often means that crops are lost, planting is delayed, and yields are lower, which directly affects food security and income. Agricultural wage labor is a crucial source of income for households that don't own much land. However, when droughts slow down farming, the demand for labor

drops, and daily earnings decrease by 30–50%, forcing families to relocate and take on high-interest loans (Yan et al., 2025). Raising livestock (cattle, goats, and poultry) is a critical way to protect against risks and have money on hand. Still, when there isn't enough food or water during droughts, many animals become sick, die, or are sold for less than they are worth, which hurts the household's assets and nutritional security. Small-scale non-farm activities, such as petty commerce, rickshaw pulling, and microenterprises, are essential for diversification; however, they are also sensitive to changes in local disposable income caused by agricultural downturns, which halt market activity during dry years. The safety of these jobs depends on the health of critical natural resources, including soil, water, and forests. Long periods of drought accelerate the deterioration of topsoil by causing wind erosion, loss of organic matter, and nutrient depletion. This creates a negative feedback loop that makes future farming less resilient. The most serious problem is a lack of water. Groundwater levels are dropping at an alarming pace (1–3 meters per year in critical areas), which causes shallow tubewell (STW) failures, increases pumping costs, and makes it harder for poorer farmers to access water for irrigation, thereby exacerbating social and economic inequalities (Yan et al., 2025). Surface water bodies, such as ponds, canals, and beels, sometimes dry up entirely, which puts both residential water security and aquatic resources at risk. Water stress and overexploitation have caused severe damage to natural forests (like the remnants of Barind sal forests) and homestead woodlots. This has made it significantly more challenging to obtain fuelwood, fodder, non-timber forest products (NTFPs), and essential ecosystem services, such as soil conservation and microclimate regulation. The demographic and socio-economic characteristics of these populations highlight significant vulnerability.

A lot of people living close together put a lot of stress on limited land and water. A large number of people are smallholder and marginal farmers who grow crops on tiny, economically unviable plots (<0.5 hectares). There is also a vast number of people who don't own land (40-60% of families) and rely significantly on insecure tenancy or wage labor. Persistent poverty levels that exceed the national average make it challenging for people to access funds, adaptive technology (such as drought-resistant plants and efficient irrigation systems), and institutional safety nets. Access to climate information, extension services, and non-farm employment opportunities is limited by low literacy rates, particularly among women and indigenous communities, such as the Santal and Orao (Mandal, 1992). Groups who are socially excluded, such as ethnic minorities and families led by women, are more vulnerable during droughts because they can't get land, credit, or move around freely, and they aren't allowed to make decisions (Mahedi et al., 2025). This combination of environmental stress, declining natural resources, and long-standing socio-economic disadvantage leads to a widespread state of precarious resilience. Droughts are particularly hazardous because they exacerbate existing vulnerabilities and threaten the very foundations of livelihood security.

## **5. IMPACTS OF CLIMATE CHANGE ON LIVELIHOODS**

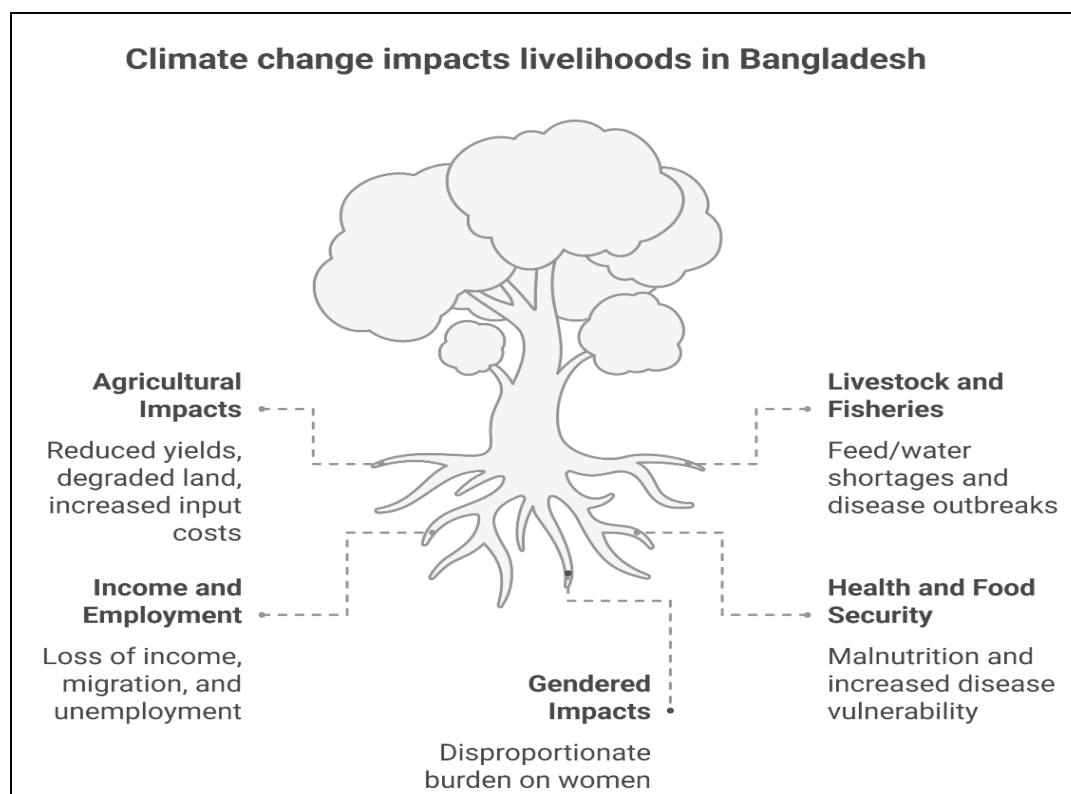
Climate change, particularly through intensified drought conditions, has far-reaching effects on the livelihoods of communities in drought-prone areas of Bangladesh. These impacts are complex, multidimensional, and often interlinked, affecting not only economic productivity but also social and

environmental well-being.

### 5.1. Agricultural Impacts

In the drought-affected areas of Bangladesh, particularly the Barind Tract and northern districts such as Rajshahi, Naogaon, and Chapai Nawabganj, agriculture is seeing increasing difficulties owing to shifting climatic patterns (Kafy *et al.*, 2023). Agriculture accounts for over 12.7% of Bangladesh's GDP and employs more than 40% of its workforce (Islam *et al.*, 2022). The increasing frequency and severity of droughts have significantly impacted agricultural production, food security, and the lives of rural communities. Drought significantly contributes to crop failure. Drought diminishes soil moisture and restricts water availability during essential growth phases, resulting in partial or total crop failures. The Bangladesh Rice Research Institute (BRRI) indicates that yield declines in severe drought years might reach 30% for Aman rice and 20% for Boro rice. During the 2018 drought, rice production in the Rajshahi area decreased by approximately 1.2 million tons, resulting in significant local economic detriment. Moreover, cropping patterns are transforming. Farmers who previously relied on high-yield, water-intensive crops, such as rice and jute, are transitioning to low-water-requirement crops, including lentils, mustard, and maize. Although these crops exhibit greater climatic resilience, they often provide diminished economic returns, hence decreasing family incomes. A 2022 study by the International Rice Research Institute (IRRI) indicated a 22% rise in lentil planting in northern areas; however, a concomitant 15% decline in net revenue per hectare relative to rice.

Soil deterioration is an escalating issue. Extended drought conditions lead to reduced organic matter, heightened salinity in some regions due to improper irrigation water management, and topsoil erosion. This results in a prolonged decline in fertility. Concurrently, water shortage is intensifying. In drought-prone regions, groundwater levels have decreased by an average of 1.5–2.5 meters over the last decade (Pham *et al.*, 2022), primarily due to excessive extraction for irrigation during arid periods. The cost of irrigation has increased in many regions, exacerbating the challenges faced by small-scale farmers. In summary, climate-induced drought has a cascading effect on agriculture, diminishing yields, deteriorating land, altering cropping methods, and escalating input costs (Md Shahriar Kabir *et al.*, 2025). Without the implementation of adaptive strategies—such as the advancement of climate-resilient crops, enhanced water management, and soil conservation—agriculture in Bangladesh's drought-prone regions faces the threat of unsustainability, potentially relegating thousands of rural people to greater poverty.



**Figure 2.** Impacts of Climate Change on Livelihoods in Bangladesh

## 5.2. Livestock and Fisheries

Livestock and fisheries, which are essential to the varied rural economy of Bangladesh, are becoming increasingly susceptible to the detrimental effects of climate change, particularly in drought-prone areas (Ado et al., 2020). These sectors provide vital nourishment, income, and employment for millions, but they are mostly overlooked in climate adaptation programs. As droughts intensify, both cattle and aquaculture systems are under unprecedented pressure.

For cattle, a significant problem is the scarcity of feed and water. Prolonged dry seasons result in the desiccation of grasslands and pastures, diminishing the supply of natural feed. Crop leftovers, which typically supplement cattle feed, are also decreasing due to reduced crop yields. The Department of Livestock Services (DLS) reports that feed availability in drought-prone regions decreased by 35% from 2010 to 2020. Consequently, small farmers sometimes have to sell or cull animals prematurely, resulting in economic and nutritional deficits. Water shortage impacts the drinking requirements of animals and the maintenance of hygiene. In regions like Bogura and Joypurhat, where groundwater levels have declined significantly, herders report traveling distances of 2 to 3 kilometers every day to access water. Extended dehydration and inadequate nutrition result in weight loss, decreased milk production, reproductive complications, and eventually heightened animal mortality. Furthermore, illness outbreaks are becoming frequent and severe. Stress and humidity foster circumstances conducive to infections such as foot-and-mouth disease, anthrax, and hemorrhagic septicemia. Ta from DLS (2022) indicates that the prevalence of livestock diseases rose by 19% during the drought seasons from 2017 to 2022. Sufficient veterinary services and a lack of knowledge among rural populations exacerbate the issue.

In the fisheries industry, diminishing water levels, rising temperatures, and unpredictable rainfall

patterns have led to the contraction of ponds, lakes, and rivers, thereby affecting aquatic ecosystems. It should decrease the dissolved oxygen levels in marine environments, potentially adversely affecting fish health and growth rates. For instance, the average fish output in the northwest decreased from 3.2 to 2.1 metric tons per acre between 2010 and 2020 (Parvin, 2021). Recovery is hindered by heightened water salinity and contamination in some areas, which exacerbate stress on fish populations, influencing their spawning and feeding behaviors. As a result, both livestock and fisheries are experiencing declines in production, leading to diminished rural income and nutrition. Increasing vulnerability requires comprehensive adaptation solutions, including climate-resilient breeds, enhanced animal husbandry practices, and sustainable aquaculture methods, to protect these essential livelihood sectors.

### 5.3. Income and Employment

Climate change poses a significant risk to rural livelihoods and employment dynamics in Bangladesh, particularly in areas vulnerable to drought. The cumulative impact of diminishing agricultural output, livestock losses, and fisheries degradation has profoundly impacted income-generating activities. This, in turn, precipitates detrimental socio-economic consequences, including migration, poverty, and regional disparity. The decline in agricultural revenue is the most apparent consequence. The Household Revenue and Expenditure Survey (HRES) indicates that the average monthly revenue from crop farming in drought-affected regions has decreased by 26% over the last decade. Seasonal income variability has become more extreme, with lean spells extending up to five months owing to altered and postponed harvests. This volatility complicates financial planning and heightens reliance on loans, sometimes from informal sources that impose excessive interest rates.

The multiplier effects of diminished agricultural production are seen in the decrease in non-farm employment. Rural artisans, transport workers, retailers, and others who rely on agrarian earnings for their livelihoods are similarly affected. Research conducted by the International Labour Organization (ILO) revealed that a 10% decline in agricultural revenue results in a 6–7% reduction in rural non-farm employment (Reardon *et al.*, 2000). This shrinkage exacerbates rural poverty and hastens out-migration. Seasonal and permanent migration have emerged as prevalent adaptive strategies. Numerous young people, especially males, leave their villages during the dry season to seek temporary employment in metropolitan areas such as Dhaka or Chittagong. 2021 research from the Bangladesh Institute of Development Studies (BIDS) indicated that seasonal migration from drought-affected regions rose by 45% from 2010 to 2020. Nonetheless, urban employment sometimes lacks security, offers inadequate compensation, and entails significant physical labor, particularly for unskilled migrants.

The unemployment rate in regions impacted by climate change exceeds the national average. In northern districts such as Kurigram and Rangpur, youth unemployment exceeds 20%, compared to the national average of 12% (Shahen, 2024). Disruptions to livelihoods caused by climate change significantly exacerbate this disparity. Income and employment disruptions yield enduring repercussions. Children from impacted homes are more prone to discontinue their education to augment family income, hence prolonging intergenerational poverty. Women and older relatives often assume more home responsibilities when men move, thus exacerbating gender inequity. Confronting these difficulties necessitates climate-resilient employment initiatives, vocational education, access to rural financing, and the diversification of livelihoods outside climate-sensitive industries. Sustainable rural employment can only be assured via such coordinated measures in a changing environment.

#### **5.4. Health and Food Security**

The convergence of climate change, drought, and health issues in Bangladesh's vulnerable areas is particularly concerning. As climatic unpredictability escalates, the risks of hunger, disease outbreaks, and food insecurity increase, particularly in regions where populations rely directly on climate-sensitive livelihoods. Drought circumstances result in reduced agricultural production, directly impacting family food accessibility and dietary variety. In northern areas, such as Rajshahi and Kurigram, the Food Security Monitoring System (2022) documented a 33% reduction in family food reserves during the 2021 drought. As food supplies decline and market prices escalate, impoverished people are increasingly compelled to reduce meal frequency or settle for less nutritious food alternatives.

Escalating food costs exacerbate this issue. The prices of rice, lentils, and vegetables rise significantly during droughts due to supply shortages. In the 2023 dry season, the average cost of coarse rice increased by 18% in drought-affected markets relative to national averages (Mishra et al., 2025). This inflation disproportionately affects low-income populations, diminishing their capacity to buy a nutritious diet. The nutritional ramifications are severe. The incidence of stunting and underweight among children under five in drought-affected areas routinely exceeds national norms. UNICEF (2022) reports that the stunting rate in Naogaon District is 39%, compared to the national average of 31%. Pregnant and nursing women are especially susceptible, with heightened risks of anemia, poor birth weight, and maternal death. Drought further promotes the spread of illness. Water shortages compel populations to use contaminated water sources, resulting in epidemics of diarrheal diseases, skin infections, and vector-borne illnesses, such as dengue and chikungunya. Inadequate sanitation and hygiene, compounded by restricted access to water, heighten susceptibility to infectious diseases. Moreover, severe heat intensifies respiratory ailments and cardiovascular stress, especially in the senior population.

The lack of sufficient health infrastructure in rural and drought-affected regions hinders the population's ability to address these health concerns. Most upazila health facilities are inadequately staffed and deficient in key medications and diagnostic equipment. This establishes a loop in which climate change not only induces health problems but also strains the current public health response. To ensure resilience, Bangladesh must invest in climate-resilient public health infrastructure, promote rural nutrition through food subsidy initiatives, expand social safety nets, and enhance community-level awareness and water management systems.

#### **5.5. Gendered Impacts**

The effects of climate change are not felt evenly. Women and disadvantaged groups in drought-prone regions bear disproportionate costs due to systemic disparities in resource access, decision-making, and mobility. When examining the gendered aspects of climate change, we must consider more than just exposure. We also need to consider how different individuals have varying abilities to adapt and recover. Women in areas affected by drought have had to work significantly harder. Women and girls have to go greater distances to get water since water sources are drying up. In certain places, like Gaibandha and Dinajpur, they spend up to 4–5 hours a day doing this. This cuts down on the time that might be spent on a job, school, or fun. During droughts, it is often more challenging to obtain firewood and prepare meals at home. Women, particularly those who are the head of their family, are more likely to be financially harmed. A 2023 UNDP poll found that women-led families in regions vulnerable to climate change allocate up to 30% of their income to environmental protection efforts. This is double the national

average. Their restricted access to loans, property ownership, and agricultural extension services further limits their capacity to adapt.

**Table 2.** Analysis of the Impacts of Climate Change on Livelihoods

| Sector                 | Key Impact                              | Statistical Information                                            |
|------------------------|-----------------------------------------|--------------------------------------------------------------------|
| Agriculture            | Crop failure, declining yields          | Droughts affect 47% of the area; rice yields are down by up to 30% |
| Livestock & Fisheries  | Feed/water shortages, disease outbreaks | Increased mortality, reduced fish populations due to salinity      |
| Income & Employment    | Loss of income, migration, unemployment | Youth unemployment is at 16%, with high seasonal migration rates   |
| Health & Food Security | Malnutrition, disease vulnerability     | Rising food prices, increased waterborne diseases                  |
| Gendered Impacts       | Disproportionate burden on women        | Women-headed households spend up to 30% on climate protection      |

Also, stress on people's livelihoods caused by climate change raises the likelihood of gender-based violence (GBV). Research conducted by BRAC (2022) indicated a 26% increase in domestic violence among homes affected by drought, sometimes instigated by financial strain or conflicts around resource allocation. Girls are also more likely to get married early and drop out of school because of economic hardship and conventional gender roles. Women are more affected by health problems. Malnutrition in pregnant and breastfeeding mothers puts both their health and their baby's health at risk. Women are more likely to contract waterborne infections because they are more likely to come into contact with contaminated water while performing domestic chores. Even though these problems exist, women are often excluded from local decision-making processes on how to mitigate the risk of disasters and adapt to climate change. In 2022, only 17% of disaster management committees at the union level in northern Bangladesh included women (MoDMR). To address these issues, all climate policies must incorporate gender-sensitive adaptation measures. This means making it easier for women to access climate funding, acknowledging and eliminating unpaid care work, increasing the representation of women in government, and ensuring that emergency assistance is gender-sensitive.

## 6. COMMUNITY COPING AND ADAPTATION STRATEGIES

In Bangladesh's northwest, an area prone to drought, communities are struggling to maintain their livelihoods. This is especially true in the Barind Tract, Rajshahi, Chapainawabganj, and Naogaon. They are using coping and adaptation methods that are firmly established but are becoming more challenging to use. Real-world data reveal a concerning truth: traditional techniques demonstrate considerable regional resilience, but they are losing their capacity to cope with the increasing frequency and severity of droughts. This is forcing families to resort to unsustainable methods to survive. Over 75% of farmers surveyed in the High Barind Tract are actively practicing crop diversification, a key strategy for enhancing rural livelihoods. They are strategically substituting Boro rice, which requires a lot of water, with maize, pulses (such as mung bean and chickpea), sesame, and indigenous vegetables. However, during extreme occurrences, production losses remain quite

substantial. The Bangladesh Agricultural Research Institute (BARI) found that conventional rice yields dropped by 40–60% while drought-tolerant alternatives dropped by 20–40% during severe droughts. At the same time, rainwater collection, an essential additional source of water, has significant physical challenges. For example, during the severe drought of 2023, 60% of family ponds in Chapainawabganj dried up too soon, making it impossible to irrigate essential crops for the next Aman season. This lack of resources drives people to take extreme measures, such as the 30% increase in distressed cattle sales in Naogaon during the 2022 dry period, which permanently deprives households of essential goods needed for future recovery.

Migration has evolved from a temporary solution to a fundamental, albeit risky, aspect of the economy that sustains millions of people in these arid regions. At the same time, it exacerbates existing problems and creates new ones. Every year, more than 2.5 million people move from the northwest to cities like Dhaka and Chittagong, as well as to other countries, mainly in the Gulf. The ensuing remittances provide an essential financial safety net. In 2022, the northwestern divisions received over \$1.5 billion in official remittances (Bangladesh Bank), which helped feed almost 8 million people. Nevertheless, this lifeline is fundamentally precarious; 35% of migrant families in Rajshahi experience substantial income interruptions due to external shocks, such as global recessions or pandemics, revealing their intrinsic climatic vulnerability. Moreover, the strategy is very exclusionary; landless workers and households headed by women migrate at rates 45% lower than households with more resources (BBS, 2021), which keeps them at increasing on-site risks without this important escape route, making inequality within the community worse.

Indigenous Knowledge (IK) systems and community-based institutions provide essential social and organizational frameworks for adaptation; nevertheless, their effectiveness is being systematically compromised by the extraordinary speed of climate change and institutional limitations. More than 80% of Barind farmers continue to use IK indicators to inform their decision-making, such as when to sow. For example, they look at the blossoming patterns of Shimul trees or the behavior of certain insects (IUCN Bangladesh, 2020). Local organizations, such as Samities, Water User Groups, and Gram Panchayats, are crucial for effective governance. They manage more than half of the local ponds and minor irrigation canals in sub-districts that are prone to drought, and they enforce complicated, culturally established regulations for fair water distribution when there isn't enough. However, IK's predicted accuracy is quickly deteriorating. Recent studies indicate that the accuracy of conventional forecasts has declined from 85% to just 55% (Jamal et al., 2024), making people less likely to trust this outdated knowledge. Additionally, only about 15% of these community institutions possess the technical expertise, financial resources, or political influence to implement significant changes, such as large-scale aquifer recharge, solar microgrids for irrigation, or climate-resilient infrastructure projects. This makes it much harder for them to deal with the growing dryness.

The severe inadequacies of existing autonomous coping techniques are evident in significant, measurable socio-economic and environmental deterioration, indicating a path toward systemic failure without considerable external intervention. There is a substantial amount of financial toxicity present. For example, 65% of households in the northwest that were affected by the drought had to take out high-interest loans (often from informal lenders who charge 25-50% monthly interest) to get through the dry seasons (PKSF, 2023). This usually leads to the sale of land or productive assets at a loss that can't be undone. Unsustainable groundwater extraction for agricultural purposes as a coping strategy is causing worrisome depletion, with levels in crucial Barind aquifers dropping by 1 to 3 meters per

year (Bangladesh Water Development Board, 2024). This is exacerbating the water shortage. The human cost is high, as evidenced in northwest districts such as Thakurgaon and Dinajpur, where rates of acute malnutrition are 30–40% higher than the national average (National Nutrition Services/UNICEF, 2022). This is primarily due to crop failures and a limited variety of diets. Women are disproportionately and increasingly burdened, spending 14 to 16 hours a day collecting water and managing resources during peak droughts—almost twice as much as they usually do, which seriously harms their health, well-being, and economic prospects (FAO Bangladesh, 2023). Basic infrastructure fails under pressure, with more than 60% of shallow tubewells (<100m depth) in the High Barind becoming unusable by the end of the dry season in years of severe drought (Department of Public Health Engineering, 2023). This makes it impossible for people to get water at home.

The total data, on the other hand, makes it clear that the drought corridors in Bangladesh are too much for communities to handle on their own. The growing "adaptation deficit," which is the gap between the effects of climate change and the ability to deal with them, currently pushes between 25–30% of families in these areas toward permanent loss of income or relocation every year (Miller *et al.*, 2022). Distress sales, crushing debt, ecological destruction, and forced migration are not just ways to deal with things; they are clear signs that a system is breaking down under constant climate strain and needs immediate, revolutionary help from outside sources. To close this gap, we need to change the way we think: Putting in place large-scale climate-resilient infrastructure (managed aquifer recharge, solar-powered irrigation), using anticipatory finance and social protection (forecast-based cash transfers), speeding up next-generation agricultural innovation (genetically tailored, short-duration, nutrient-dense crops that smallholders can grow), and giving local institutions the resources, technical expertise, and decision-making power they need to make adaptation investments. Without such a coordinated and large-scale effort, the remarkable yet limited resilience of these communities might be lost entirely, rendering climate adaptation a local problem into a long-term humanitarian disaster.

## 7. GOVERNMENT AND NGO INTERVENTIONS

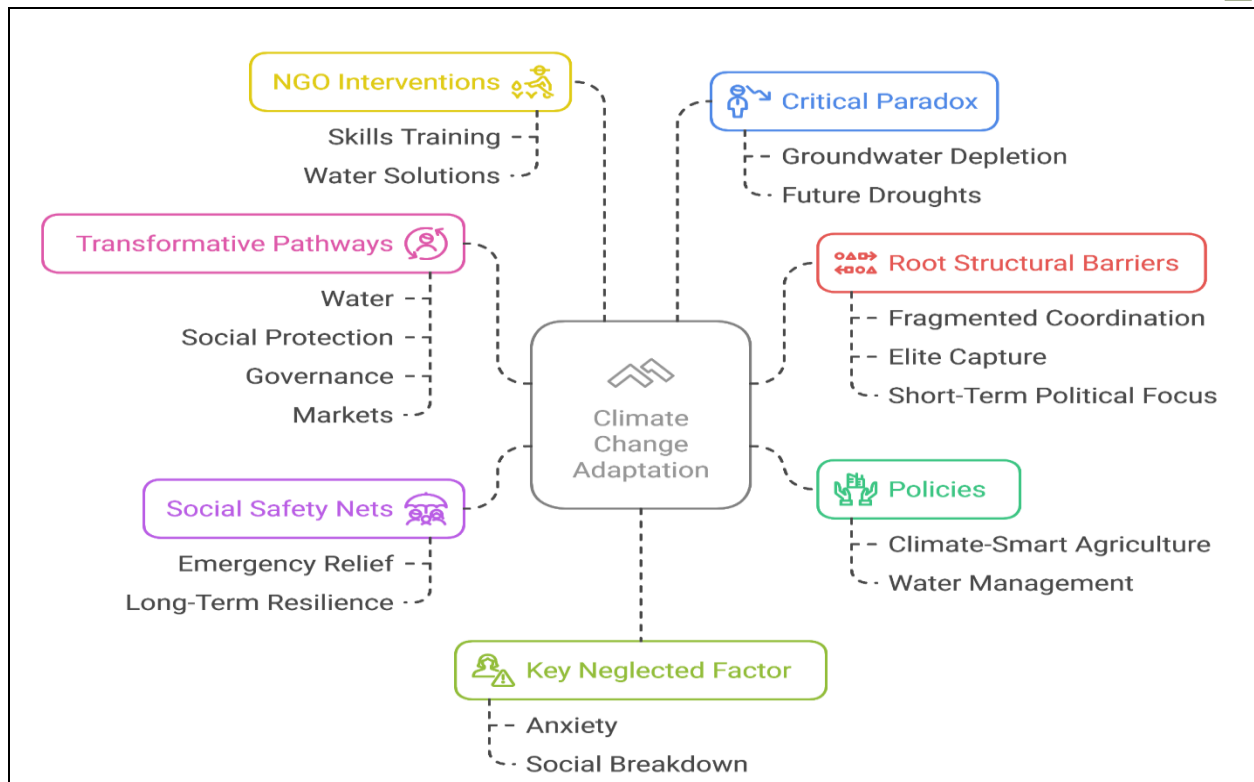
The increasing dryness in Bangladesh's northwestern regions and Barind Tract requires interventions that go beyond just providing temporary relief to address the deep-seated structural and systemic causes of vulnerability. However, the Government of Bangladesh (GoB) and NGOs are currently facing significant obstacles in their efforts, including misaligned incentives, entrenched power dynamics, and approaches that aren't transformative enough. The fundamental issue resides in the enduring disconnection between national policy objectives, exemplified by the ambitious climate resilience targets outlined in the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) (Hossain & Ali, 2024), Delta Plan 2100, and National Adaptation Plan (NAP), and the local realities concerning resource allocation, institutional capacity, and political will at the implementation level (Hasan *et al.*, 2020; Van Alphen *et al.*, 2021). These frameworks do a great job of promoting climate-smart agriculture (CSA) and integrated water resource management (IWRM). Still, they fail to support marginal farmers because agricultural extension services are severely underfunded and lack the specialized expertise in drought mitigation that they require.

Additionally, the costs of truly drought-tolerant seeds and water-saving technologies are too high, and the availability is limited. Finally, land tenure insecurity makes sharecroppers and the landless less likely to invest in soil health or water conservation infrastructure. At the same time, social safety nets (SSNs) such as the Vulnerable Group Development (VGD), Vulnerable Group Feeding (VGF), and

Test Relief (TR) programs serve as essential but flawed lifelines (Ferdous & Ullah, 2023). They are often undermined by problems like politicized beneficiary selection, delays in disbursement that happen when drought stress is at its worst, benefit levels that are too low to help people recover instead of survive, and a fundamental design flaw that treats symptoms instead of causes by providing short-term consumption support without clear links to building long-term adaptive capacity or diversifying income sources beyond agriculture that are vulnerable to climate change.

NGOs, which have a significant presence in the community and generate innovative ideas, fill essential gaps with projects such as BRAC's or Practical Action's community-based adaptation initiatives (Roborgh et al., 2024), skill development programs for alternative livelihoods, and localized water management solutions, including pond sand filters, rainwater harvesting systems, and promoting efficient irrigation practices (Ssekyanzi et al., 2024). However, their impact is often limited by project-based funding cycles that lead to unsustainable "islands of success," inadequate market analysis and support for newly trained entrepreneurs that lead to saturated local markets for low-skill trades, and an insufficient focus on intersecting vulnerabilities that allow elite capture of resources or sidelines the specific needs of women, ethnic minorities, and the ultra-poor. The groundwater depletion paradox creates a particularly harmful unintended consequence. Well-meaning efforts to improve irrigation access through shallow tube wells (often supported by NGOs) or government-deep tube wells, along with energy subsidies, help people cope with drought in the short term. However, these efforts also accelerate the unsustainable extraction of aquifers that are already running dry. This creates a devastating feedback loop that exacerbates water scarcity in the long term and renders people more vulnerable in the future. This is a clear example of how interventions can solve immediate problems while creating new ones. Moreover, the widespread disregard for the significant psychosocial impact of chronic drought stress—manifesting as anxiety, depression, and diminished social cohesion due to the breakdown of traditional support networks in the face of resource scarcity—constitutes a significant oversight in both governmental and non-governmental organization initiatives, which predominantly emphasize material resources despite indications that psychological distress critically impairs communities' ability to participate in adaptation efforts actively.

There are bigger problems that are harder to fix, caused by errors in political economics and governance that lie behind these operational issues. Local elites often skew the targeting of beneficiaries and the allocation of resources in both SSNs and NGO projects, systematically leaving out the most marginalized. Short-term political goals always take precedence over long-term investments in resilience, such as watershed management or aquifer recharge. Finally, fragmented institutional mandates and a lack of strong coordination platforms between key GoB agencies (such as the Department of Agricultural Extension, the Bangladesh Water Development Board, and the Department of Disaster Management) and NGOs lead to unnecessary duplication of efforts, coverage gaps, and a disastrous misallocation of scarce resources in the face of rising climate threats. Market failures exacerbate the problem. For example, promoting alternative livelihoods is ineffective if rural value chains that can withstand climate change, accessible finance beyond microcredit (which can become a debt trap during droughts), and functional market linkages don't develop simultaneously.



**Figure 3.** Climate Change Adaptation Challenges and Solutions

Additionally, the absence of enforceable groundwater regulations allows unsustainable extraction to continue, thereby undermining other efforts to enhance water security. To make revolutionary change happen, a fundamental reconfiguration is needed: To stop elite capture, we need to combine pro-poor land access strategies with strong community monitoring; to make adaptation and relief frameworks more effective, we need to include mental health and psychosocial support (MHPSS); to make groundwater governance more sustainable, we need to shift subsidies toward water-saving technologies and enforce managed aquifer recharge and abstraction limits; to make SSNs into adaptive social protection systems, we need to proactively scale them up with early warnings and link them to public works that build resilience; to give local Union Parishads real resources and authority for planning that fits their needs; and to encourage real knowledge co-creation between farmers, researchers, and policymakers to enable quick, evidence-based adaptation. To truly close the significant gap between what policymakers say and what people experience when they are vulnerable to drought, we need to move beyond small, project-based solutions that address power imbalances, prioritize sustainable resource governance, and build rural economies that are diverse and resilient to climate change. The climate crisis is worsening, so we can't rely solely on temporary fixes.

## 8. POLICY RECOMMENDATIONS

Bangladesh is at a hydrological tipping point: the rapid depletion of aquifers, the collapse of rain-fed agriculture, and the forced migration of people across its drought-prone corridors all require a mobilization of policy, resources, and political will on a scale not seen since World War II (Nagarajan, 2009). The time left to prevent an irreversible socio-ecological catastrophe is running out faster than expected. The groundwater levels in the Barind and High Barind areas are dropping by more than 1

meter every year. This puts the livelihoods of 8.4 million people who rely on farming and pastoral systems that are already at their limits at risk (McDermott et al., 2010). This is not a menace that is far away. Approximately 40% of small irrigation canals are currently broken, making it difficult to access water during crucial planting periods. The policy must go beyond talk and put into action the following non-negotiable requirements:

First, break up the hydrological suicide pact that water-intensive Boro rice farming keeps going. The policy must make it illegal to extract groundwater immediately and set volumetric prices for aquifers that are critically overdrawn. It must also redirect 50% of agricultural subsidies toward the large-scale implementation of proven alternatives, such as drought-tolerant crops (BRRI Dhan 84, maize, and pulses), drip/sprinkler irrigation (which reduces usage by 30-60%), and decentralized rainwater harvesting systems (Uddin et al., 2022). If this doesn't happen, important aquifers will run out of water in 15 to 20 years, which is too late to change. Second, eliminate bureaucratic early warning failures and replace them with intelligence networks managed by the community. More than 70% of farmers in areas where drought is most severe still don't get useful predictions, which leads to huge crop losses. Invest in AI-powered hyper-local forecasting right now (combining automated sensors with local indications) and make it a law that mobile networks must send out vernacular alerts in real-time. Empower Community-Based Organizations as first responders; pilots show these cuts losses by 20–25%. Third, implement a national strategy to transform people's livelihoods, with a focus on the most vulnerable groups. When droughts struck, women, landless workers, and young people were often left almost wholly cut off from the economy. Launch a National Climate Workforce Initiative to educate 1.2 million individuals about solar technologies, internet services, and aquaculture practices that can withstand droughts. Give these groups priority by providing them with stipends and assistance with childcare. Establish Climate Resilience Economic Zones in nodal towns (Bogura, Rajshahi) to promote job creation outside of farming in green technology, manufacturing, and agro-processing (Mahedi et al., 2025). To fund this, utilize the \$500 million Livelihood Transformation Fund, which provides low-interest loans and venture capital. Fourth, upgrade the infrastructure and institutions for a dry future. Broken canals, fractured reservoirs, and ineffective administration exacerbate every drought. Ensure that all water and transportation infrastructure meet obligatory climate-proofing requirements and eliminate separate catastrophe committees by establishing unified District Resilience Authorities with delegated finances and community oversight. Most importantly, automate social protection triggers to increase cash transfers and start insurance payments within 48 hours of declaring a drought. This will stop people from selling their property in despair. Fifth, provide control directly to the people who are on the front lines of the drought. Right now, marginalized groups have less than 10% of the say in how adaptation money is spent, yet they are the ones who are most affected by it. Make community co-governance a requirement by law and set aside 40% of local adaptation expenditures for projects planned, run, and monitored by grassroots groups. Make indigenous knowledge a real science by incorporating local phenological markers into national forecasting systems. The math of survival is straightforward: if you don't allocate 1.2% of GDP (\$4.3 billion) to this integrated structure every year, the system will start to fall apart. This is not just a budget item; it is a moral obligation to the people on the front lines of the climate disaster. Every step that is put off exacerbates hydrological bankruptcy. Every policy that is broken gives the desert more land. The drought corridors in Bangladesh have sent their last warning; history will decide what to do next.

## 9. CONCLUSION

This thorough analysis highlights the complex and escalating impacts of climate change, particularly drought, on the livelihoods of rural residents in Bangladesh's drought-affected regions. The evidence from quantitative assessments and qualitative insights confirms that climate-induced drought is a chronic, escalating threat multiplier that undermines agricultural productivity, water security, income stability, food access, and social cohesion. The northeastern Barind Tract depicts a region of significant vulnerability, where environmental degradation intersects with systematic socio-economic disadvantage, resulting in a precarious cycle of livelihood deterioration.

The research reveals that while communities have traditionally responded to environmental challenges through indigenous knowledge systems, crop diversification, seasonal migration, and water conservation techniques, these self-reliant coping mechanisms are becoming increasingly inadequate in the context of escalating climatic extremes. The adaptive ability of rural families is consistently being surpassed by the magnitude and velocity of hydrological and ecological stress, as evidenced by increasing rates of starvation, distress migration, debt, and social inequality, which underscore the human cost of climate inaction. The unequal burden should be particularly noted since women, the landless, and ethnic minorities encounter persistent obstacles to resources, services, and decision-making within both official and informal institutions.

Despite the existence of government regulations, social protection programs, and donor-funded NGO efforts, prevailing institutional and policy responses remain fragmented, underfunded, and insufficiently tailored to the actual circumstances of drought-affected communities. While short-term relief strategies are essential, they are inadequate for fostering long-term resilience. The statistics require a radical shift from reactive, project-based approaches to proactive, systems-oriented adaptation that integrates climate-resilient infrastructure, inclusive governance, and targeted economic transition strategies. To bridge the expanding adaptation gap, Bangladesh must reconfigure its development strategy in drought-affected regions. This entails restructuring agricultural policy to emphasize low-water crops and sustainable irrigation methods, transforming social safety nets into proactive protection systems, investing in climate-resilient employment opportunities for at-risk communities, and empowering local institutions with the necessary technical, financial, and political authority to spearhead adaptation initiatives. The urgency is evident: without expanded, cohesive, and equitable action, the socio-ecological structure of Bangladesh's drought-prone areas faces the threat of permanent disintegration.

This review's conclusions emphasize that climate change adaptation is both an environmental need and a developmental and moral obligation. The resilience of Bangladesh's most vulnerable populations will hinge on our collective capacity to synchronize research, policy, and local initiatives toward a common objective of achieving sustainable, inclusive, and climate-resilient livelihoods.

## CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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