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Original Research Article

Impacts of Drought on Food Security in Bangladesh

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Abstract: Drought has emerged as a critical threat to food security in Bangladesh, a country heavily reliant on agriculture for economic stability and livelihoods. This study explores the causes, impacts, and vulnerabilities associated with drought, focusing on its effects on agricultural productivity and food availability. Drought in Bangladesh is driven by inadequate rainfall, regional disparities in precipitation, and the escalating effects of climate change, including rising temperatures and altered rainfall patterns. These factors have led to significant crop losses, particularly in staple foods like rice, wheat, and potatoes, resulting in higher food prices, reduced dietary diversity, and increased malnutrition, especially among vulnerable populations such as women and children. The northwestern and southwestern regions of Bangladesh are particularly susceptible to drought, with smallholder farmers bearing the brunt of its impacts due to limited resources for adaptation. Long-term consequences, including soil degradation, declining groundwater levels, and reduced agricultural resilience, further exacerbate food insecurity. While the government and international organizations have implemented measures such as drought-resistant crops, improved water management, and early warning systems, challenges like inadequate funding and infrastructure limit their effectiveness. To address these challenges, this study emphasizes the need for a holistic approach that integrates climate adaptation, disaster risk reduction, and social protection measures. Investments in resilient crop varieties, affordable irrigation technologies, and community-based initiatives like rainwater harvesting are essential to enhance agricultural resilience. Strengthening social safety nets and supporting vulnerable populations during periods of food scarcity are also critical. By adopting a comprehensive strategy, Bangladesh can mitigate the impacts of drought, build resilience in its agricultural systems, and ensure long-term food security in the face of a changing climate. This study provides valuable insights for policymakers and stakeholders working to address the complex interplay between drought, agriculture, and food security in drought-prone regions.

Keywords: Drought, Food Security, Agricultural Productivity, Climate Change, Bangladesh.

INTRODUCTION

Droughts in March and April inhibit timely land preparation and tillage, delaying planting of crops during monsoon season (Paul, 1998). Increased climate variability means additional threats to drought-prone environments and is considered a major crop production risk factor. It forces farmers to depend on low-input and low-risk technologies, leaving them incapable to adopt new technologies that would allow them to get maximum gains during favorable seasons and less able to recover quickly after disasters. Increasing climate risks

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undermine development and poverty reduction efforts in drought-prone areas. Future climate variability and change will aggravate these problems even more in drought-prone environments. Drought is the most complex and least understood of all natural disasters in Bangladesh. It is a natural disaster which causes the greatest loss in the world and has the largest impacts among all the natural disasters (Chunqiang, 2010). It is one of the major causes of crop loss worldwide, reducing average yields for most crop production by more than 50% (Islam *et al*., 2014; Wang *et al*., 2003). In recent years, concern has grown worldwide that droughts may be increasing in frequency, severity and duration given changing climatic conditions and documented increases in extreme climate events (Sivakumar *et al*., 2014; Peterson *et al*., 2013) though it's characteristics will vary from one climate regime to another (Iglesias *et al*., 2012). It is a recurring natural hazard (Wilhite *et al*., 2005) that can cause widespread damage to agricultural production. Additionally, droughts have a multidimensional effect on human being in terms of several socio-economic parameters like human health, scarcity of labor, disease prevalence, etc. (Adger, 1999). It triggers to food insecure and elevate the poverty level through direct effects on crop production (Zimmerman *et al*., 2003). Like other countries of the world, Bangladesh also faces the adverse impact of drought owing to its geographical position.

Drought, a slow-onset natural disaster, has emerged as a critical threat to food security in Bangladesh, a country heavily reliant on agriculture for both economic stability and sustenance. With over 70% of its population engaged in agricultural activities, the nation is particularly vulnerable to climatic extremes, including droughts, which disrupt crop production, reduce food availability, and exacerbate economic instability (Rahman *et al*., 2020). The interplay between climate change and drought has intensified in recent decades, leading to more frequent and severe dry spells that threaten the livelihoods of millions, particularly in the northwestern and southwestern regions of Bangladesh (Alam *et al*., 2017). Bangladesh's geographical and climatic characteristics make it highly susceptible to drought. The country experiences three primary cropping seasons: Kharif-1 (mid-May to mid-June), Kharif-2 (mid-June to mid-October), and Rabi (mid-October to mid-May). Droughts during these seasons, particularly in the Rabi and Kharif-1 periods, have been shown to significantly reduce agricultural output, with up to 90% of crop losses occurring in drought-affected areas (Habiba *et al*., 2013). This has dire consequences for food security, as agriculture contributes approximately 13% of the country's GDP and employs a significant portion of the rural population (World Bank, 2021). The impact of drought on food security is multifaceted, affecting not only food availability but also access, utilization, and stability. Reduced crop yields lead to higher food prices, making it difficult for low-income households to afford basic necessities (Hossain *et al*., 2019). Furthermore, droughts often force farmers to abandon traditional crops, such as rice and wheat, in favor of less water-intensive alternatives, which may not provide the same nutritional value or economic return (Shahid & Behrawan, 2008). This shift can exacerbate malnutrition and poverty, particularly among vulnerable populations such as women and children. In addition to its immediate effects, drought has long-term implications for food security in Bangladesh. Repeated exposure to drought conditions can deplete soil fertility, reduce groundwater levels, and diminish the resilience of agricultural systems, making recovery increasingly difficult (Karim & Mimura, 2008). Climate change projections suggest that the frequency and intensity of droughts in Bangladesh are likely to increase, further compounding these challenges (IPCC, 2021). Addressing the impact of drought on food security requires a multifaceted approach, including improved water management, drought-resistant crop varieties, and social safety nets to support affected communities. The socio-economic impacts of drought in Bangladesh are profound, particularly for rural communities that depend on agriculture for their livelihoods. Droughts not only reduce crop yields but also disrupt the entire agricultural value chain, affecting food processing, distribution, and market accessibility. For instance, during the 2017 drought in the Barind region, farmers reported losses of up to 60% of their rice production, leading to widespread food shortages and increased reliance on external aid (Bhuiyan *et al*., 2019). Such disruptions disproportionately affect smallholder farmers, who lack the resources to invest in irrigation or alternative livelihoods, pushing them further into poverty and food insecurity. Moreover, drought-induced water scarcity exacerbates existing challenges in Bangladesh's agricultural sector. Groundwater, a critical resource for irrigation, is increasingly depleted due to over-extraction and reduced recharge during dry spells. This has led to a decline in water tables, particularly in the northwestern regions, where groundwater levels have fallen by an average of 1.5 meters per year over the past decade (Shahid & Hazarika, 2010). As a result, farmers are forced to rely on expensive and unsustainable irrigation methods, further straining their financial resources and reducing their capacity to cope with future droughts.

The nutritional consequences of drought are equally concerning. Reduced agricultural productivity often leads to a decline in dietary diversity, as households are forced to prioritize staple crops over more nutritious options such as fruits, vegetables, and livestock products. This shift can result in micronutrient deficiencies, particularly among children and pregnant women, who are already vulnerable to malnutrition (Ahmed *et al*., 2019). For example, a study conducted in drought-affected areas of Rajshahi found that the prevalence of stunting among children under five increased by 15% during periods of severe drought (Haque *et al*., 2020). In response to these challenges, the government of Bangladesh, in collaboration with international organizations, has implemented various adaptation and mitigation strategies. These include the promotion of drought-resistant crop varieties, improved water management practices, and the establishment of early warning systems to alert farmers of impending dry spells (Islam *et al*., 2021). However, the effectiveness of these measures is often limited by inadequate funding, poor infrastructure, and a lack of awareness among rural communities. Community-based approaches have shown promise in enhancing resilience to drought. For instance, the introduction of community-managed rainwater harvesting systems in the drought-prone areas of Chapai Nawabganj has helped farmers sustain crop production during dry seasons (Rahman *et al*., 2018). Similarly, farmer cooperatives have played a crucial role in disseminating knowledge about climate-smart agricultural practices, such as crop rotation and intercropping, which can improve soil health and reduce water consumption (Karim *et al*., 2020). Despite these efforts, the long-term sustainability of food security in Bangladesh remains uncertain. Climate models predict that the frequency and intensity of droughts will continue to rise, posing significant challenges for agricultural productivity and food systems (IPCC, 2021). To address these challenges, a holistic approach is needed, one that integrates climate adaptation, disaster risk reduction, and social protection measures. This includes investing in research and development to create more resilient crop varieties, expanding access to affordable irrigation technologies, and strengthening social safety nets to support vulnerable populations during periods of food scarcity. This study is much more important because this paper aims to provide background information for a discussion on drought from the climate change perspective which affects the food security in Bangladesh. All dimensions of food, water and natural capital security are affected by climate extremes and variability and likely to be affected by drought (Parry *et al*., 2007). While drought is commonly presented as a gradual shift in climatic trends, its impacts will be most strongly felt by resource insecure populations through changes in the distribution, nature and magnitude of extreme events as these affect crops, disease outbreaks and soil and water quality (Field *et al*., 2012). In Bangladesh, agriculture is one of the main economic drivers (Chowdhury *et al*., 2013). Despite its contribution to the overall economy, this sector is challenged by multiple factors predominantly climate-related disasters like drought. Drought is a normal, recurrent climate feature (Keshavarz *et al*., 2010) which, if badly managed can lead to a loss of crop production, food shortages and for many, starvation (Paul, 1998). Particularly over the last decade, unsustainable development and improper use of natural resources have increased vulnerability to drought in some parts of Bangladesh.

The objective of this study is to explore the concept of food security, and the causes of drought, and assess its impacts on agricultural productivity and overall food availability.

2. REVIEW LITERATURE

2.1. Concept of Drought

Drought is a prolonged period of inadequate water supply, marked by extended deficiencies in precipitation. Unlike abrupt disasters, drought develops gradually, making it challenging to pinpoint its onset and end (Achite *et al.*, 2022). It impacts agriculture, ecosystems, and human livelihoods by creating severe water shortages. This section outlines the definitions, types, causes, and historical significance of drought, reflecting its complex nature and widespread effects.

2.1.1 Definitions

Many people believe that drought is the most complicated but least known of all-natural hazards, affecting more people than any other threat. It is distinct from other natural disasters such as hurricanes, tropical cyclones, and earthquakes, which occur over finite time periods and cause visible damage (Wilhite, 2021). The phenomenon is difficult to research due to its slow onset and inability to discern when it began and when it ended (Abuzar *et al.*, 2017). Below are some of the definitions of drought as obtained from different drought research.

A drought is an extended period of months or years when a region notes a deficiency in its water supply, whether surface or underground water especially due to existence of a precipitation level that is below average (Achite *et al.*, 2022). Bayissa *et al.*, (2018) define drought as 'an abnormally dry condition that persists for a long period of time'. However, drought happens with different frequency in practically every part of the globe, in all sorts of economic systems, and in both developed and developing countries, therefore the methodologies used to characterize it must consider geographical and ideological distinctions. As a result, in areas where precipitation is seasonal and lengthy intervals without rain are common, such a definition is unrealistic.

Drought can also broadly be defined as a long-term average condition of the balance between precipitation and evapotranspiration in a particular area, which also depends on the timely onset of monsoon as well as its potency (Wilhite *et al.*, 1987). On the other hand, drought refers to a deficiency of precipitation over an extended period, resulting in a water shortage that causes extensive damage to crops, living as well as non-living things (Bera *et al.*, 2018). Again, drought refers to lack of rainfall as great as so long continued to affect injuriously the plant and animal life of a place and to deplete water supplies both for domestic purposes and the operation of power plants especially in those regions where rainfall is normally sufficient for such purposes (Dracup *et al.*, 1980).

The UNDP (2008) define drought as 'the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems.' However, Drought should not be viewed as merely a physical or natural phenomenon. Rather, drought is the result of an interplay between a natural event and the demand placed on water supply by human-use systems (Wilhite *et al.,* 2000) that is to say, in reality, drought has both a natural and social component.

All the above definitions have one thing in common 'water deficit over an extended period of time'. Wilhite *et al.,* (1987) concluded that definitions of drought should reflect a regional bias since the water supply is largely a function of the climatic regime. Therefore, drought refers to a deficiency of water over an extended period of time with high impacts on the environment and agriculture in a given region. The present study will adopt this prolonged water deficiency and its impact on the environment and ultimately the adverse impact on livelihood of farm people.

Faranda *et al*., (2023) define drought as a prolonged period of water scarcity, exacerbated by climate change.

Colombo *et al*., (2023) define a snow drought as a significant reduction in snowpack, which can lead to hydrological droughts.

Tripathy and Mishra (2023) describe compound droughts as droughts that coincide with heatwaves, amplifying the impact.

Liu *et al*., (2023) define extreme drought as an event characterized by rapid onset, high intensity, and large affected areas.

Hao, *et al.*, (2022) describe drought as "a period of prolonged dryness due to significantly below-average precipitation, leading to substantial water deficits and adverse impacts on agricultural productivity, water resources, and socio-economic stability"

Mishra *et al.,* (2021) define drought as "a prolonged period characterized by insufficient precipitation relative to the norm, resulting in reduced water availability that adversely affects agriculture, ecosystems, and socio-economic conditions"

Zhu, *et al.,* (2020) define drought as "a persistent deficit in precipitation leading to decreased water availability and severe consequences for agriculture, water management, and ecological systems, often necessitating adaptive management strategies"

Spinoni *et al.,* (2019) define drought as "a period of sustained below-average rainfall that results in significant water deficits, leading to crop failures, economic losses, and adverse impacts on both natural and human systems, often requiring the implementation of drought resilience measures."

Petersen and Bindi (2018) define drought as "a prolonged reduction in water availability due to below-average rainfall that severely impacts agricultural productivity, water supply, and food security, with particular challenges observed in regions with limited water resources."

Mukherjee *et al.,* (2018) define drought as "a persistent period of anomalously dry conditions that cause significant water scarcity, stress on natural ecosystems, and challenges for agricultural productivity and human livelihoods across various regions."

Naumann *et al.,* (2018) define drought as "a prolonged period of dry conditions caused by below-average precipitation, leading to water deficits that impact agriculture, energy production, and water management practices, often requiring coordinated drought risk management strategies."

Liu *et al.,* (2018) describe drought as "a deficit in water availability due to sustained dry conditions over extended periods, leading to critical impacts on agricultural systems, natural ecosystems, and the socio-economic well-being of affected populations."

Zhao *et al.,* (2017) describe drought as "a meteorological anomaly where precipitation levels fall significantly below the normal range over an extended duration, leading to widespread water shortages and adverse effects on human, agricultural, and natural systems."

Damania *et al.,* (2017) define drought as "a protracted dry spell that leads to significant disruptions in water availability, agricultural productivity, and human livelihoods, particularly in vulnerable regions, necessitating the adoption of adaptive water management strategies."

Van Loon *et al.,* (2016) describe drought as "a prolonged period of lower-than-normal water availability that affects not only natural ecosystems but also human socio-economic activities, with implications for water management and conservation practices."

Mekonnen and Hoekstra (2016) describe drought as "a prolonged period of reduced precipitation that affects the availability of water for agriculture, hydropower, and domestic uses, with increasing challenges in regions already experiencing water stress."

Hao and Singh (2015) define drought as "an extended period characterized by significantly below-average precipitation, resulting in a reduction in water availability and wide-ranging impacts on agriculture, hydrological systems, and socio-economic conditions."

Kingston *et al.*, (2015) define drought as "a natural phenomenon characterized by prolonged periods of insufficient precipitation, causing significant reductions in water availability and severe consequences for agriculture, water management, and regional economies, particularly under the influence of climate change."

Vicente-Serrano *et al.*, (2014) define drought as "a reduction in water availability resulting from a sustained period of below-normal precipitation, with severe impacts across multiple sectors, including agriculture, energy production, and ecological systems, often influenced by regional climate variability."

Dutra *et al.*, (2014) define drought as "a prolonged deficiency in precipitation that results in significant deficits in soil moisture, reduced streamflow, and lowered reservoir levels, often monitored through a combination of meteorological, hydrological, and remote sensing data."

Taylor *et al.*, (2013) describe drought as "a prolonged period of below-average rainfall that leads to water shortages, crop failures, and widespread environmental, economic, and social consequences, with increasing frequency and intensity due to global climate change."

Van Loon and Van Lanen (2013) state that drought is "a natural event arising from prolonged periods of below-average precipitation, leading to reduced water storage, diminished flow in rivers and groundwater systems, and cascading impacts on ecosystems and human activities."

Tallaksen and Van Lanen (2012) describe drought as "a natural hazard characterized by below-average water availability that can persist for months or even years, leading to substantial environmental, social, and economic consequences across various sectors."

Sheffield and Wood (2012) define drought as "a prolonged deficit in moisture supply relative to what is typically expected, resulting in disruptions in normal water use, reductions in crop productivity, and potential threats to water resources."

Svoboda *et al.*, (2012) describe drought as "a deficiency in precipitation over a prolonged period that leads to significant water shortages, negatively affecting agricultural production, water supply, and natural ecosystems, and often requiring the implementation of drought monitoring and mitigation strategies."

Mishra and Singh (2011) define drought as "a natural hazard that occurs due to a sustained lack of precipitation over a long period, leading to significant reductions in water resources, agricultural output, and the well-being of communities dependent on water availability."

Dai (2011) defines drought as "a period of abnormally dry weather that persists long enough to cause serious hydrological imbalances, leading to significant reductions in water supplies and adverse impacts on ecosystems, agriculture, and human activities."

Vicente *et al.*, (2010) describe drought as "a prolonged period of abnormal moisture deficit that severely impacts water resources, agricultural productivity, and ecological balance, often requiring substantial management interventions

2.1.2 The types of drought

Droughts are grouped into four main types: agricultural drought, meteorological drought, hydrological drought, and socio-economic drought. They are defined and discussed below according to the disciplinary perspectives (Heim, 2002).

2.1.2.1 Agricultural drought

Agricultural drought is measured in terms of deficiency in soil moisture, rainfall, ground water and reduction in crop yield (Abuzar *et al.*, 2017). Drought in agriculture refers to an imbalance in the water content of the soil during the growing season which is affected by other factors such as crop water requirements, water-holding capacity and evaporation rate is largely dependent on rainfall amount and distribution. Since soil moisture supplies are often quickly depleted, agriculture is typically the first economic sector to be affected by drought particularly if the time of moisture shortage is associated with high temperatures and windy conditions (Wilhite, 2021). The Soil Moisture Percentile (SMP), Normalized Difference Vegetation Index (NDVI), Crop Moisture Index (CMI), Temperature Condition Index (TCI), Vegetation Condition Index (VCI), Vegetation Health Index (VHI), Normalized Soil Moisture (NSM), and Standardized Soil Moisture Index (SSI) are some of the most commonly used agricultural drought indicators. Agricultural drought usually precedes meteorological drought (Hao *et al.*, 2018). However, in 2020, Bangladesh experienced significant variations in drought conditions. Certain regions, particularly in the northwestern parts of the country, were marked as experiencing "Severely Drought" to "Extremely Drought" conditions. These areas faced substantial agricultural challenges, including reduced crop yields, water scarcity, and increased stress on irrigation systems. The severe drought conditions likely affected staple crops such as rice, which is crucial for food security in Bangladesh. Areas categorized under "Moderately Drought" were also prevalent, indicating that while these regions faced drought conditions, the impact was less severe compared to the hardest-hit areas. Farmers in these regions may have encountered difficulties in maintaining crop productivity but could potentially manage with adaptive agricultural practices and water conservation measures. Regions labeled as "Normal Drought" or "No Drought" were relatively better off, with adequate water supply to support agricultural activities. These areas likely maintained stable crop production and had sufficient water resources for irrigation and other needs.

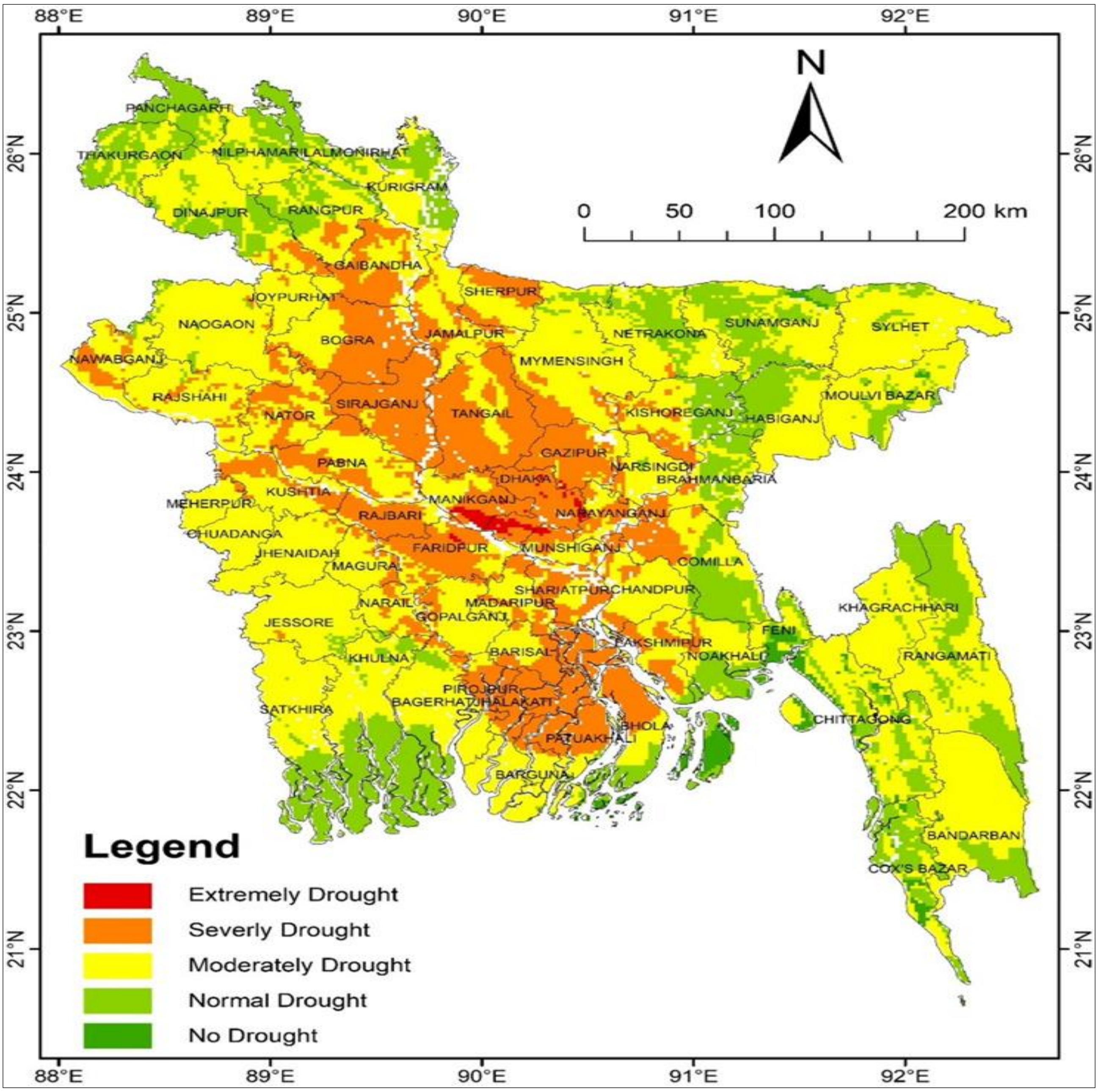

Figure 1.1: Agricultural drought Map
Source: Aziz, M. A *et al*., 2022

2.1.2.2 Meteorological drought

Meteorological drought is typically defined by a deficiency in precipitation over a specific time period. This definition can vary regionally, as atmospheric conditions responsible for precipitation deficits depend on the local climate (Wilhite, 2021). Several indices are used to describe meteorological drought, including the Standard Precipitation Index (SPI), Standard Precipitation Evapotranspiration Index (SPEI), Percentage of Normal Rainfall, and the Palmer Drought Severity Index (PDSI). Each of these indices helps in assessing the severity and spatial extent of drought, with over 100 indices available for use globally (Zargar *et al*., 2011). These indices vary in their sensitivity to climatic conditions, making them particularly useful in drought monitoring and preparedness, especially under changing climate conditions (Mukherjee *et al*., 2018).

2.1.2.3 Hydrological drought

Hydrological drought refers to a duration of insufficient surface and subsurface water supplies for existing water uses of a given water resources management system. For hydrological drought analysis, streamflow data has been commonly used. Geology is one of the key factors affecting hydrology, according to regression studies linking droughts in stream flow to catchment properties (Belal *et al.*, 2014). Hydrological drought occurs when there is insufficient surface and subsurface water to meet the existing demands of a water management system. Streamflow data is a common measure for hydrological drought analysis, and geology plays a key role in influencing hydrology, as demonstrated by studies linking streamflow drought to catchment properties (Singh *et al*., 2017). This type of drought is typically characterized by a significant reduction in surface runoff or the depletion of groundwater sources (Jasechko *et al*., 2017). Consequently, water availability for irrigation, hydroelectric power generation, and household and industrial uses diminishes (Cuartas *et al*., 2022).

2.1.2.4 Socio-economic drought

Socio-economic drought is the final phase of drought that occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply (Belal *et al.,* 2014). Socio-economic drought occurs when the demand for an economic good exceeds supply due to a weather-related water shortfall. It represents the impact of drought on human activities, including both direct and indirect effects. This type of drought is closely tied to meteorological anomalies, where extreme events disrupt the normal balance of supply and demand considered by regulatory and economic bodies (Shi *et al*., 2018). Socio-economic droughts manifest in various sectors such as agriculture, hydropower, and water supply, often leading to significant economic losses and reduced productivity (Freire-González *et al*., 2017). These events are influenced by climatic variability and human-induced changes such as land-use patterns and water management practices (Zhao *et al*., 2019).

2.1.3 History of drought in Bangladesh

This overview examines significant drought years in Bangladesh, detailing their impacts on agriculture, water resources, and regional conditions. It also provides insights into major droughts and their severe consequences on the environment and economy.

Table 1.1: Significant drought years in Bangladesh

Year	**Description**	**Authors**
1971	Severe drought exacerbated by the Bangladesh Liberation War	Hossain, 2003
1980	Significant agricultural disruption	Mian & Hossain, 1984
1982-1983	Severe drought impacting agriculture and economy	Islam & Karim, 1985
1994	Notable drought conditions affecting crop yields and water availability	Rahman & Khan, 1995
1997	Severe drought affecting large areas and leading to reduced agricultural output	Chowdhury, 1998
2000	Significant drought challenges in agriculture and water resources	Khan & Chowdhury, 2001
2009	Notable reductions in agricultural productivity and water shortages	Mollah, 2010
2014	Drought impacting various regions, agriculture, and water availability	Haque & Ahmed, 2015
2015	Severe drought impacting agricultural production and water resources	Islam, 2016
2019	Significant agricultural and economic impacts	Sarker & Rahman, 2020

Source: FAO (2007); Banglapedia (2018)

From 1971 to 2019, Bangladesh faced multiple severe droughts that significantly impacted agriculture and water resources. Major events include the 1982-1983 drought, which severely disrupted agricultural production and the economy, and the 1997 drought, which led to extensive reductions in crop yields. The 2000 drought presented significant challenges to both agriculture and water management. More recently, droughts in 2014 and 2015 exacerbated issues in agricultural productivity and water availability, illustrating the ongoing vulnerability of the region to such climatic extremes.

Table 1.2: Major droughts in Bangladesh with their impacts

Year	**Impacts of Drought**
1973	One of the most severe droughts of the last century, affecting the north-western part of Bangladesh in 1974.
1975	Affected almost half of the total population and covered around 47% of the total area of Bangladesh.
1979	Affected around 42% of arable land and 45% of the total population. Significant reduction in rice production (approx. 2 million tons) and widespread crop loss.
1981–1982	Affected monsoon crop production in these two consecutive years.
1984	Caused a significant reduction in rice production, approximately 52,000 metric tons.

1989	Most rivers in north-west Bangladesh dried up; dust storms triggered due to dry topsoil in districts like Naogaon, Nilphamari, and Thakurgaon.
1994–1995	The most persistent drought of recent times, significantly damaging rice and jute production in north-west Bangladesh. Consequences extended into 1995–1996.
2000	Affected Rangpur division of northern Bangladesh with a significant decrease in rice and wheat production.
2006	Around 25–30% reduction in Aman rice production observed in the north-western part of Bangladesh.

Source: FAO (2007); Banglapedia (2018)

3. METHODOLOGY

This paper is based on secondary data. To fulfill the objectives of this study, a variety of published and unpublished research articles, papers, books, and the latest reports by international organizations such as FAO and UNDP, on the Impact of Drought on Food Security were collected from various databases, Google Scholar, and other reliable sources. The searches included a combination of keywords and phrases such as "Impacts of drought on food security in Bangladesh," "Drought in Bangladesh," "Climate change impacts on Bangladesh," "Sustainable food systems in Bangladesh," and "Challenges and strategies for food security in drought-prone regions." The review process was conducted from March 2024 to February 2024, focusing on sources published and unpublished papers were identified during the search. After applying selection criteria—such as topic suitability, recency, relevance, and data quality. The criteria prioritized studies that provided detailed insights into the socio-economic and agricultural impacts of drought in Bangladesh, as well as causes and agricultural crop production. The review compiled and synthesized evidence using figures and tables sourced from reliable studies. These data visualizations were supplemented by calculations and analyses conducted by the authors. Themes such as drought-induced agricultural challenges, socio-economic vulnerabilities, and potential solutions were organized to provide a comprehensive understanding of drought's impact on food security in Bangladesh.

4. CHAPTER III REVIEW OF FINDINGS

4.1 Concept of Food Security

The concept of food security is a fundamental aspect of global development and human well-being. According to the Food and Agriculture Organization (FAO), food security exists when "all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). This definition, established during the 1996 World Food Summit, highlights the multidimensional nature of food security, which encompasses four key dimensions: availability, access, utilization, and stability of food resources (FAO, 2008). Availability refers to the physical supply of food, which is influenced by agricultural production, distribution networks, and trade policies. It ensures that sufficient quantities of food are consistently produced and supplied to meet the needs of a population (FAO, 2008). Access, on the other hand, focuses on the ability of individuals and households to obtain food. This dimension is shaped by economic factors such as income levels, food prices, and social structures, as well as physical proximity to food sources (Barrett, 2010). Without adequate access, even abundant food supplies may fail to alleviate hunger and malnutrition. Utilization emphasizes the biological use of food, ensuring that individuals consume a diet that meets their nutritional requirements. This dimension considers factors such as food safety, dietary diversity, and health status, as well as knowledge and practices related to food preparation and storage (FAO, 2008). Finally, stability refers to the ability of individuals, households, and nations to maintain food security over time, even in the face of shocks such as economic crises, conflicts, or environmental disasters (Pinstrup-Andersen, 2009). Stability underscores the importance of resilience in food systems and the need to address vulnerabilities that could disrupt food access or availability. The concept of food security has evolved significantly since its inception in the mid-20th century. Initially, the focus was primarily on food production and availability. However, it became evident that hunger and malnutrition persisted even in regions with abundant food supplies, leading to a broader understanding of food security that incorporates social, economic, and environmental factors (Maxwell & Smith, 1992). Today, food security is recognized as a critical component of sustainable development, with strong linkages to global challenges such as climate change, population growth, and economic inequality (FAO, 2022).

Achieving food security requires a holistic approach that addresses not only food production but also equitable access, nutritional quality, and system resilience. Policymakers and stakeholders must work together to design and implement strategies that strengthen food systems, reduce vulnerabilities, and ensure that all people have access to sufficient, safe, and nutritious food (FAO, 2008).

4.2 Drought Vulnerability

This map provides a detailed visualization of drought vulnerability across Bangladesh, highlighting regional disparities in drought risk. The northwestern region, including the Barind Tract, is classified as "High" to "Very High" vulnerability due to its arid climate and reliance on rain-fed agriculture. In contrast, the northeastern and southeastern regions exhibit "Low" to "Moderate" vulnerability, reflecting their higher rainfall and better water availability.

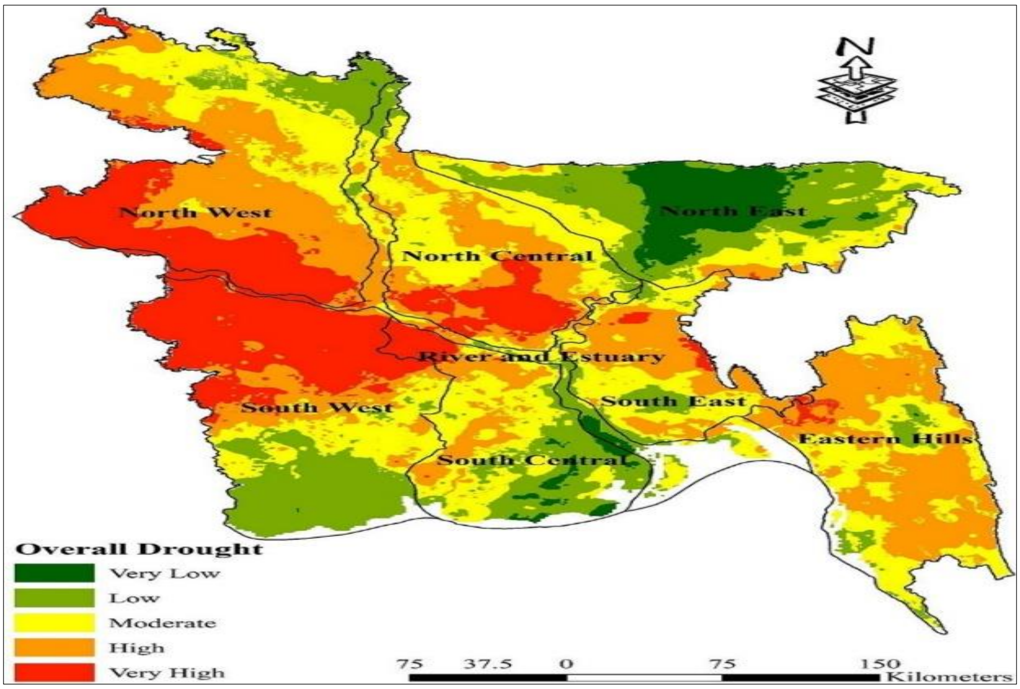

Figure 1: Drought Vulnerability Map
Source: Sarkar, S. K *et al*., 2024

The chart given below illustrates the percentage distribution of drought vulnerability across different regions of Bangladesh. The South West and North Central regions show significant proportions of "High" and "Very High" vulnerability, reflecting their susceptibility to drought due to low rainfall and high temperatures. In contrast, the Eastern Hills region exhibits a higher percentage of "Low" to "Moderate" vulnerability, indicating better water availability and lower drought risk. The chart provides a clear visual representation of regional disparities in drought vulnerability, aiding in targeted mitigation and adaptation strategies.

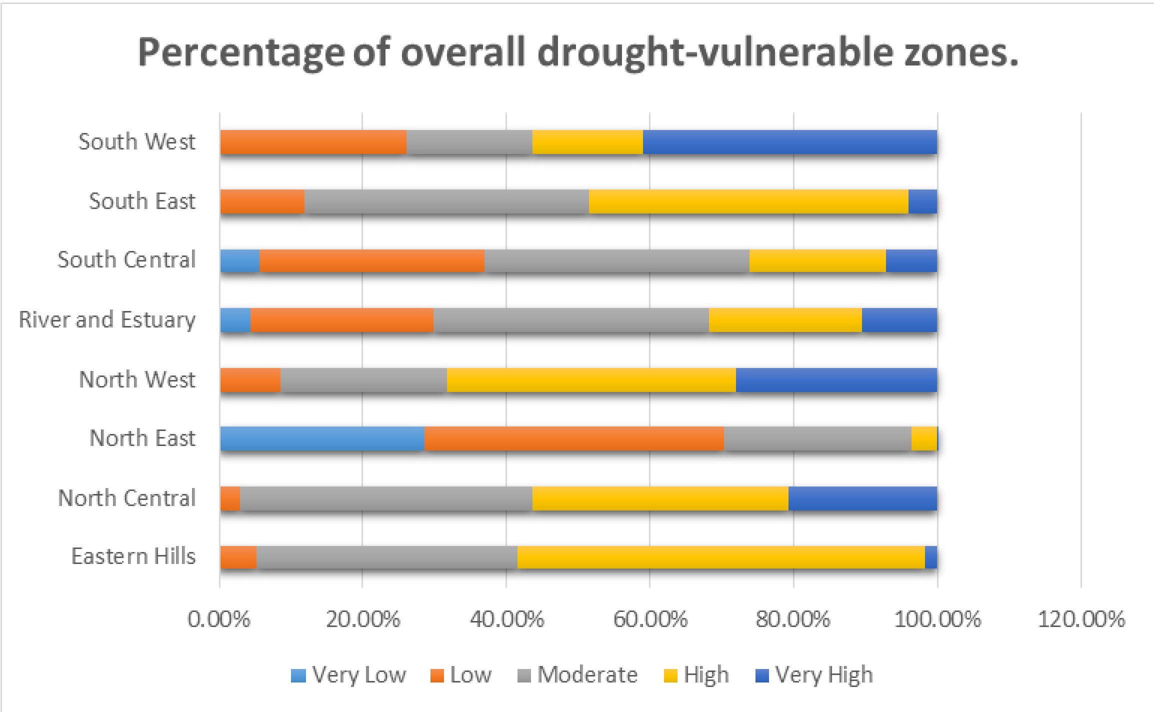

Figure 2: Percentage of overall drought-vulnerable zones
Source: Sarkar, S. K *et al*., 2024

4.3 Drought affected area in Bangladesh

Normally northwestern part of the country encounters more droughts than the other parts of the country. In Bangladesh, the Barind (upland of Northwestern part) has been experiencing drought conditions for the last two to three decades. This area is designated as the severe drought-prone areas (Figure 2). It covers Barind Tract, Punarbhava floodplain and Ganges river flood plain area. This drought-prone region covers most part of the greater Dinajpur, Rangpur, Pabna, Rajshahi, Chapai Nawabganj, Bogra, Joypurhat and Naogaon district. After severely drought affected Northwestern region, Southwestern part of Bangladesh is also facing drought impacts. But the severity of drought in this region is moderate. Among South western region, mainly Jhenaidah, Jessore and Satkhira districts experiences drought during the dry season (Habiba *et al.*, 2011). This has an enormous impact on the crop production as the production of all winter crops goes down with the arrival of droughts. Droughts also come with land degradation, low livestock population, unemployment, and malnutrition (Chowdhury, 2010).

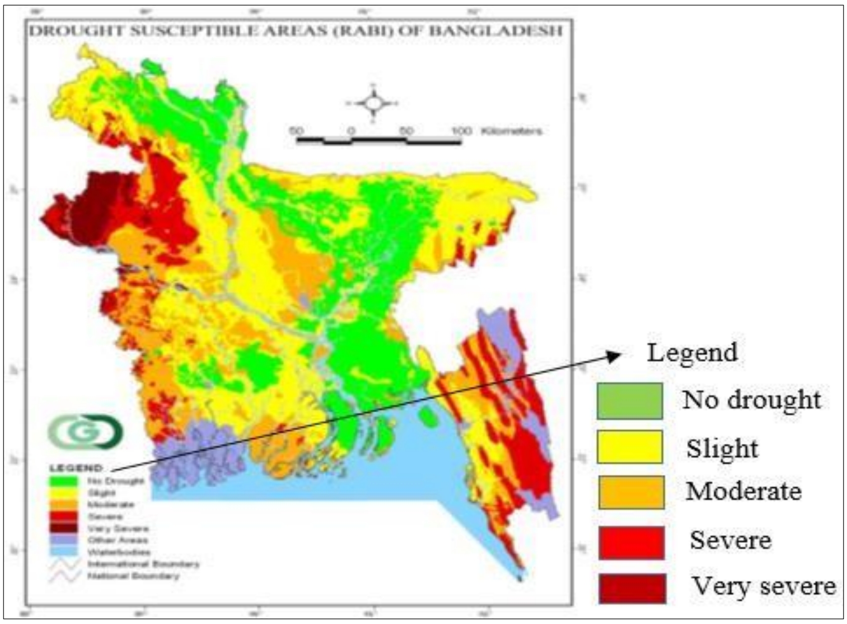

Figure 3: Drought-prone areas of Bangladesh
Source: Delaporte and Maurel, 2016

Bangladesh is at higher risk from droughts. Drought conditions due to deficiency in rainfall affect different parts of Bangladesh mostly during the pre-monsoon and post-monsoon periods. One study has shown (Figure 3) that from 1949 to 1979, drought conditions had never affected the entire country and total population in any drought year. The drought of 1979 was one of the most severe in recent times. The percentage of drought-affected areas was 31.63 percent in 1951, 46.54 percent in 1957, 37.47 percent in 1958, 22.39 percent in 1961, 18.42 percent in 1966, 42.48 percent in 1972, and 42.04 percent in 1979 (Figure 4) (Ha and Ahmad, 2015).

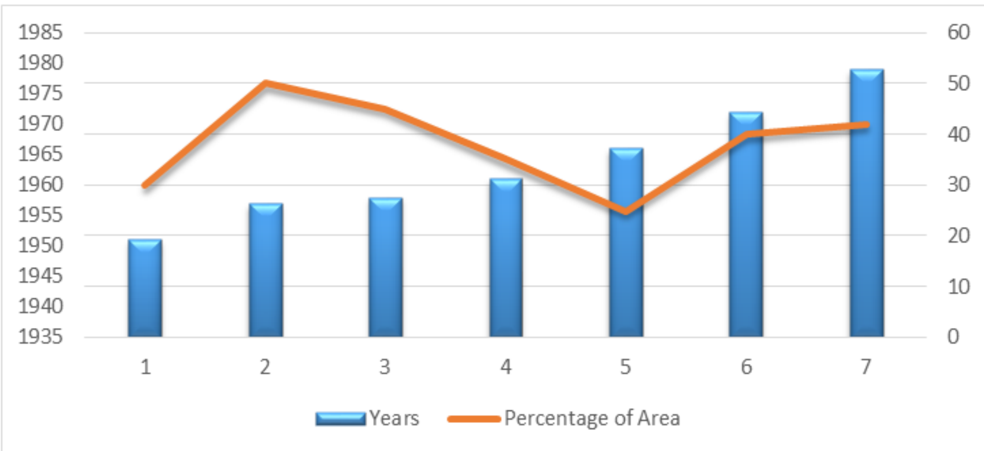

Figure 4: Drought affected areas of Bangladesh in different years
Source: Ha and Ahmad, 2015

Table 1: Area facing both agricultural and meteorological drought risks

Sl. No	Drought Risk	No. of Districts	Name of Districts	Area (km^2)	% of Area
1	No risk	2	Sirajgong, Naogaon	5437.34	16.86
2	Slight risk	4	Kurigram, Nawabgong, Bogra, Joypurhat	7322.45	22.71
3	Moderate risk	5	Rangpur, Rajshahi, Pabna, Natore, Lalmonirhat	9581.58	29.72
4	Severe risk	3	Dinajpur, Nilphamari, Gaibandha	6867.32	21.29
5	Very severe risk	2	Panchagarh, Thakurgaon	3036.31	9.42
Total		**16**		**32245**	**100%**

Source: Murad and Islam, 2011

A study reported that the percentage of areas in each district of the north-west region facing combined drought risk (Table 2). Sirajgong and Naogaon are two districts free from drought risk. Slight and moderate risk areas encompass 22.71% and 29.72% of total geo-graphical area (Table 1). Severe and very severe risk prevails in nearly 21.29% and 9.42% of the area which includes the districts that are major producers of food grains and different vegetable, (Murad and Islam, 2011).

4.4 Causes of Drought in Bangladesh

Drought in Bangladesh is influenced by a combination of natural and anthropogenic factors. Among these, rainfall variability, regional disparities in precipitation, and climate change are the most significant contributors. This section examines these causes in detail, supported by data from recent studies.

4.4.1 Inadequate Rainfall

Distribution of rainfall throughout the seasons is important. Rainfall is inadequate (time, intensity and distribution) throughout the seasons (Figure 5). A study conducted in the northwest part of Bangladesh covering two severe drought-prone districts, namely Rajshahi and Chapai-Nawabganj and comprises a total of 14 upazilla. Climatically, this region belongs to the dry humid zone with annual average rainfall varying from 1,400 to 1,900 mm (Shahid, 2011). Rainfall varies widely from year to year as well as from place to place. In 2000, for instance, the total annual rainfall in this area was 1,690 mm, whereas in 2010 it went down to 793 mm. On the contrary, in 2006, the annual total rainfall of Bangladesh was 2,178mm, whereas in drought-prone areas it was 1,193 mm (Habiba *et al.*, 2011). The monthly mean rainfall distribution in the study area varies. Average monthly humidity varies from 62% (in March) to 87 % (in July) with a mean annual of 78 % (Jahan *et al.*, 2010). According to Bangladesh Water Development Board (BWDB), the annual evapotranspiration of the area ranges from 370 to 1,120 mm. In the study area, it has been demonstrated that evapotranspiration exceeds more than 0.5 times during the dry season than the monsoon season, thus, accelerating agricultural drought and affecting food security.

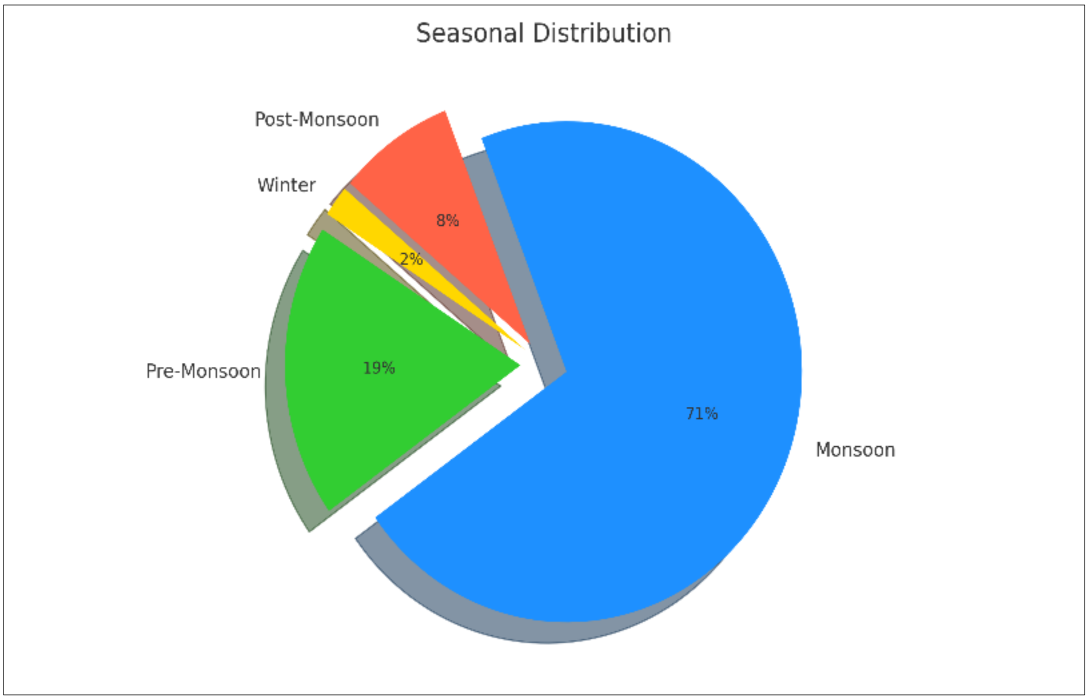

Figure 5: Season wise rainfall in Bangladesh
Source: Hossain, 2015

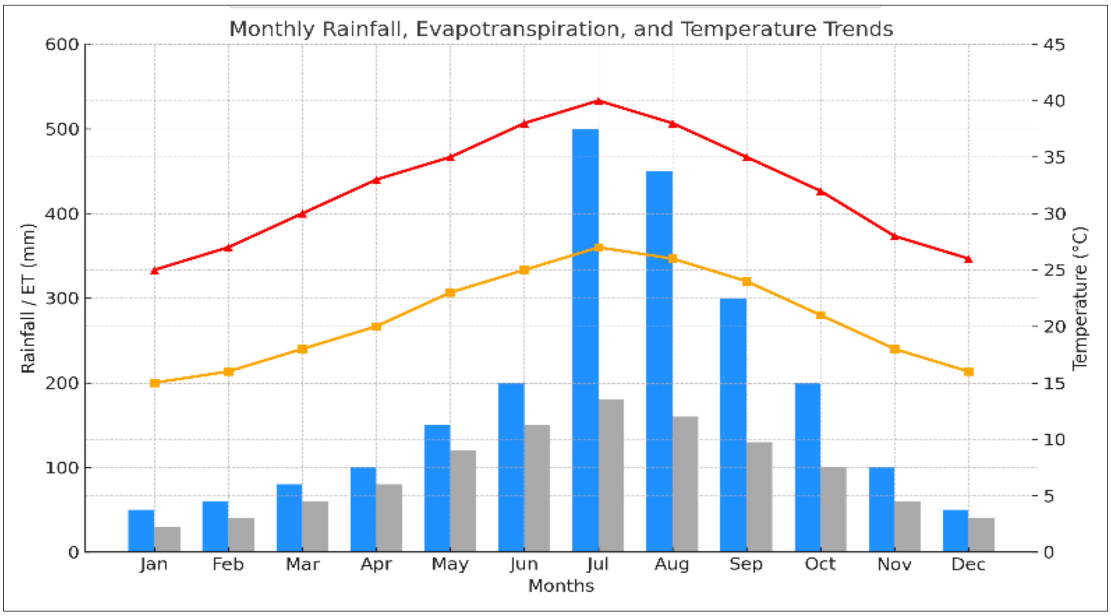

Figure 6: Mean monthly rainfall, evapotranspiration and temperature in drought prone region
Source: Selvaraju *et al.*, 2006

The mean monthly rainfall of the regions varies. The rainfall pattern is a uni-model that peaks in July. Rainfall exceeds the potential evapotranspiration in monsoon months (June to September) but is less than evapotranspiration in the remaining months (Figure 6). Highest maximum temperature occurs in April, and the highest minimum temperature occurs in June and July (Selvaraju *et al.*, 2006).

4.4.2 Rainfall Variability

Rainfall variability, particularly the decline in pre-monsoon and post-monsoon rainfall, has been a major driver of drought in Bangladesh. Studies have shown that pre-monsoon rainfall has decreased by 8 mm per decade, while post-monsoon rainfall has declined by 4 mm per decade during the period 1971–2010 (Shahid, 2011). In the northwestern region, which is particularly vulnerable to drought, pre-monsoon rainfall declined by 252 mm, and post-monsoon rainfall by 289 mm during 2011–2020 (Islam *et al.*, 2020). These trends have significantly impacted water availability, especially in agriculturally dependent regions. Table 2 summarizes the decline in pre-monsoon and post-monsoon rainfall across different regions of Bangladesh.

Table 2: Decline in Pre-Monsoon and Post-Monsoon Rainfall (1971–2010)

Season	Rainfall Decline	Region
Pre-Monsoon	8 mm per decade	Nationwide
Post-Monsoon	4 mm per decade	Nationwide
Pre-Monsoon	252 mm (2011–2020)	Northwestern Bangladesh
Post-Monsoon	289 mm (2011–2020)	Northwestern Bangladesh

Source: Shahid, S. (2011, Islam, A.R.M.T. *et al.*, (2020)

4.2.2 Regional Disparities in Rainfall

Bangladesh exhibits significant regional disparities in rainfall distribution, which contribute to varying levels of drought vulnerability. The northwestern region, with an average annual rainfall of 1,400 mm, is highly vulnerable to drought due to its arid climate and reliance on rain-fed agriculture. In contrast, the northeastern region receives over 4,000 mm of rainfall annually, making it less susceptible to drought. The southwestern region, with an average annual rainfall of 1,800 mm, experiences moderate drought vulnerability (Rahman *et al.*, 2017). Table 3 provides an overview of regional rainfall variability and drought vulnerability in Bangladesh.

Table 3: Regional Rainfall Variability in Bangladesh (1980–2018)

Region	Average Annual Rainfall (mm)	Drought Vulnerability
Northwestern Bangladesh	1,400	High
Northeastern Bangladesh	4,000+	Low
Southwestern Bangladesh	1,800	Moderate

Source, Rahman *et al.*, 2017

4.4.3 Drought Indices and Rainfall Trends

Drought indices such as the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI) have been widely used to monitor and assess drought conditions in Bangladesh. The SPI has identified increasing drought frequency in the northwestern regions, while the SPEI, which incorporates temperature data, has been more effective in capturing drought severity nationwide (Islam *et al*., 2020; Ahmed *et al*., 2019). Both indices indicate worsening drought conditions due to declining rainfall and rising temperatures. Table 4 summarizes the key findings from studies using drought indices to analyze rainfall trends and drought severity.

Table 4: Drought Indices and Rainfall Trends

Drought Index	Key Findings	Region
SPI (Standardized Precipitation Index)	Identified increasing drought frequency in northwestern regions.	Northwestern Bangladesh
SPEI (Standardized Precipitation Evapotranspiration Index)	Captured drought severity more effectively by incorporating temperature.	Nationwide
SPI and SPEI	Both indices show worsening drought conditions due to declining rainfall.	Nationwide

Islam, A. R. M. T *et al*., (2020), Ahmed, K *et al*., (2019).

4.4.4 Climate Change as a Cause of Drought in Bangladesh

Climate change has emerged as a significant driver of drought in Bangladesh, exacerbating existing vulnerabilities and altering weather patterns. The country's geographical location and dependence on monsoon rainfall make it particularly susceptible to the impacts of climate change. This section reviews the key findings related to climate change and its contribution to drought conditions.

4.4.5 Rising Temperatures and Evaporation Rates

One of the most direct impacts of climate change is the rise in global temperatures, which has significantly affected Bangladesh. Over the past few decades, average temperatures in the country have increased by 0.5°C to 1.0°C, with projections suggesting a further rise of 1.0°C to 1.5°C by 2050 (Mondal *et al*., 2015). This temperature rise has led to higher evaporation rates, reducing soil moisture and surface water availability. As a result, drought conditions have intensified, particularly in the northwestern and southwestern regions, where water resources are already scarce. Table 5 summarizes the observed and projected temperature trends and their impact on drought vulnerability in Bangladesh.

Table 5: Temperature Rise

Parameter	Trend	Impact on Drought
Temperature Rise	0.5°C to 1.0°C (past decades)	Increased evaporation, reduced soil moisture
Projected Temperature Rise	1.0°C to 1.5°C by 2050	Worsening drought conditions

Source: Mondal *et al*., (2015)

4.4.6 Altered Rainfall Patterns

Climate change has also disrupted traditional rainfall patterns in Bangladesh, leading to more erratic and unpredictable monsoons. The frequency of extreme weather events, such as prolonged dry spells and intense rainfall, has increased. For example, the weakening of monsoonal southerly flow has reduced rainfall in the eastern parts of the country during the monsoon season, contributing to drought conditions (Alamgir *et al*., 2019). These changes have made it increasingly difficult for farmers to predict planting and harvesting seasons, further exacerbating water scarcity and agricultural losses. Table 6 provides an overview of the altered rainfall patterns and their impact on drought conditions.

Table 6: Altered Rainfall Patterns Due to Climate Change

Parameter	Trend	Impact on Drought
Monsoon Rainfall	Erratic and unpredictable	Prolonged dry spells, water scarcity
Extreme Weather Events	Increased frequency	Intense rainfall followed by dry spells

Source: Alamgir *et al*., (2019).

4.4.8 Sea Level Rise and Salinity Intrusion

Another critical impact of climate change is sea level rise, which has caused salinity intrusion in coastal regions of Bangladesh. Rising sea levels, at a rate of 3–8 mm per year, have reduced the availability of freshwater for irrigation and drinking, indirectly contributing to drought-like conditions in these areas (Sarwar, 2013). Salinity intrusion has also affected groundwater quality, further limiting water resources in drought-prone regions. This has had severe consequences for agriculture, as saline water is unsuitable for most crops, leading to reduced yields and economic losses. Table 7 highlights the trends in sea level rise and salinity intrusion and their impact on drought.

Table 7: Sea Level Rise and Salinity Intrusion

Parameter	Trend	Impact on Drought
Sea Level Rise	3–8 mm per year	Salinity intrusion, reduced freshwater
Groundwater Salinity	Increasing	Limited irrigation and drinking water

Source: Sarwar (2013).

4.5 Impacts of Drought on Agriculture

4.5.1 In agriculture

Though agriculture is the prime sector of Bangladesh, it is severally affected by different natural hazards for instance drought. Historical data revealed that, every five to ten years, Bangladesh is affected by the extreme drought events. Nevertheless, local droughts occur regularly and affect crop production. The end results of drought usually first appear on agriculture and then impacts on food production, water resources and farmer's life and livelihood (Habiba *et al.*, 2012). Ultimately it affects the food security of the country. Mainly, inadequate pre-monsoon rainfall, a delay in the onset of the rainy season or an early departure of the monsoon leads to droughts in Bangladesh (Shafie *et al.*, 2009). Monsoon failure often brings famine to the affected regions and as a result crop production reduces drastically. Every year 3 to 4 million hectares of lands are affected by droughts of different magnitudes. Agricultural activities in Northwestern regions of Bangladesh are particularly exposed to droughts almost three cropping season. During the kharif season, it causes significant destruction to the T. aman crop is approximately 2.32 million ha every year. In the Rabi season, about 1.2 million ha of agricultural land faces droughts of different magnitudes. Pre-monsoon drought is called Rabi and Pre-Kharif drought since it affects both Rabi and Pre-Kharif crops. The commonly affected major crops include HYV Boro, Aus, wheat, pulses, sugarcane, and potatoes. Significant damages can occur where irrigation opportunities are limited. Post-monsoon drought is also known as Kharif drought as it affects Kharif crops. Aman rice is the most common Kharif crop that is affected by post-monsoon drought as its reproductive stage severely constrained by shortage of available moisture. Table 8 represents drought prone areas by cropping seasons.

Table 8: Drought affected areas by cropping season

Crop season	Area under various drought severity class (in million ha)				
	Very severe	Severe	Moderate	Slight	Unaffected
Pre-kharif	0.403	1.15	4.76	4.09	2.09
Kharif	0.344	0.74	3.17	2.90	0.68
Rabi	0.446	1.71	2.95	4.21	3.17

Source: Ahmed and Roy, 2007

In kharif season, normally aman rice is affected due to drought. As a result, a substantial amount of yield loss is occurred (Dey *et al.*, 2012). Droughts adversely affect the crop production, causes annual damages of 2.32 million hectares' crop production (Habiba *et al.*, 2011). Scarcity of water limits crop production while irrigation coverage is only 56% (Cell, 2006). In Bangladesh, rice faces the highest loss due to drought because rice production is very much dependent on water availability. During drought period rice does not get enough water which causes production loss. Additionally, drought also affects the production of other major crops (Table 9).

Table 9: Impact of drought on agriculture and crop production

Crops	(%) Yield Reduction			
	Slight	Moderate	Severe	Very Severe
T. Aman	0-20	20-35	35-45	45-100
B. Aus	0-10	10-30	30-40	40-100
Wheat	0-40	40-50	50-59	59-100
Mustard	0-30	30-40	40-50	50-100
Potato	0-60	60-70	70-80	70-100

(T. Aman= Tranplanted Aman, B. Aus= Broadcast Aus)

Source: Ahmed, 2006

Moreover, another study conducted (Habiba *et al.*, 2012) in northwestern region of Bangladesh revealed that about 53.33% production of rice was reduced significantly whereas the production of potato, jute, onion and bean were decreased 13.33%, 26.66%, 6.66% and 4% respectively due to drought (Figure 7).

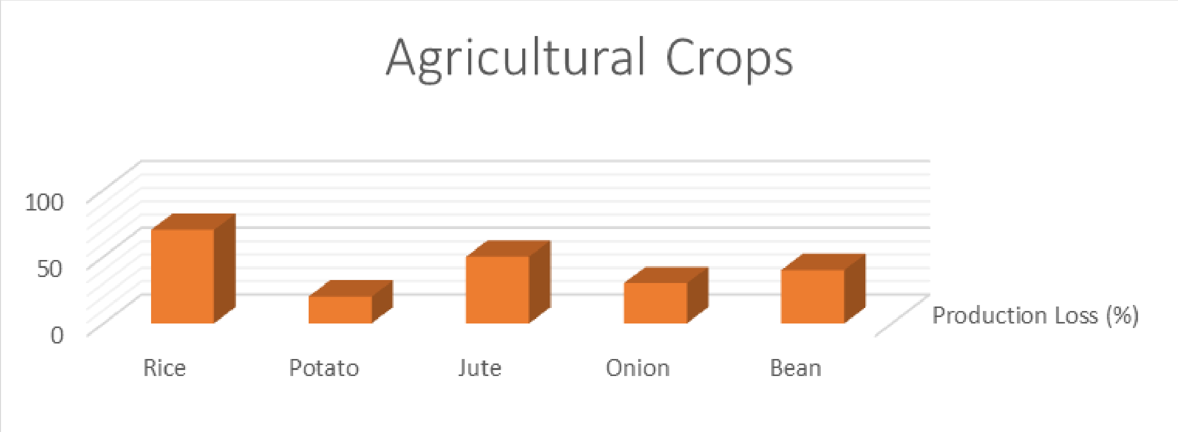

Figure 7: Agriculture impact of drought according to production loss of agriculture crops (%)
Source: Habiba *et al*., 2012

Drought frequently occurs in Bangladesh and causes huge destruction to the crops.

5. CONCLUSION

Drought has emerged as a critical threat to food security in Bangladesh, a country where agriculture remains the backbone of the economy and a primary source of livelihood for millions. This study has explored the intricate relationship between drought and food security, shedding light on the causes, impacts, and vulnerabilities associated with this slow-onset disaster. The findings reveal that drought, driven by inadequate rainfall, regional disparities in precipitation, and the escalating effects of climate change, has significantly disrupted agricultural productivity, particularly in the drought-prone northwestern and southwestern regions. The consequences of drought are far-reaching, affecting not only food availability but also access, utilization, and stability. Crop losses, especially in staple foods like rice, wheat, and potatoes, have led to rising food prices, reduced dietary diversity, and increased malnutrition, particularly among vulnerable groups such as women and children. Smallholder farmers, who form the backbone of Bangladesh's agricultural sector, are disproportionately affected, as they lack the resources to adapt to changing conditions or recover from repeated droughts. Moreover, the long-term impacts of drought—such as soil degradation, declining groundwater levels, and reduced agricultural resilience—pose additional challenges to sustainable food production. Despite efforts by the government and international organizations to mitigate these impacts through drought-resistant crops, improved water management, and early warning systems, significant gaps remain. Limited funding, inadequate infrastructure, and low awareness among rural communities hinder the effectiveness of these interventions. As climate change continues to exacerbate drought conditions, the need for a comprehensive, multi-faceted approach becomes increasingly urgent. To safeguard food security in Bangladesh, it is essential to integrate climate adaptation, disaster risk reduction, and social protection measures. This includes investing in research for resilient crop varieties, expanding access to affordable irrigation technologies, and strengthening social safety nets to support vulnerable populations during periods of food scarcity. Community-based initiatives, such as rainwater harvesting and farmer cooperatives, have shown promise and should be scaled up to enhance local resilience. In the face of a changing climate, Bangladesh must prioritize sustainable agricultural practices and proactive drought management strategies. By addressing the root causes of drought and building the resilience of its agricultural systems, the country can better navigate the challenges posed by this recurring natural hazard and ensure a food-secure future for its population. The lessons learned from Bangladesh's experience with drought and food security offer valuable insights for other drought-prone regions grappling with similar challenges in an era of climate uncertainty.

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