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Impact of Climate Change on Economic Development Associated with Water Scarcity: A Review

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Abstract: Concerns about climate change-induced water scarcity has the potential to hinder development activities. This study aimed to investigate the impact of climate change-related water scarcity on economic development. The study was based on a comprehensive analysis of secondary data obtained from online various sources, including websites, journals, and publications. The analysis revealed a robust inverse correlation between economic growth and water shortages resulting from climate change, with adverse consequences observed in multiple sectors, including health, energy, and agriculture, among others. This study recommends prioritizing the development of water infrastructure, enhancing groundwater replenishment, promoting wastewater recycling and rainwater harvesting practices, improving agricultural techniques, and adopting cutting-edge water conservation technologies to address water scarcity and foster sustainable water resource management.

Keywords: *Climate change, Economic development, Groundwater, Human health, Water scarcity*

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1. Introduction

Climate change refers to momentous changes in global temperature, precipitation, wind patterns, and other indicators of climate that occur over several decades or longer. Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. Climate change encompasses global warming but refers to the broader range of changes that are happening to our planet, including rising sea levels, shrinking mountain glaciers, accelerating ice melt in Greenland, Antarctica, and the Arctic, and shifts in flower and plant blooming times (Woodward, 2009). This will have an impact on form, distribution, quality, and availability.

Climate change is expected to have a significant impact on freshwater ecosystems, with consequences varying regionally, locally, and depending on the habitat type. Flooding and contamination could endanger aquatic systems, and international relations may be impacted. Wetlands are vulnerable to damage from climate change, such as loss of carbon stored in the soil, soil structure changes, increased flooding or drying, saltwater intrusion, alterations to plant or animal communities, and water availability and timing changes (Philander, 2008; Whitehead et al., 2009; Xia et al., 2015; Moomaw et al., 2018). Additionally, the local impacts of climate change may be felt internationally in addition to locally. The extended drought in the country, which forced the rural poor into the cities only to find their future constrained by authoritarian control and inaction, is a contributing factor to the war in Syria and the refugee crisis that has resulted from it (Sosa-Nunez and Atkins, 2016).

Water scarcity is a significant issue globally, as illustrated by the population distribution and freshwater availability presented in Table 1 (UN-Water-2007; UNU-2013; IPCC-2014; AWDO, 2016; Masago et al., 2019).

Table 1: A brief description of population distribution and water availability around the world

Continent	Global Population (%)	Fresh water available (%)
Asia	60.5	36
Africa	14	10
Europe	11.3	8
North and Central America	7.3	15

South America and Caribbean	6.4	26
Oceania	0.5	5

According to Rajsberman (2006), a person is water insecure when he or she lacks access to safe and inexpensive water to meet the demands of drinking, washing, or livelihood. Water crises, shortages, deficits, and stress are all examples of water scarcity. Physical and economic water shortages are the possible causes of water scarcity (Figure 1). Economic water shortages are a result of inadequate water management resources, whereas physical water scarcity refers to a scenario in which natural water supplies cannot satisfy the region's demand (UNWWDR, 2012).

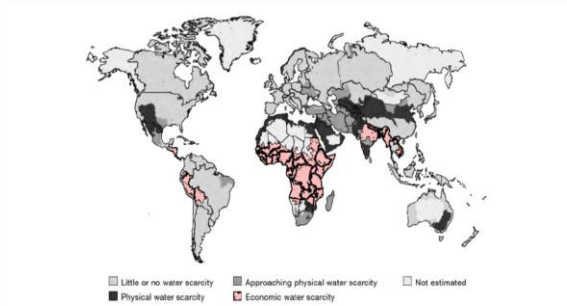

Figure 1: Global physical and economic water scarcity

For human development, water is a crucial component. One-third of the world's population, or 1.1 billion people, reside in areas affected by the water crisis, according to the United Nations (Shaw and Thaitakoo, 2010; Mostafa et al., 2017; Islam and Mostafa, 2023; Uddin et al., 2011). According to some scholars, there is a causal relationship between acute conflicts and water scarcity (Wolf, 2001), which can result in war or extremely tense political situations (Westing, 1986). Conflicts and catastrophes are caused by a lack of water, which can lead to territorial rights and political power disputes. Water infrastructure is often attacked during armed conflicts to display authority and cut off access to water, as seen in airstrikes on reservoirs in Yemen and Syria (Prigge-Musial, 2019).

The lack of freshwater on a global scale is a major obstacle to human development and the Sustainable Development Goals. It is caused by agricultural products being exchanged and consumed elsewhere, and is a crucial input for other industries (Gleick, 2011; Dalin et al. 2012; Forum, 2015, Vörösmarty, 2015; Islam and Mostafa, 2020; Islam and Mostafa, 2021a; Islam and Mostafa, 2022a). Due to these ties in economic exchange, local water systems are affected by changes in worldwide use (Marston, 2015). Water is a crucial input for other industries like energy, transportation, and manufacturing. These multi-regional, multi-sector dynamics will be more crucial to our knowledge of the causes and effects of water shortages as a result of continued population expansion, climate change, and globalization (OECD, 2012; Chowdhury, et al., 2015; Serder et al., 2020).

For this reason, this study was focused on the economic impacts of climate change. The main objective of this study was to assess the impact of climate change on economic development associated with water scarcity. This study had some specific objectives as:

(i) To identify the relationship between climate change and economic development

(ii) To identify the climatic causes of water scarcity

(iii) To assess the economic impact of water scarcity

(iv) To provide some recommendations to reduce water scarcity.

2. Materials and methods

The study primarily relied on secondary data. The authors collected data from various journals, articles, and newspapers. Open access (OA) levels across multiple nations and scientific disciplines were examined in this study using data sourced mainly from Google Scholar (GS). A total of 120 articles and reviews were selected for this study, spanning publication dates from 1973 to 2022.

Qualitative synthesis was employed by the author to analyze the collected data. Qualitative synthesis involves a systematic review that synthesizes the results of numerous studies. It possesses limitations such as the inability to modify data collection, questions, measures, or procedures. However, its strengths lie in its capacity to enhance the understanding of data and its utility for historical research. To fulfill the objectives of this study, which aimed to explain the economic impact of water scarcity and establish the relationship between climate change and economic development, the data and information were utilized in a manner that aligned with all the study's objectives.

3. Results and discussion

3.1. Climate change, economic growth and living standard

Numerous studies have estimated the impacts of climate change. Climate change has a significant impact on economic growth, with agriculture, coastal regions, and the elderly being particularly affected (Islam and Mostafa, 2022b; O'Brien et al., 2004; Parry and others, 2007; Lucas and Simone, 2011). Climate change will have negative effects on economic development, resulting in a loss of 5% of GDP and a decline in the growth rate of developing nations (Stern and others, 2006; Dell et al., 2008).

The economics of climate change: no action is an option was a paper published in 2021 by the Swiss Re Institute. It stated that climate change could wipe out 10% of the world's economy by 2050 if no action is taken. Bangladesh, India, and Pakistan are at risk of GDP loss and poverty increases due to climate change (The Financial Express, 2022; Roy, 2021; Stern, 2006; World

Bank, 2022). The predicted GDP loss for rising temperatures is given in Table 2.

Mani et al. (2018) used average temperature and precipitation data coupled with household survey data to conduct district-level research in South Asia. The study looked at how changes in climatic conditions affected the average person's standard of living. According to the study's findings, as opposed to the status quo, rising average temperatures caused a fall in living conditions in Bangladesh, Pakistan, Sri Lanka, Nepal, and India. Due to their generally cooler climates, only Afghanistan and Nepal experienced harmful effects. This scenery is given in Table 2.

Table 2: Predicted GDP loss for rising temperature and change in living standard under the carbon intensive scenario.

Location	**GDP loss (%)**	**Predicted year**	**Reference**
World	5	2050	Stern and others (2006)
Developing nations	0.6 to 2.9	-	Dell *et al* (2008)
China	24	2050	SRI (2021)
Africa	27.6	2050	SRI (2021)
Middle East	4.7	2050	SRI (2021)
Europe	11	2050	SRI (2021)
US, UK and Canada	10	2050	SRI (2021)
Bangladesh	2 to 9	2100	The financial express, February 18, 2022
India	3 to10	2100	Roy (2021)
	10	2100	Stern (2007)
Pakistan	18 to 20	2050	World Bank (November 10, 2022)
Predicted change in living standard under the carbon intensive scenario			
Location	Change in Living standard (%)	By predicted year	Reference
India	-2.8	2050	Mani *et al.*(2018)
Sri Lanka	-7.0	2050	Mani *et al.*(2018)
Bangladesh	-6.7	2050	Mani *et al.*(2018)
Pakistan	-2.9	2050	Mani *et al.*(2018)
Nepal	4.1	2050	Mani *et al.*(2018)
Afghanistan	11.9	2050	Mani *et al.*(2018)

3.2. Climate change and water

The main climate change consequences related to water resources are increases in temperature, shifts in precipitation patterns and snow cover, and a likely increase in the frequency of flooding and droughts. Climate change has influenced water quality in different parts of the world, as shown in Table 3. Climate change has a major impact on livestock in developing countries, affecting feeds, heat stress, water, diseases, and biodiversity. Effects vary depending on location, livestock systems, and species (Thornton et al., 2009; IFAD, 2010). The quantity and quality of feed will be affected mainly due to an increase in atmospheric CO2 levels and temperature (Chapman et al., 2012). The effects of climate change on the quantity and quality of feeds are dependent on location, livestock systems, and species (IFAD, 2010). Some of the impacts on feed crops and forage are:

Increases in CO2 concentration have a stronger impact on C3 species and grain yields, while C4 species thrive in hotter climates and utilize water more efficiently. Temperatures between 30 and 35 °C may promote the growth of herbage, but outcomes may vary depending on the environment, production method, and plant type (Chapman et al., 2012; Hatfield and Prueger, 2011; Thornton et al., 2009, 2015; Rotter and van de Geijn, 1999; Wand et al., 1999). However, the outcomes may differ based on the environment, employed production method, and plant type (Hatfield and Prueger, 2011; IFAD, 2010; Thornton et al., 2009; Thornton and Herrero, 2010).

Populations with less genetic diversity are at risk, and climate change is one of the main causes of this biodiversity loss (UNEP, 2012). The predicted biodiversity loss (%) due to climate change is given in Table 3.

Table 3: Effects of climate change on water quality and predicted biodiversity loss

Effects of climate change on Water quality				
Location	**Study period**	**Observation**	**Effects**	**Reference**
USA	1948–1994	Increased rainfall and runoff are linked to localized outbreaks	Waterborne illness.	Curriero *et al.* (2001)
Taiwan, China	1998	With rainfall rates >31 mm h-1, there was a greater than 50% chance of finding enterovirus infections.	Rain increases the risk of an enterovirus pandemic..	Jean *et al*. (2006)
22 upland waters in UK	1988–2002	Temperature rose, Changing rainfall patterns, acid rain, terracing, and CO2 enrichment.	dissolved organic matter rose	Evans *et al.* (2005)
River Meuse, western Europe	1976–2003	Increased water temperature, elements, and heavy metals are contributing to pollution.	Droughts, There were more nutrients present, which led to algal blooms.	Van Vliet and Zwolsman (2008)
27 rivers in Japan	1987–1995	Increases in ambient temperature, Changes in and increases in precipitation.	Increased organic matter, sediments, and chemical oxygen demand levels in water.	Ozaki *et al.* (2003)

Predicted Biodiversity loss due to climate change

Species	Biodiversity loss (%)	Reference
All species worldwide	15 to 37	Thomas *et al*. (2004)
Plant and animal	20 to 30	IPCC (2014)
Livestock breeds	20	FAO (2007)
Chicken (breeds)	33	FAO (2007)
Pigs (breeds)	18	FAO (2007)
Cattle (breeds)	16	FAO (2007)
Mammalian	60-70	FAO (2007)
Mammalian (Developing regions)	7-10	FAO (2007)
Mammalian (Developed countries)	20-28	FAO (2007)

3.3. Climate change and water

The excessive salinity of surface and groundwater in Gopalpur and Durgabati villages of Bangladesh is a major issue due to climate variability (Abedin et al., 2018), and the distribution of water salinity is changing due to sea level rise (Serder et al., 2020; Dankelman et al., 2008; Jakobsen et al., 2002; Faisal and Parveen, 2004; Alam, 2003; the IPCC, 2001; and the World Bank, 2000).

Surface water is contaminated with salinity due to natural and anthropogenic sources, including floods, cyclones, tidal surges, and sea level rise. Floods and tidal surges contaminate freshwater resources, leading to waterborne illnesses (Islam and Mostafa, 2021b; Islam et al., 2013; Rahaman and Bhattacharya, 2006; Huq and Ayers, 2008; Mahmuduzzaman et al., 2014; Chong et al., 2014; Mustari and Karim, 2014; Rahim and Mostafa, 2021; Shamsuddoha and Chowdhury, 2007; Dasgupta et al., 2014; WaterAid, 2012; Sikder and Jian, 2014).

Previous research has emphasized the effects of climate change, including sea level rise, unpredictable rainfall, high evaporation, and an increase in the frequency and severity of catastrophes, which is hastening the lack of access to safe drinking water in southwest coastal Bangladesh (Hasan et al., 2013; Abedin et al., 2018; Khan et al., 2011; Uzzaman, 2014; Dasgupta, 2011). Bangladesh's yearly rainfall is anticipated to decrease owing to climate change in the future (Rahman, 2017).

3.4. Climate change and production

Climate change has a major impact on agricultural yields, productivity, labor supply, energy supply and demand dynamics, international trade, and overall economic effects. Studies have shown negative effects on

crop yield, disrupted crop cycles, and worker productivity. Heat stress affects output, cognitive function, and workdays (Carleton and Hsiang, 2016; Auffhammer and Schlenker, 2014; Auffhammer et al., 2012; Lobell et al., 2011; Burke et al., 2015; Mani et al., 2018; Seppänen et al., 2006; Graff Zivin et al., 2018; Somanathan et al., 2015). Climate variability and change are a major source of fluctuations in global food production, particularly in developing countries, and are predicted to increase in the future, resulting in negative impacts on food prices, food security, and land-use decisions (Thornton et al., 2014; Sabiiti, 2016; Sabiiti et al., 2018; FAO, 2019). Yields from rainfed agriculture in some African countries could be reduced by up to 50% by 2020 (Sabiiti et al., 2018).

Climate change is having a severe impact on crop production in Bangladesh, with a 400-degree increase in temperature resulting in a 28% reduction in rice production and a 68% reduction in wheat production by 2050 (Rezvi, 2018). Due to climate change, livestock production will be decreased in Bangladesh due to diseases, scarcity of forage, heat stress, and breeding strategies (Chowdhury et al. 2016). The IPCC predicted in 2007 with high confidence that in southern Europe, climate change would reduce crop productivity (IPCC, 2007). Pakistan's crops are highly sensitive to changes in temperature and water availability, and temperature rises in the region of 0.5°C–2°C could lead to around an 8%–10% loss in yield by 2040 (Dehlavi et al., 2015). A study on the climate sensitivity of Brazilian and Indian agriculture by Sanghi and Mendelsohn (2008) reported that temperature has a more powerful effect on farm values and net revenues than precipitation. The predicted crop yield loss due to climate change is given in Table 4.

Water scarcity in many parts of the world is a major obstacle to climate adaptation, as it can lead to rising labor costs, lower productivity, increased investment risks, and the loss of export markets. It also has dire consequences on a global scale, such as decreased travel and tourism, rising labor costs, and lower productivity due to increased health burdens (Schewe et al., 2014; IPCC, 2019a; Fogden and Wood, 2009). Businesses and industries require a lot of water to produce goods and services, which has caused water prices to rise and farmers to fight for the right to utilize it (Cartwright, 2009).

Water scarcity is a major factor in energy production, leading to higher energy costs and electricity shortages, which will eventually lead to an increase in energy prices (Ross, 2016; Cartwright, 2009). The predicted loss or reduced crop yield due to climate change is shown in Table 4.

Table 4: Climatic causes of water scarcity and predicted loss crop yield due to climate change

Climatic causes of water scarcity	**Location**	**Study Period**	**Reference**
Drought/ lack of rainfall	Bangladesh (Southwestern Coastal region)	September to November, 2017	Abedin *et al*. (2018)
Flood/ heavy Precipitation	Southeast Asia and South Pacific	1961-1998	Manton *et al.* (2001)
	Bangladesh (Southwestern Coastal region)	September to November, 2017	Abedin *et al.* (2018)
	Bangladesh	1984-2011	Sikder and Jian (2014)
High salinity in surface and ground water	Bangladesh (Southwestern Coastal region)	September to November, 2017	Abedin *et al*. (2018)
	Bangladesh	1984-2011	Sikder and Jian (2014)
	Bangladesh	1960-2008	Huq and Ayers (2008)
	Bangladesh (Coastal areas)	1959-2013	Mahmuduzzaman *et al*. (2014)
Sea level rise	Southeast Asia and South Pacific	1961-1998	Manton *et al.* (2001)
	Bangladesh	1984-2011	Sikder and Jian (2014)
	Bangladesh	1990-2011	Mustari and Karim (2014)
	Bangladesh (Coastal areas)	1793-2006	Shamsuddoha and Chowdhury (2007)
High temperature	Southeast Asia and South Pacific	1961-1998	Manton *et al.* (2001)
Tidal Surge	Bangladesh	1949-2011	WaterAid (2012)
	Bangladesh	1990-2011	Mustari and Karim (2014)

	Bangladesh (Coastal areas)	1793-2006	Shamsuddoha and Chowdhury (2007)

Predicted loss or reduced crop yield due to climate change

Location	Reduced crop yield (%)	Predicted year	Reference
Africa	up to50	2020	Sabiiti *et al.*(2018)
South Asia	up to 30	The mid 21-st century	IPCC (2007)
Europe	up to 50(non-irrigated crops)	2050	EEA (2019)
Pakistan	8-10	2040	Delavi *et al.*(2015)
Bangladesh	8 (rice) and 32 (Wheat)	2050	Rezvi (2018)
India	Up to 26	2100	Sanghi and Mendelsohn (2008)
Brazil	Up to 39	2100	Sanghi and Mendelsohn (2008)

3.5. Climate change and health

The relationship between climate change and human health is multidimensional. IPCC 2007 shows that climate change has altered the distribution of some infectious disease vectors, altered the seasonal distribution of some allergenic pollen species, and increased heat wave-related deaths. In 2000, climate change was estimated to have caused the loss of over 160.000 lives. The following health outcomes were included: Episodes of diarrheal disease; cases of Plasmodium falciparum malaria; fatal accidental injuries caused by coastal floods and landslides; and no availability of the recommended daily calorie intake (malnutrition). The health consequences of unsafe water can have potential economic repercussions. So, climate change has definitely influenced human health, as shown in Table 5.

Table 5: Effects of climate change on human health in Bangladesh and the USA

Location	**Affected conditions by climate change**	**Infected Diseases**	**Reference**
Bangladesh	Increasing frequency of heat waves	heatstroke, dehydration and aggravation of cardiovascular diseases in elderly people	Birdem Med J 2012; 2(2): 75-76
	Variable precipitation patterns	The floods and water logging that increase the incidence of diarrhoea, cholera and skin and eye diseases. Malnutrition increases vulnerability to water- and vector-borne diseases, including dengue in Dhaka. and Chittagong.	Birdem Med J 2012; 2(2): 75-76
	Rising sea levels	These increase Risk of coastal flooding, displacement, and health problems. such as cholera, diarrhoea, malnutrition and skin diseases, etc.	Birdem Med J 2012; 2(2): 75-76

Current estimates in chronic health conditions that interact with the health risks associated with climate change in the USA

Health conditions	Study period	Current estimates	Reference
Alzheimer's Disease	2010-2050	Approximately 5 million Americans over 65 had Alzheimer's disease in 2013	Hebert *et al.* (2013)
Asthma	2001-2010	Average asthma prevalence in the U.S. was higher in children (9% in 2014) than in adults (7% in 2013). Since the 1980s, asthma prevalence	NCHS (2015), CDC (2015), Akinbami *et al.* (2012),

		increased, but rates of asthma deaths and hospital admissions declined.	Moorman *et al.*(2012)
Chronic Obstructive Pulmonary Disease (COPD)	1980-2010	In 2012, approximately 6.3% of adults had COPD. Deaths from chronic lung diseases increased by 50% from 1980 to 2010.	CDC (2015), Kosacz *et al*. (2012)
Diabetes	2008-2012	Diabetes affects 9% of U.S. population, with type 1 and type 2 being more common.	CDC (2014)
Cardiovascular Disease	1970-2010	Cardiovascular disease (CVD) is the leading cause of death in the U.S.	Heidenreich *et al.* (2011)
Obesity	1999-2010, 2011-12	In 2009–2010, approximately 35% of American adults were obese. In 2012, approximately 32% of youth (aged 2–19) were overweight or obese.	Ogden *et al.* (2014) Flegal *et al.*(2012), Ogden *et al.*(2012)

Table 5 shows that heatstroke, dehydration, cardiovascular diseases, waterborne diseases, vector-borne diseases, cholera, diarrhea, malnutrition, and skin diseases are increasing in Bangladesh due to climate change. In addition, Table 5 also shows that due to climate change in the USA, Alzheimer's disease, asthma, chronic obstructive pulmonary disease, diabetes, cardiovascular disease, mental illness, obesity, and disability are increasing.

Mojid (2020) has mentioned that Bangladesh faces several climate change-related challenges in its socio-economic developments. The major challenges are (i) floods, (ii) droughts, (iii) riverbank erosion, (iv) sea-level rise and salinity intrusion, and (v) cyclones and storm surges. Challenge-causing events are directly impacted by climate change.

4. Conclusion

The study observed a negative relationship between climate change and economic development. It identified some climatic causes that increase water scarcity. These causes were drought, flood, salinity increase in surface and ground water, sea level rise, high temperatures, and tidal surge. The study illustrated that water scarcity caused negative impacts on economic growth and agricultural production. It harms the energy sector and the health sector as well. The study recommends some ways to help reduce water scarcity, including water infrastructure management, groundwater recharge, aquifer recovery and storage, saving water whenever possible, Education, harvesting and recycle water, advance technology related to water conservation, improve practices related to farming.

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