

## CLIMATE CHANGE EFFECTS ON LIVESTOCK PRODUCTION IN BANGLADESH AND ITS ECONOMIC IMPACTS

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### ABSTRACT

This study aims to understand how climate change affects livestock production in Bangladesh from 1971 to 2020 and its economic impacts. Different econometric tests, such as unit root tests, Johansen cointegration test, and the fully modified OLS (FMOLS) method, are used to conduct the study. The findings show that livestock production is negatively impacted by higher temperatures, increased precipitation, and greenhouse gas emissions. Greenhouse gas emissions leads to global warming and increase the mortality rate of livestock. Additionally, higher temperatures result in decreased metabolism, reduced feed intake, and increased heat stress. Excessive rainfall creates a damp and humid environment, leading to various diseases. On the other hand, lower temperatures and flood-affected areas have positive effects on livestock production. Warmer minimum temperatures improve water quality, reduce diseases and parasites, and enhance the breeding success of livestock. Floods provide increased water availability, sediments, nutrients, and more grassland. The economic influences caused by climate change in the livestock sector are massive. This has adverse effects on farms' profitability, employment rates, income, insurance expenses, production costs, and demand-pull inflation. Notably, from 2009 to 2020, the livestock industry suffers substantial economic losses due to climate change. To mitigate climate change's impact on livestock production in Bangladesh, implementing improved livestock management techniques, efficient water systems, resilient animal breeds, and alternative feed sources is crucial. Collaborative efforts between policymakers, agricultural institutions, and international organizations are essential to encouraging farmers to adopt climate-smart practices.

**Keywords:** Climate Change, Livestock Production, Economic Impacts

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## INTRODUCTION

Climate change is a global problem that is widely recognized as a critical environmental issue of the 21st century, posing significant challenges and having widespread effects on various socio-economic spheres. Bangladesh stands out as a highly vulnerable nation with respect to the risks posed by climate-related disasters and hazards (Agrawala et al., 2003). The Intergovernmental Panel on Climate Change (2007) predicted that the negative impact of climate change would continue to exacerbate the socio-economic situation in Bangladesh. Specifically, rural areas, where the local population heavily relies on livestock, fisheries, and agricultural pursuits for their sustenance, will suffer significant economic losses (IFAD, 2009). Agriculture and livestock production face particular vulnerability, especially in developing nations like Bangladesh.

Bangladesh's livestock sector stands as the nation's second-largest sector, following fisheries, in catering to the country's protein needs (BARC, 2011). The livestock industry in Bangladesh plays an indisputable role in fostering the nation's economic development, ensuring food and nutrition security, generating self-employment opportunities, and, of utmost significance, combating poverty (Bangladesh Economic Review, 2023). Livestock is rapidly growing in Bangladesh, contributing around 2 % to the GDP and over 16 % to the agriculture sector in FY 2021-22. With a livestock population of over 43 crores, the country is now self-sufficient in meat production, meeting the demand for 830 grams of meat per capita and supporting a significant portion of the population, with 20 % directly and 50 % indirectly dependent on the sector (Hossan, 2023).

The adverse consequences of climate change, marked by elevated temperatures, unpredictable rainfall variations, and severe weather occurrences, are now becoming more frequent and are predicted to worsen in the upcoming years. These changes in climate have detrimental impacts on livestock production and productivity worldwide, both in direct and indirect ways. Furthermore, climate change impact on livestock diversity, genetics, breeding practices, and overall livestock management (Ahmed et al., 2013).

According to Chauhan and Ghosh (2014) heat stress is the primary climate-related concern in Indian Sub-Continent which significantly hampers the overall performance and reproductive capabilities of livestock. Sutherst (1995) found that with the shifting pattern of temperature and rainfall, frequent breaking out of animal diseases could happen as carriers spread. In such a situation cattle face more tick infestations in Australia and New Zealand context. According to Ngarava et al. (2021), flooding had the greatest impact on small animals like sheep, chickens, pigs, goats, and cows, particularly for families living in areas prone to floods in South Africa. This led to a decrease in the number of sheep, cattle, goats, and poultry.

Hussain and Rehman (2022) found in Pakistan that over the long term, the production of milk, mutton, fats, skins, and blood is positively linked to increased CO<sub>2</sub> emissions.

Conversely, the production of poultry meat, eggs, hair, hides, bones, beef, and wool is associated with negative impacts on carbon dioxide emissions. Moreover, their short-term findings also indicated that milk, mutton, fats, skins, and blood production have a positive effect on CO<sub>2</sub> emissions, whereas poultry meat, eggs, hair, hides, bones, beef, and wool production are detrimental to carbon dioxide emissions.

Understanding the economic impacts caused by climate change is crucial for effective policymaking and adaptation plans. This study investigates through econometric methods how climate change affects livestock production in Bangladesh and its economic impacts, shedding light on vulnerabilities faced by different groups and enabling the development of strategies to enhance resilience and eco-friendly practices.

## MATERIALS AND METHODS

### Data Collection

This study makes use of annual time series data ranging from 1971 to 2020. The data were sourced from various secondary references. Average precipitation and temperature data, including both minimum and maximum values, were obtained from the climate change knowledge portal (Climate Change Knowledge Portal, 2021). Greenhouse gas emissions data and information regarding flood-affected regions were collected from two distinct sources: the CO<sub>2</sub> country profile for Bangladesh by Hannah Ritchie and Max Roser (Hannah et al., 2020), and the Bangladesh Water Development Board (Annual Flood Report, 2020), respectively. The livestock production index (2014-2016=100) serves as a proxy for livestock production, and the relevant data were gathered from the World Bank (The World Bank, 2023).

### Model Specification

To approximate the data, this investigation centers on five climate change-related factors in Bangladesh: emissions of greenhouse gases, areas affected by floods, average precipitation, as well as the minimum and maximum temperatures. The log-log model is used for the analysis. A log-log model, which involves taking the logarithm of both the independent and dependent variables, is employed to address nonlinearity, stabilize heteroscedasticity, enhance interpretability, simplify complex relationships, handle multiplicative effects, reduce data skewness, improve the residual distribution for regression, and analyze percentage changes in variables in various fields. The examination takes into account the subsequent model:

$$\text{LNLSTOK}_t = \alpha_0 + \alpha_1 \text{LNGREHG}_t + \alpha_2 \text{LNFLOOD}_t + \alpha_3 \text{LNPCIPT}_t + \alpha_4 \text{LNTEMPRMIN}_t + \alpha_5 \text{LNTEMPRMAX}_t + U_t \dots \dots \dots (i)$$

Where, LNLSTOK = Log of livestock production index, LNGREHG = Log of greenhouse gas emissions, LNFLOOD = Log of flood affected area, LNPCIPT = Log of precipitation, LNTEMPRMIN = Log of minimum temperature, and LNTEMPRMAX = Log of maximum temperature.

### Econometric Methods

To assess the stationarity of the variables, we employed the augmented Dicky-Fuller (1979) and Phillips-Perron (1988) tests. We used the fully modified OLS (FMOLS) model to show how climate change affects livestock productivity.

The FMOLS technique offers significant advantages across various aspects. It excels in producing dependable parameter estimates, even when dealing with limited sample sizes. Furthermore, it effectively tackles complex issues such as endogeneity, serial correlation, omitted variable bias, and measurement errors. Notably, this approach accommodates variations in long-term parameters, as evidenced by the research of Kalim and Shahbaz (2009) and Fereidouni et al. (2017). Prior to applying FMOLS, it is crucial for the variables to demonstrate co-integration at the first difference. In our analysis, all variables exhibit co-integration.

## RESULTS AND DISCUSSION

### Descriptive Statistics

The variables' descriptive statistics from 1971 to 2020 are shown in Table 1. The mean, median, maximum, and minimum values for each variable are illustrated in the table.

Table 1. Descriptive statistics

	Lnrehg	Lnlflood	Lnpcipt	Lntemprmin	Lntemprmax	Lnlstok
Mean	0.2222	9.9634	7.7018	3.0380	3.4135	3.9955
Median	0.1864	10.2611	7.7056	3.0342	3.4121	4.0232
Max	0.5247	11.5154	7.9531	3.0763	3.4528	4.7361
Min	0.0295	6.0378	7.4260	2.9997	3.3891	3.3428
Observations	50	50	50	50	50	50

Source: Eviews software on the basis of annual time series data (1971-2020).

### Unit Root Test

To evaluate the stationarity of the variables under study, we utilized the augmented Dickey & Fuller (1979) and Phillips & Perron (1988) unit root tests. The outcomes, which are displayed in Tables 2 and 3, reveal that the unit root tests were carried out twice. Initially, they were conducted on the original levels of the variables, and subsequently on the first difference. These tests were performed using various specifications, including constant, constant and trend, and none. The results from both tests demonstrate that all the variables exhibit stationarity at the first difference, meaning their integrated order is  $I(1)$ .

Table 2. Augmented Dickey-Fuller (ADF) unit root test

Variables	Level			First Difference		
	Constant	Constant and Trend	None	Constant	Constant and Trend	None
LNGREHG	0.50	0.83	0.37	0.00***	0.00***	0.00***
LNFLLOOD	0.99	0.30	0.56	0.02**	0.01**	0.00***
LNPCIPT	0.00***	0.00***	0.68	0.00***	0.00***	0.00***
LNTEMPRMIN	0.00***	0.00***	0.74	0.00***	0.00***	0.00***
LNTEMPRMAX	0.00***	0.00***	0.68	0.00***	0.00***	0.00***
LNLSTOK	0.96	0.27	0.99	0.00***	0.00***	0.00***

Source: Eviews software on the basis of annual time series data (1971-2020). Notes: \*\*\* P<0.01, \*\*P<0.05.

Table 3. Phillips-Perron (PP) unit root test

Variables	Level			First Difference		
	Constant	Constant and Trend	None	Constant	Constant and Trend	None
LNGREHG	0.48	0.91	0.38	0.00***	0.00***	0.00***
LNFLLOOD	0.00***	0.00***	0.65	0.00***	0.00***	0.00***
LNPCIPT	0.00***	0.00***	0.74	0.00***	0.00***	0.00***
LNTEMPRMIN	0.00***	0.00***	0.82	0.00***	0.00***	0.00***
LNTEMPRMAX	0.00***	0.00***	0.74	0.00***	0.00***	0.00***
LNLSTOK	0.97	0.27	0.99	0.00***	0.00***	0.00***

Source: Eviews software on the basis of annual time series data (1971-2020). Notes: \*\*\* P<0.01, \*\*P<0.05.

### Co-integration Test

Determining the ideal lag length is crucial prior to conducting cointegration tests, as it significantly affects the outcomes of these tests. To identify the optimal lag length, an unrestricted vector auto regression (VAR) technique was utilized. Various lag selection criteria, including LR, FPE, SC, and HQ, predominantly support the selection of a single lag. Consequently, a cointegration test was performed with a lag length of one. Table 4 displays the results of the Johansen (1988) cointegration analysis, including that both the trace statistics and Max-Eigen statistics indicate the existence of four and three cointegrating equations, respectively, at significance levels of 1%, 5%, and 10%. This confirms a long-term relationship between livestock production and explanatory variables.

Table 4. Results of Co-integration Test

No. of CE(S)	Trace statistic value	Prob.	Max-Eigen statistic value	Prob.
None	133.53***	0.00	0.46.24***	0.00
At most 1	87.28***	0.00	27.60	0.23
At most 2	59.68***	0.00	26.15*	0.07
At most 3	33.53**	0.01	20.28*	0.06
At most 4	13.24	0.10	11.09	0.14
At most 5	2.15	0.14	2.15	0.14

Source: Eviews software on the basis of annual time series data (1971-2020). Notes: \*\*\* P<0.01, \*\*P<0.05, \*P<0.10.

### Estimated Results of Fully Modified OLS (FMOLS) and Discussion

The study utilized an advanced regression technique, fully modified OLS (FMOLS), to obtain its results. It is evident that greenhouse gas emissions (LNGREHG) are linked to a reduction in livestock (LNLSTOK) production, but it is insignificant (Table 5). The release of greenhouse gases, such as carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>), leads to global warming, causing a rise in overall temperatures. This has negative effects on heat-sensitive livestock like dairy cattle and poultry in Bangladesh. It reduces their food consumption, decreases milk production, affects their ability to reproduce, and raises the risk of mortality. Livestock are significantly impacted by temperature variations as they affect essential factors like rainfall, forage availability, production, reproduction, and overall health. Forage production, for instance, is influenced by elevated temperatures, increased CO<sub>2</sub> levels, and variations in precipitation (Sawalhah et al., 2019).

From Table 5, we see that the maximum temperature (LNTEMPRMAX) has negative and significant effects on livestock (LNLSTOK) production, and it is very high (-21.158). It means that a 1% increase in the maximum temperature leads to a 21.158% decline in livestock production. Changes in the climate can induce discomfort in livestock and poultry. When temperatures rise, their metabolism accelerates, resulting in reduced growth rates among the animals. Consequently, this decline in growth negatively impacts the production of meat, milk, and eggs (Ministry of Environment and Forestry, 2009). Conversely, higher ambient temperatures are associated with reduced feed intake, leading to decreased overall production (Mack et al., 2013). Elevated maximum temperatures may lead to heat stress in livestock, causing harmful changes in their physiology and metabolism that negatively affect their overall well-being, productivity, and ability to reproduce. Rising temperatures have notable and negative consequences on livestock productivity, impacting various aspects, including the animals' thermoregulation abilities (DeShazer, et al., 2009). Rising temperatures and diminished precipitation lead to decreased rangeland

productivity and exacerbate their deterioration. Elevated temperatures are known to hinder animals' appetite and result in reduced efficiency in converting feed (Rowlinson, 2008).

From the analysis it has been observed that precipitation (LNPCIPT) has negative and significant impacts on livestock production. Elevated levels of rainfall can create favorable conditions for the rapid growth of disease-causing microorganisms and parasites. Damp and humid environments serve as breeding grounds for ailments such as foot and mouth disease, mastitis, and various gastrointestinal infections, greatly affecting the health and efficiency of livestock. The heavy precipitation poses significant challenges for managing livestock, as it can damage infrastructure and make roads inaccessible. This hinders the transportation of crucial resources like feed, water, and veterinary services. Additionally, inadequate shelter and drainage systems increase animal stress and vulnerability to diseases. The consequences of climate change, such as temperature fluctuations and irregular rainfall patterns, can lead to the emergence and spread of vector-borne diseases and the proliferation of parasites and new infections (Thornton & Herrero, 2008).

We got positive and significant effects of minimum temperature (LNTEMPRMIN) on livestock (LNLSTOK) production and the coefficient is very high (22.563). It means that a 1 % increase in the minimum temperature leads to a 22.563% increase in livestock production. Warmer, moderate minimum temperatures can hinder their survival and reproduction, resulting in reduced disease and parasite burdens on livestock and ultimately increasing their production. The connection between moderate minimum temperatures and livestock production is intricately tied to environmental factors, which indirectly influence the process. Warmer, moderate minimum temperatures create a more favorable environment for reproduction, leading to improved breeding success and higher livestock productivity. Warmer minimum temperatures improve grass nutritive value, positively impacting the health of livestock. However, higher temperatures lead to a decrease in grass's nutritive value due to methane production. These elevated temperatures are correlated with higher levels of NDF (Neutral detergent fiber), an essential parameter for assessing feed and forage quality, particularly in livestock nutrition. On the other hand, low temperatures ( $< 0^{\circ}\text{C}$ ) result in lower NDF values (Lee, et. al., 2007).

Finally, we got positive and significant impacts from the flood affected area (LNFLOOD) on livestock (LNLSTOK) production (Feng et al., 2021), which was not expected. In Bangladesh, floods bring abundant water resources to the affected regions, creating favorable conditions for livestock farming. Adequate water is essential for rearing livestock and maintaining fodder crops for their sustenance. The country's floodplains, when the waters recede, provide lush vegetation that serves as natural grazing land for animals, improving their feeding conditions. Additionally, the floodwaters carry sediments and nutrients that enrich the soil in these areas, enhancing the nutritional value of the vegetation and fodder, which positively affects the health and productivity of the livestock.

Table 5. Results of fully modified OLS (FMOLS)

Dependent variable: LNLSTOK

Variables	FMOLS			
	Coefficient	Std. error	t-statistics	Prob.
C	25.965	20.3367	1.2767	0.21
LNGREHG	-0.282	0.5965	-0.4731	0.64
LNFLLOOD	0.268	0.0775	3.4594	0.00***
LNPCIPT	-2.706	0.5625	-4.81	0.00***
LNTEMPRMIN	22.563	6.2844	3.5904	0.00***
LNTEMPRMAX	-21.158	8.8334	-2.3953	0.02**
R <sup>2</sup>	0.44			

Source: Eviews software on the basis of annual time series data (1971-2020). Notes: \*\*\* P<0.01, \*\*P<0.05.

### Economic Impacts

Livestock production faces significant economic losses due to heat stress. This condition visibly impacts various aspects, such as reduced feed consumption, decreased production efficiency concerning milk yield or weight gain per unit of feed energy, slowed growth rate, diminished egg production, and impaired reproductive efficiency (Daramola et. al., 2012). Rising temperature is likely to result in more expensive energy, with electricity and fuel prices going up. This could directly affect the financial viability and expenses involved in livestock farming, possibly leading to decreased investments in the industry. As a consequence, overall productivity and output may suffer with possibility of increased unemployment challenges in Bangladesh in the livestock sector. Climate change-induced illnesses may cause a substantial number of livestock succumb to the diseases, resulting in significant financial setbacks for the farmers. Consequently, many find themselves compelled to abandon this profession. Many people are employed in food industry, that is consuming significant quantities of chicken, meat, beef, eggs, and mutton on a daily basis to cater to customer demands. However, challenges in livestock production can impede the growth of this business and result in a decline in job opportunities.

Climate change may pose threats of the scarcity of feed and water. The changing patterns of precipitation and rising temperatures affect the availability and quality of fodder and water resources for livestock, leading to increased production costs, including investments in cooling systems for animals, water management infrastructure, and measures to control emerging pests. Extreme weather events such as cyclones, floods, and storms further compound the problems by causing damage to livestock shelters, barns, and other infrastructure, resulting in a substantial financial burden for farmers who must rebuild or repair these facilities. Moreover, the



disruptions caused by climate change throughout the livestock supply chain affect feed manufacturers, veterinarians, traders, and other stakeholders, leading to market instability and volatility that can negatively affect the income of livestock farmers. Additionally, as climate risks rise, farmers may experience higher insurance costs as they seek to protect their livelihoods from climate-related risks, which in turn results in increased insurance premiums. Addressing these multifaceted challenges requires implementing comprehensive adaptation and mitigation strategies to enhance the sector's resilience and protect the livelihoods of farmers.

The elevated temperatures negatively impact both milk yield and composition in dairy livestock, particularly those of superior genetic quality (Wheelock et al., 2010). Climate change induces strain in domesticated animals and birds. Elevated temperatures result in heightened body metabolism, subsequently impeding livestock growth and leading to decreased meat, milk, and egg output (Ministry of Environment and Forestry, 2009). The reduced productivity in livestock production leads to a scarcity of meat, milk, eggs, and its by-products like leather, resulting in a rise in demand-pull inflation. Bangladesh's leather sector has emerged as the nation's second-most significant contributor to foreign currency earnings, trailing only behind the RMG industry. Various items, such as bags, shoes, belts, jackets, hats, and wallets, are manufactured from animal skin. The success and growth of the leather industry are closely tied to the availability of livestock skin. However, the leather industry's profitability and job opportunities are adversely impacted by the low productivity of livestock, including cows, buffaloes, goats, horses, and sheep.

Between 2009 and 2020, the livestock industry experienced a substantial economic decline of 80,145.16 million Takas as a consequence of climate change. Specifically, the financial losses attributable to drought amounted to 1,268.14 million Takas, while floods accounted for 45,329.29 million Takas, water logging for 3,194.99 million Takas, and cyclones for 16,504.51 million Takas (Bangladesh Disaster-related Statistics, 2015 & 2021). Ensuring an appropriate temperature is crucial when it comes to designing shelters and making husbandry choices for vulnerable cold-sensitive creatures like poultry, swine, and young animals. Severe cold spells or power outages in enclosed animal facilities can lead to financial losses due to higher rates of animal sickness and mortality (Mader, 2003).

As the impact of climate change continues to grow, it is becoming increasingly probable that extreme weather events such as droughts and floods will become more frequent. In non-grazing systems, where animals are kept in controlled environments, the direct consequences of climate change are expected to be limited. Instead, the major effects will likely be indirect, primarily affecting agricultural production through reduced yields and higher prices of animal feed. To address the situation, the adoption of energy-saving programs like bio carburants is being considered, although it is important to note that this may also lead to a rise in energy prices (OECD-FAO, 2008). Finding a balanced and sustainable approach to mitigate these potential challenges is of paramount importance for the future of agriculture and food security.

## CONCLUSION

Due to climate change, Bangladesh suffered substantial economic losses in livestock industry. The study revealed that higher temperatures, and increased precipitation, negatively impacted livestock production by promoting the spread of animal diseases, lowering metabolism, reducing food consumption and increasing the heat stress to animals. Too much rain creates a damp and humid environment, leading to the occurrence of various diseases. Conversely, lower temperatures and flood-affected areas had positive effects on livestock production. Warmer minimum temperatures have positive effects on water quality, to help reduce diseases, parasites and improve breeding success of livestock. The lower yield caused negative consequences for farms' profitability, employment rates, income, insurance expenses, production costs, and demand-driven inflation. The key to mitigating climate change's impact on livestock production in Bangladesh lies in implementing improved livestock management techniques, efficient water systems, resilient animal breeds, and alternative feed sources. Collaborative efforts between policymakers, agricultural institutions, and international organizations are crucial to supporting and incentivizing farmers to adopt climate-smart practices.

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