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The Impacts Of Climate Change On Agricultural Profitability And Productivity In Chapai Nawabganj, Bangladesh

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Abstract

Agricultural production is the backbone of the economy of Bangladesh. It provides livelihoods for millions and ensuring food security, but the profitability and productivity are increasingly strained by climate-induced stresses. This study is an effort to assess the impacts of climate change on agricultural profitability and productivity with focus on major crops, including rice, wheat, and mustard in Chapai Nawabganj district, Bangladesh. A simple random sampling is used to collect primary data from 300 farmers in two unions of Shibganj Upazila. A profit function was used to determine whether the major crops production was profitable or not and Cobb-Douglas production function was also applied to assess the factors of these prime crop production in the study area. The result reveals that the major crops production including rice, wheat, and mustard are profitable per bigha with the values of 34,086.26 BDT, 17,575.57 BDT, and 26,299.79 BDT respectively in the study area but not satisfactory according to farmer's opinion. Labor, pesticides, and transport were the three most important factors causing rice production while fertilizer and labor were the contributing factors of wheat and mustard respectively. Besides, among 300 respondents, the largest proportion (24.67%) reported average annual financial losses of BDT 20,001–25,000 due to pests, diseases, droughts, strong winds, or high temperatures. To combat climate change impacts in Chapai Nawabganj, policies should focus on promoting climate-resilient crops, efficient water management, soil health improvement, and sustainable agricultural practices, enhance access to credit, insurance, and market infrastructure. In addition, invest in farmer training, climate information systems, and public-private partnerships for adaptive technologies may be way of improving sustainable agricultural productivity.

Keywords: Climate Change, Profitability in Agriculture, Crop productivity, Cobb-Douglas Production Function, Climate-Resilient Farming, Bangladesh.

1.Introduction

Bangladesh's economy is predominantly agricultural oriented employing and feeding nearly 50% of its population and enhancing food and income security. The agricultural sector, however, bears a diminishing profit attributed to various negative impacts of climate change on the production (Islam et al., 2023; Sultana et al., 2023; Rahman et al., 2022). Over the past few decades, this country has been particularly subject to climate change impacts due to its location and climatic conditions. This includes rise in temperature with irregular precipitation patterns, flooding, and long dry seasons making cultivation nearly impossible and raising risks of production most especially for the staple crops (Ali et al., 2023; Esha, and Rahman,2021; Alam, K. 2015). Notably in a productive district, Chapai Nawabganj where mango and rice farming is prevalent, especially elevation of temperature has brought challenges in the farmers' socio-economic status (Ghosh et al., 2023; Abdullah et al., 2021; Rahman, and Khatun, 2019).

The local farmers are experiencing a decline in the growing seasons, changes in the seasons of rainfall, and the spread of pests which affect the yield and profitability of the crops grown (Sohel, M. H et al. 2019). For instance, in a study conducted by Meghla, T. and Rahman, M. S. (2020); in rural Bangladesh, unfashionable rains were associated with decreased crop output due to unfavorable agricultural yield conditions. Furthermore, the study established that increasing costs of inputs for example water, fertilizers, and pesticides have not only disrupted climatic patterns but have also lowered net returns to the farmers (Rahman Shaibur, M et al. 2018). It is found that other aspects such as education, the size of the landholding, and the level of technology available to the farmers are very crucial in enabling the farmer's effective response to the climatic challenges (Ghosh, M. K et al. 2023). For instance, (Chowdhury, M. A. et al. 2022; Karmakar, S. 2019; Meghla, T., and Rahman, M. S. 2020) showed that facilitating access to better technologies and agricultural information improved the ability of farmers in the northern regions of Bangladesh to cope with the adverse impacts of climate change.

However, in Chapai Nawabganj, factors including low literacy, poverty, and weak infrastructure create significant barriers to transition. These socio-economic factors further increase the degree of exposure of the small-scale farmers to both environmental and economic shocks (Ektear Uddin,

M et al. 2018). The issue of climate change is very crucial since it not only affects crops but also market prices for agricultural products, and therefore it directly affects the revenues of the farmers (Sultana, R et al. 2023). Similar studies have been done in other agrarian regions, for example, the West Bengal region in India and Nepal, among others. For instance, in West Bengal, Sarkar, M., and Modak, B. K. (2024) similarly found that the incidence of extreme weather variability resulted in lower farm output with farmers reporting a loss of 20-30% of incomes. In the same spirit, (Ratul, A. A et al. 2023) in Nepal observed that farmers were also forced to change their crops or drop farming altogether because erratic weather patterns and high input prices were deteriorating prospects for crop production. These results point to the increased effect of climate change outside agriculture in the South Asian region, calling for appropriate sector-specific mitigation measures to protect and sustain agricultural livelihood systems.

In response to the urgency of these challenges, this study focuses on understanding the socio-economic status of farmers in Chapai Nawabganj and evaluating the viability of agricultural production in relation to climate impact. One of the important components of this research task is determining the factors affecting the profitability of the crops grown around the region with a focus on dominant crops such as rice, mustard and wheat which supports the economy greatly. Moreover, this study will assess the possible effects of climate change on yields of crops and discuss possible ways in which the negative impacts can be avoided. The outcomes of the present study are anticipated to provide useful insights for policy initiatives that foster productive agriculture without compromising the environment in Chapai Nawabganj.

2. Research Methodology

2.1 Study area and Survey Design

The study uses primary and secondary data from two unions in ShibganjUpazilla, Bangladesh, with 300 farmers selected using simple random sampling. Secondary data is collected from various sources, including books, journals, newspapers, and publications. The study's geographical location is provided by a map.

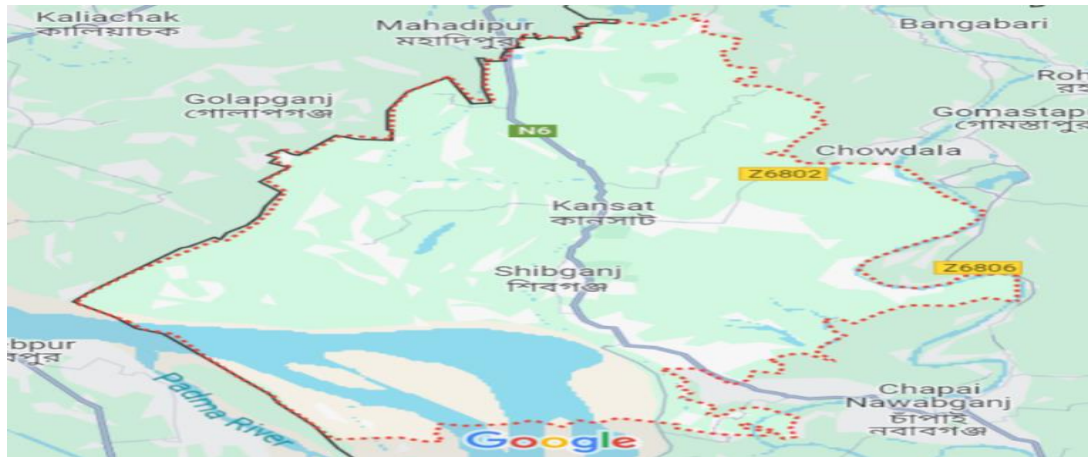


Figure .1 Map of the study area

Source: www.google.com, 2024

2.2 Profitability Analysis

The study uses a profit equation to analyze the profitability of crop production practices in the study area, calculating total revenue and total cost, which includes variable costs like seeds, cultivation, irrigation, fertilizers, pesticides, labor, and transportation. Therefore the following profit equation is applied to assess the profitability of Crop farming practices in this study.

$$\Pi = TR - TC$$

Where Π = profit or net return, TR = total revenue and TC = total cost.

2.3 The Cobb-Douglas Production Function

The Cobb-Douglas production function is used in this study to estimate the effects of factor inputs on agricultural production. The Cobb-Douglas production function is specified:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} X_7^{\beta_7} X_8^{\beta_8} e^u \dots \dots \dots (1)$$

Equation (1) is an exponential function. This function can be transformed into a linear function by taking logarithm to both sides of equation (1) as follows:

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + u \dots (2)$$

2.4 Econometric Model for Rice Production

$$\ln Y_1 = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + u \dots (2)$$

Where Y1 is the value of average rice yield, X_1 is cost of seed (TK.), X_2 is cost of Cultivation (TK.), X_3 is cost of Irrigation (TK.), X_4 is cost of fertilizers (TK.), X_5 is cost of Pesticides (TK.), X_6 is cost of labor (TK.), X_7 is cost of Transportation (TK.), and X_8 is others cost (TK.), All variables are measured considering per bigha rice production income per year. Ln is a natural logarithm; β_0 is intercept constant term; U_i is error term. Finally, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ are regression coefficients or parameters of the respective variables to be estimated.

2.5 Econometric Model for Wheat Production

$$\ln Y_2 = \ln \alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \alpha_6 \ln X_6 + \alpha_7 \ln X_7 + \alpha_8 \ln X_8 + U_i \dots (2)$$

Where Y2 is the value of average wheat yield, X_1 is cost of seed (TK.), X_2 is cost of Cultivation (TK.), X_3 is cost of Irrigation (TK.), X_4 is cost of fertilizers (TK.), X_5 is cost of Pesticides (TK.), X_6 is cost of labor (TK.), X_7 is cost of Transportation (TK.), and X_8 is others cost (TK.), All variables are measured considering per bigha wheat production income per year. Ln is a natural logarithm; α_0 is intercept constant term; U_i is error term. Finally, $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8$ are regression coefficients or parameters of the respective variables to be estimated.

2.6 Econometric Model for Mustard Production

$$\ln Y_3 = \ln \gamma_0 + \gamma_1 \ln X_1 + \gamma_2 \ln X_2 + \gamma_3 \ln X_3 + \gamma_4 \ln X_4 + \gamma_5 \ln X_5 + \gamma_6 \ln X_6 + \gamma_7 \ln X_7 + \gamma_8 \ln X_8 + U_i \dots (2)$$

Where Y3 is the value of average mustard yield, X_1 is cost of seed (TK.), X_2 is cost of Cultivation (TK.), X_3 is cost of Irrigation (TK.), X_4 is cost of fertilizers (TK.), X_5 is cost of Pesticides (TK.), X_6 is cost of labor (TK.), X_7 is cost of Transportation (TK.), and X_8 is others cost (TK.), All variables are measured considering per Bigha mustard production income per year. Ln is a natural logarithm; γ_0 is intercept constant term; U_i is error term. Finally, $\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6, \gamma_7, \gamma_8$ are regression coefficients or parameters of the respective variables to be estimated.

2.7 Data and Explanation of the key variable

Table 1: List of variable with explanation

| Variable Name | Explanation | Measure. Unit | Expec. Sign |
|--|--|---------------|-------------|
| Dependent variable- crop production income | Annual income (Sale of crop per bigha) | BDT/Year | |
| Explanatory variable | | | |
| Seed | Cost of crop production(per acre) | BDT/Year | + |
| Cultivation | Cost of crop production(per acre) | BDT/Year | + |

| | | | |
|----------------|-----------------------------------|----------|---|
| Irrigation | Cost of crop production(per acre) | BDT/Year | + |
| fertilizer | Cost of crop production(per acre) | BDT/Year | + |
| Pesticides | Cost of crop production(per acre) | BDT/Year | + |
| Labor | Cost of crop production(per acre) | BDT/Year | + |
| Transportation | Cost of crop production(per acre) | BDT/Year | + |
| Others | Cost of crop production(per acre) | BDT/Year | + |

Source: Author's Own Calculation, 2024

For attaining the study objectives, the dependent variable is crop production income which is taken as annual income (Sale of crop) and measured by BDT/Year. The explanatory variables are seed, cultivation, irrigation, fertilizers, pesticides labor, transport and others which are taken as cost of per bigha crop production and measured by BDT/Year. The expected sign are shown by the above table.

3. Discussion Of Results

3.1 Table 2: Summary Statistics of Socioeconomic Variables of Study Area

| Variables | Mean | Standard Deviation | Minimum | Maximum |
|-------------------------------------|-------------------------------|--------------------|---------|---------|
| Age (years) | 39.33 | 6.53 | 20 | 65 |
| Education Level(Year of Schooling) | 9.42 | 2.14 | 0 | 19 |
| Family Members | 1.8 | 0.667 | 1 | 7 |
| Second Profession Income | 16834 | 6474.07 | 4,000 | 30,000 |
| Household Agricultural based Income | 28333 | 5111.23 | 10,000 | 75,000 |
| Monthly Expenses | 18,834 | 5213.69 | 9000 | 60,000 |
| Land Under Cultivation (Bigha) | 5.83 | 3.36 | 1 | 15 |
| Market Access (%) | 76.67 | 15.55 | 12 | 88 |
| Agricultural Experience (Years) | 13.83 | 7.57 | 2 | 25 |
| Occupation | Agriculture(1 st) | | 40.00 | |
| | Agriculture(2 nd) | | 60.00 | |
| | Service | | 27.77 | |
| | Business | | 33.33 | |
| | Labor(non-agri) | | 27.77 | |
| | Rural transport | | 5.55 | |
| | Total | | 100.00 | |
| Hosing Condition | Pucca | | 50.00 | |
| | Adha-pucca | | 33.33 | |
| | kutchha | | 16.66 | |
| | Total | | 100.00 | |

Source: Author's Own Calculation based on Survey Data, 2024

The table summarizes the study's sample demographic, occupational, income, and housing conditions. The mean age of the sample is 39.33 years, and the education level is quite uniform with a mean of 9.42 years. Families tend to be small with an average of 1.8 members and a maximum of 7 members. The average monthly income of respondents from secondary professions is 16,834 BDT, while their earnings from agriculture stand at an average of 28,333 BDT showing the need to diversify in earnings. On average, they spend 18,834 BDT on provisions every month indicating the expenses are for the sustenance. The respondents cultivated an average of 5.83 bighas with 76.67% market access and had an average of 13.83 years of farming experience. In terms of occupation, 60%, with agriculture being the primary occupation, while 27.77% are engaged in services, 33.33% in business, 27.77% in labor and 5.55% in transportation. Participants owned pucca houses (50%), adha-pucca (33.33%) and kutchha (16.66%) houses demonstrating differences in their living conditions. This information paints a picture of a rural economy with multiple sources of livelihood and differences in housing quality.

3.2 Table 3: Profitability Measurement of Rice Production (BDT)

| Input cost and output value per Bigha | Amount/Bigha | Percentage of total cost |
|--|---------------------|---------------------------------|
| 2. Seed cost | 513.09 | 2.52 |
| 3. Cultivation cost | 2491.28 | 12.22 |
| 4. Irrigation cost | 2501.82 | 12.28 |
| 5. Fertilizer cost | 3458.12 | 16.97 |
| 6. Pesticides cost | 1351.46 | 6.63 |
| 7. Labor Cost | 9627.35 | 47.26 |
| 8. Transport cost | 345.30 | 1.70 |
| 9. Other cost(equipment) | 84.10 | 0.41 |
| 10. Total cost(TC) | 20372.51 | 100 |
| 11. Total value of production(TR) | 54458.77 | |
| 12. Profit(TR-TC) | 34086.26 | |

Source: Author's Own Calculation based on Survey Data, 2024

Table 3 gives an analysis of the profitability of rice planting on one bigha of land expressed in Bangladeshi Taka (BDT), including its input costs and the total value of production. It can be observed that labor cost contributes the highest to production cost accounting for 47.26% (9,627.35 BDT) of the production cost per bigha of 20,372.51 BDT which is the total cost of production inputs. Fertilizer cost at 3,458.12 BDT, represents 16.97% while water (irrigation) and cultivation costs take 12.28% and 12.22% respectively. Other costs are for, pesticides 6.63%, seeds 2.52%, transportation and transport related infrastructure 1.70%, and 0.41% for general equipment. Every bigha of land under rice production fetches a revenue of 54,458.77 BDT that after total costs leaves

behind a profit of 34,086.26 BDT. This profit figure infers that there is high yield of return depending on the amount invested and therefore rice production does very well in the area covered by the study, This data also emphasizes on how much labor and fertilizers are used in the process of production, which points out that if these costs are optimized, profitability might be improved. This evaluation of profitability, which relies on survey conducted in 2024, is useful in understanding how costs are distributed, and the economics of rice cultivation in the area.

3.3 Table 4: Profitability Measurement of Mastard Production (BDT)

| Input cost and output value per Bigha | Amount/Bigha | Percentage of total cost |
|--|---------------------|---------------------------------|
| 2. Seed cost | 334.70 | 4.15 |
| 3. Cultivation cost | 1697.96 | 21.08 |
| 4. Irrigation cost | 512.43 | 6.36 |
| 5. Fertilizer cost | 2856.39 | 35.46 |
| 6. Pesticides cost | 637.40 | 7.91 |
| 7. Labor Cost | 1717.14 | 21.31 |
| 8. Transport cost | 211.58 | 2.63 |
| 9. Other cost(equipment) | 88.60 | 1.10 |
| 10. Total cost(TC) | 8056.20 | 100 |
| 11. Total value of production(TR) | 34355.98 | |
| 12. Profit(TR-TC) | 26299.79 | |

Source: Author's Own Calculation based on Survey Data, 2024

Table 4 summarizes the profitability analysis on mustard production (BDT/ Bigha). The input cost incurred for mustard production is 8,056.20 BDT per bigha of land and fertilizer cost constitutes the maximum share of the costs accounting for 35.46% (2,856.39 BDT) of total cost. In addition to that, labor cost at 21.31% (1,717.14 BDT) and the cost of cultivation at 21.08% (1,697.96 BDT) are also considerable costs within the total cost basket. The remaining costs are of pesticides at 7.91%, irrigation at 6.36%, seeds at 4.15%, transport at 2.63% and other equipment costs at a relatively lower 1.10% within the overheads. The overall income earned through production of mustard seeds stands at 34,355.98 BDT per bigha which leaves a net of 26,299.79 BDT profit after total costs have been reported. This measure of profitability suggests that there is great potential in investment, indicating that growing mustard in the study region is economically feasible. The main costs being incurred are mainly in the areas of fertilizers, labor and cultivation which means that it is important to optimize these costs if higher profits are to be achieved.

3.4 Table 5: Profitability Measurement of Wheat Production (BDT)

| Input cost and output value per Bigha | Amount/Bigha | Percentage of total cost |
|--|---------------------|---------------------------------|
| 2. Seed cost | 1062.44 | 10.53 |

| | | |
|-----------------------------------|----------|-------|
| 3. Cultivation cost | 1861.81 | 18.45 |
| 4. Irrigation cost | 1225.43 | 12.14 |
| 5. Fertilizer cost | 2393.03 | 23.71 |
| 6. Pesticides cost | 666.87 | 6.60 |
| 7. Labor Cost | 2568.91 | 25.46 |
| 8. Transport cost | 245.99 | 2.44 |
| 9. Other cost(equipment) | 66.52 | 0.66 |
| 10. Total cost(TC) | 10091.02 | 100 |
| 11. Total value of production(TR) | 27666.59 | |
| 12. Profit(TR-TC) | 17575.57 | |

Source: Author's Own Calculation based on Survey Data, 2024

According to Table 5, wheat production profit analysis is performed on a per bigha basis in Bangladesh Taka(BDT). The total input cost of producing wheat works out to be 10,091.02 BDT per bigha. Labor costs account for the highest share of expenses, accounting for 25.46% (2,568.91 BDT) that of total costs, while costs for fertilizers accounting for 23.71% (2,393.03 BDT) is just behind it. Expenses on cultivation account for 18.45% (1,861.81 BDT), and seeds account for 10.53% (1,062.44 BDT) of this total. Irrigation water is required also at 12.14%, and pesticides account for 6.60%. Transport costs along with other machinery expenses are small, accounting for only 2.44% and 0.66% respectively. The total income earned as a result of growing wheat is 27,666.59 BDT bigha wise making a profit of 17,575.57 BDT net of all the expenditures on inputs. This measure of profitability suggests that the investment outlay for producing wheat in the area of the study is worthwhile. Meanwhile, because of high labor and fertilizer and cultivation costs, attempts to control these costs would be beneficial.

3.5 Table 6: Regression Result of Factors Affecting Rice production

| Variable name | Coefficient. | Robust Std. Err. | P- value |
|-------------------|--------------|------------------|----------|
| Seed | 0.0163* | 0.0911 | 0.059 |
| Cultivation | 0.0676 | 0.0406 | 0.101 |
| Irrigation | 0.0590* | 0.1373 | 0.072 |
| Fertilizer | 0.0418* | 0.0227 | 0.080 |
| Pesticides | 0.2116** | 0.0789 | 0.014 |
| Labor | 0.2690*** | 0.0584 | 0.000 |
| Transport | 0.0512** | 0.0235 | 0.041 |
| Other (equipment) | 0.0631** | 0.0292 | 0.042 |
| -cons | 7.0810*** | 0.3387 | 0.000 |

N= 300; F(8, 292); = 97.73; Prob.>F= 0.0000 ; R² = 0.9657; VIF=8.77

Note: Significant at: *p<0.01, **p<0.05, *p<0.1**

Source: Author's Own Calculation based on Survey Data, 2024

Table 6 provides an analysis of the regression results concerning the factors that affect the production of rice. The model investigates the other input variables with their respective coefficients, standard errors and p- values. The coefficient of determination R^2 is high at 0.9657 which shows that the model explains around 96.57 percent of the variation of rice output production, which is considered a good fit. Out of the different variables, labor has the most pronounced and positive effect on rice production, with a coefficient of 0.2690 ($p < 0.01$) showing that an increase in labor input leads to even more production. Pesticides also have a favorable effect on production that is represented by the coefficient of 0.2116 at $p < 0.05$ which demonstrates that production is enhanced by efforts put to control pests. Transportation and equipment costs also relate positively to production and both recorded a significance at $p < 0.05$ level. Fertilizer (0.0418), water (0.0590), and seed (0.0163) are considered to be additive inputs but are only weakly significant $p < 0.1$ meaning they do help in production but to not as great extend as other factors do. The constant (7.0810) was significant $p < 0.01$ and this represents the baseline production levels. All in all, the findings show that labor, pesticides, and transport play an important role in the production of rice. Therefore, augmenting these sectors is expected to result in significant enhanced productivity. The variance inflation factor (VIF) of 8.77 is within the tolerable range indicating minimal multicollinearity among the variables in the model.

3.6 Table 7: Regression Result of Factors Affecting Mastard Production.

| Variable name | Coefficient. | Robust Std. Err. | P- value |
|-------------------|--------------|------------------|----------|
| Seed | 0.3957** | 0.1635 | 0.036 |
| Cultivation | 0.5650*** | 0.3156 | 0.004 |
| Irrigation | 0.2220* | 0.1211 | 0.097 |
| Fertilizer | 0.2114** | 0.1592 | 0.014 |
| Pesticides | 0.0509* | 0.1775 | 0.080 |
| Labor | 0.0852*** | 0.1072 | 0.004 |
| Transport | 0.2121 | 0.1366 | 0.152 |
| Other (equipment) | 0.1645 | 0.1853 | 0.396 |
| -cons | 1.9352 | 1.2003 | 0.138 |

N= 190; F(8,182); = 18.91; Prob.>F= 0.0000 ; $R^2 = 0.9514$; VIF=6.70

Note: Significant at: * $p < 0.01$, ** $p < 0.05$, * $p < 0.1$**

Source: Author's Own Calculation based on Survey Data, 2024

Table 7 presents the empirical results based on regression analysis of the factors affecting mustard production, particularly the extent of the relationship between input levels and output. The model possesses a high fit, with R^2 standing at 0.9514 meaning the model can adequately account for about 95.14% of the variations in mustard production. Of all the factors considered in this study,

cultivation costs are the most significant contributors to increases in mustard production, as shown by a coefficient of 0.5650 ($p < 0.01$). This shows that increased cultivation costs are expected to yield better results. Other than that, seed costs tend to positively affect production as well, with a coefficient of 0.3957, which is significant at $p < 0.05$, pointing out the need for better seeds for better production. This positive effect on output levels of mustard production is supported and statistically significant with respective coefficient values of 0.2114 for fertilizer costs and 0.2220 for irrigation costs at $p < 0.05$ and $p < 0.1$ levels of significance. This infers that the growers should avail basal and top-dress fertilization as well as irrigation in order produce optimally. Labor costs also provide a positive contribution to the production of mustard (0.0852, $p < 0.01$), which illustrates that labor will play an important role in this crop farming activity. Pesticides, on the other hand, are not as important, although they do have a slight positive effect (0.0509, $p < 0.1$). However, in connection to transport, and in correlating other implements inputs, a positively insignificant increase in mustard production is observed. A trend that is likely not very critical. The constant term is non-significant since it suggests that production, in this case, does not turn out to be strong in the absence of the aforementioned factors. Therefore, there is reasonable multicollinearity between variables as shown by the VIF of 6.70. These results also point out that there is a need to invest in cultivation practices, seed quality, fertilizers and irrigation facilities and labor if high yields of mustard are to be obtained.

3.7 Table 8: Regression result of factors affecting Wheat production

| Variable name | Coefficient. | Robust Std. Err. | P- value |
|-------------------|--------------|------------------|----------|
| Seed | 0.0185** | 0.0490 | 0.010 |
| Cultivation | 0.0160 | 0.0121 | 0.101 |
| Irrigation | 0.0841* | 0.0906 | 0.065 |
| Fertilizer | 0.5735*** | 0.0987 | 0.000 |
| Pesticides | 0.4281*** | 0.1049 | 0.001 |
| Labor | 0.0261** | 0.0120 | 0.043 |
| Transport | 0.0668 | 0.0394 | 0.107 |
| Other (equipment) | 0.0113 | 0.0468 | 0.112 |
| -cons | 2.9632*** | 0.3152 | 0.000 |

N= 280 ; F(8,172); = 296.61; Prob.>F= 0.0000 ; R² = 0.9909; VIF=7.77

Note: Significant at: *p<0.01, **p<0.05, *p<0.1**

Source: Author's Own Calculation based on Survey Data, 2024

The examination of factors that affect wheat production and its determinants present the regression results in table 8, where R² is 0.9909. This indicates that 99.09% of wheat production is accounted for by the model, which conforms to the very strong fit of the structure and explains that almost

all the concerns that account for wheat yield are included in the model. Out of the input variables examined, the costs of fertilizers (coefficient 0.5735, $p < 0.01$) exert the most considerable positive influence on wheat production signaling that fertilizer is paramount to raising the output of food crops. A positive and significant effect is also noted as regards pesticides (coefficient 0.4281, $p < 0.01$), hence underscoring the importance of pest control in the healthy production of wheat. Factors such as irrigation (coefficient 0.0841, $p < 0.1$) and seed costs (coefficient 0.0185, $p < 0.05$) are also positively correlated with production, although irrigation is only slightly significant. While labor costs (coefficient 0.0261, $p < 0.05$) also positively influence wheat yield, suggesting that labor input is a critical component of productivity. Transport costs, along with costs associated with other equipment, are statistically insignificant; hence, they are regarded as having a negligible influence on production in this model. The constant term is also significant (2.9632, $p < 0.01$), indicating an average level of wheat production. The variance inflation factor indicated 7.77 which means that multicollinearity may not have been a serious challenge. In conclusion, these findings ascertain that the use of fertilizer, pesticides, and labor are key in improving wheat cultivation.

3.8 Table 9: Distribution of respondents by damage of Agricultural production due to Pest and Disease, Droughts, Heavy Wind, Hail Storm, High Temperature (Tk. Yearly)

| Income | Frequency | Percent |
|-----------------|------------------|----------------|
| <10000 | 42 | 14.00 |
| 10001-15000 | 61 | 20.33 |
| 15001-20000 | 70 | 23.33 |
| 20001-25000 | 74 | 24.67 |
| 25001-30000 | 28 | 9.33 |
| 30000 and above | 25 | 8.33 |
| Total | 300 | 100.00 |

Source: Author's Own Calculation based on Survey Data, 2024

In table 9, the respondents have been categorized according to the annual financial losses suffered from the cultivation caused by a range of factors such as pests, diseases, droughts, strong winds and hail, or high temperature. Among the 300 respondents, the largest proportion of 24.67% of the respondents indicated suffering average annual losses of 20001- 25000 Bangladeshi Taka (Tk), which is the widest range of losses marked in this range. Following this, 23.33% of the respondents reported losses of 15001 to 20000 Tk and 20.33% losses between 10001 and 15000 Tk. Notably, however, about 14% of the respondents reported losses of less than 10000 Tk every year which implies a lesser but still significant share of households suffering limited damage. A minority group (9.33%) of the respondents indicated that the damages experienced in a year lay between

the costs of 25001-30000 Tk, 8.33% of the respondents experienced a loss greater than 30000 Tk. This distribution highlights that in the study area, most of the agricultural households face a moderate level of economic losses to heavy losses arising from climatic and environmental degradation that affects production. In addition, the summary demonstrates the extent of the exposure of the farmers to income loss arising from probable adverse effects on the environment, thus emphasizing the need for better control of pests, adaptation to changes in the prevailing climatic conditions, and mitigation of economic losses in farming. The data from the survey conducted in 2024 forms the basis of these recommendations for assisting farmers who are noted to be disadvantaged.

Conclusion

The research on assessing the effect of climate changes on agriculture profitability and productivity in Chapai Nawabganj, Bangladesh is revealing in regard to how crop production is influenced in the area. The study investigates climate-induced changes and their consequences on critical agricultural factors, demonstrating how the increasing input costs of labor, fertilizers, irrigation, and other factors can considerably impact the profitability of various crops such as rice, mustard, and wheat. It is worth noting that the high costs of labor and fertilizers contributed the most to the overall costs of production, thereby indicating their roles towards maintaining profitability. Likewise, it is shown that outputs in agriculture are very much positively correlated with a specific set of key inputs which include pesticides, transport, and equipment, while changes in seed, irrigation and cultivation costs tend to have a rather less proportionate effect on productivity. The research design, which involves the combination of primary data from farmers in Shibganj Upazila and data from the econometric models such as the Cobb-Douglas production function, helps in explaining the issues of agrarian productivity in a comprehensive manner. The findings indicate that both labor and pest management practices are food production determinants, especially in a changing climate. In rice, where labor was revealed to be the most expensive production factor, labor was found to be the most significant cost in rice production, while fertilizing and cultivation practices costs were the high-cost factors in mustard and wheat production respectively. The ability to determine what drives input factors and what influences output in agriculture under climate change is a principal merit of this study. With such a grasp of these dynamics, the research provides useful suggestions on how the farmers can improve their crop production strategies in the face of

the changing climate. In addition, the research brings forth salient findings on the policy responses that the governments should implement in order to support the farmers in the process of climate change. It is very important that the policymakers work on measures that reduce the effects of increased prices of inputs, especially fertilizers, labor and insurance plus subsidizing of pesticides. In addition, it is equally important to expand the irrigation facilities and the availability of transport and market information to help the farmers lower the production costs. The adaptive capacity of farmers has to be improved by such training programs and by providing financial assistance for the use of climate resistant technologies. Finally, this paper also urges the integration of both short and longterm strategies to enhance agricultural sustainability and productivity in Chapai Nawabganj while addressing climate change issues.

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