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# Socio-Economic and Environmental Factors Influencing the Output of Rice Farmers in Kaduna State and Federal Capital Territory, Nigeria

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## ABSTRACT

This study investigated the socio-economic and environmental factors influencing the output of rice farmers in Kaduna State and Federal Capital Territory, Nigeria. A multi-stage sampling technique was employed to select 185 respondents. Primary data were used based on a well-structured questionnaire. The data was analyzed using descriptive and inferential statistics. The findings reveal that the majority of the farmers are female (76.22%) with an average age of 48 years. Most are married (88.11%) with an average household size of 9 persons and have spent an average of 6 years in school education. The farmers have significant farming experience (18 years) but limited access to credit (8.65%) and the average monthly income was ₦36, 189.8. The socio-economic factors such as age, household size and cooperative membership, along with environmental factors such as rainfall variation and heat waves significantly influence the output of rice farmers. Environmental changes significantly impact output of rice farmers, with change in temperature, heat waves, migration, loss of crop due to soil degradation and reduction in size of water bodies being the most reported issues. These changes could

lead to reduced output, poor harvests, and increased health hazards. The study recommended adaptation strategies such as multiple crop types and planting dates and mitigation efforts such as minimizing agrochemical use and reduce food and water wastage.
**Keywords:** Adaptation strategies, environmental change, propensity score matching, socio- economic factors

# INTRODUCTION

Environment is defined as the physical, biological, socio-cultural, and political elements that affect a person's ability to survive and meet their needs for development. Furthermore, the environment is everything around us, and without it, survival is not conceivable (Adesiyan, 2005). All living things are influenced by their surroundings in terms of their health, life cycles, and mortality. According to Akinbode (2012), the environment encompasses all the locations and circumstances in which we live, work, and interact with others in pursuit of cultural, religious, political, and socio-economic goals that lead to personal fulfilment and advancement in the community. As sustainable development encompasses three essential dimensions; social, economic, and environmental. it is imperative that we make sure our actions today enable us to meet both our current needs and the requirements of future generations without compromising (Agbola, 2008). Due to human activity, the natural environment is changing to the point where it is becoming more challenging to characterize or understand. However, man's surroundings also have an impact on him and his actions, therefore there is a reciprocal interaction between man and his surroundings. Both natural and human processes can cause environmental change. By converting and moving huge amounts of energy and materials, environmental systems and human activities both contribute to environmental changes. Through the cycling of materials through geological, biological, oceanic, and atmospheric processes, natural systems convert the sun's energy into living matter and bring about changes. Contrarily, human activities transform raw resources and energy into goods and services to satisfy human needs and aspirations.

The environment is affected greatly by changes in land use, both locally and globally. These major changes result in the loss of biodiversity on a local, regional, and global scale, increased soil erosion, increased sediment loads, and erratic water cycle patterns (Lambin and Geist, 2006). Local changes in land use and cover have an impact on micro-climatic resources, which directly affect local inhabitants' means of subsistence (Sultan, 2016). About 15% of all anthropogenic greenhouse gas emissions are attributed to the cattle industry, while the other 10% are attributable to land use change, which includes deforestation, cropping, and the conversion of vegetation to built-up areas (FAO, 2016). One of the main causes of low and declining agricultural production, which subsequently worsens poverty is land degradation. (Okeleye et al., 2016; Kirui, 2016).

The majority of the poor in developing nations live in rural areas, despite the fact that the development rate of urban slums has increased over the past ten years which exposes them to harsh effect of environmental change (Oni-Jimoh et al., 2018). Climate, food security, and human security are all significantly impacted by soil protection and sustainable land use (Amundson et al., 2015). Global migration is viewed as a complicated and rising phenomenon. As a result of hazards and disasters brought on by nature (the environment) and climate, there were no fewer than 26.4 million people displaced per year between 2008 and 2015, and this tendency has continued to rise (Froese and Schilling, 2019).

Sub-Saharan Africa has diverse patterns of rural-urban migration, environmental, political, cultural, demographic, or socio-economic issues may push people to migrate. Most of the time, a combination of the aforementioned criteria affects the decision to relocate (Sedoo et al., 2019). Because there is a shortage of housing due to migration to metropolitan areas, many urban inhabitants live in unofficial housing (Amrevurayire and Ojeh, 2016).

One strategy for coping with climate change is migration (IOM, 2016). According to the International Organization for Migration (IOM) (IOM, 2017), migration that is well-managed, safe, and regular can support the expansion and improvement of agriculture, economy, rural residents' means of subsistence, and food security. Climate change-related agricultural asset degradation is causing a production reduction and sharply diminishing rural communities' chances for employment (Okeleye and Olurunfemi, 2016). Rural-urban migration is influenced by both poverty and food insecurity (IOM,2017). Potential paths from climate change to migration include increases in the frequency and severity of weather- and climate-induced risks, including rapid and slow-onset events (FAO,2016). Extreme weather events, which have a quick onset and often have an immediate effect, are directly related to migration and climate change (FAO,2016). Rural people sometimes experience displacement as a result of natural catastrophes linked to these sudden-onset events damaging their assets and/or output (IPCC,2014, Okeleye and Olurunfemi,2016).

Nigeria, and specifically Northern Nigeria, which had previously been noted for its agricultural production, is now severely impacted by climate change and soil degradation in the form of frequent drought and flood (IPCC,2007). Due to the over-reliance on rainfed agricultural practices and the extreme poverty of the population, the majority of the crops are less productive (IPCC, 2007). The majority of farming households in North Central and North West, Nigeria have between one and four individuals who relocate each year as a result of disasters caused by climate change and changes in land use, which makes it harder for them to be food secure (Ngutsav et al., 2021). Poor access to excellent education, an inadequate health care system, low agricultural yields, and poverty are a few of the main variables that influence rural-urban migration (IOM, 2016). Although many academics have discussed migration as a technique for adapting to climate change (Davis et al., 2018), it is also referred to as the inability to adapt or mitigate (Mayer,2011).

This study investigated the socio-economic and environmental factors influencing the output of rice farmers in Kaduna State and Federal Capital Territory, Nigeria.

# MATERIALS AND METHODS

The study was carried out in the Federal Capital Territory and Kaduna State, Nigeria. The study adopted a multi-stage random sampling technique. In the first stage, four (4) Area Councils were randomly selected in Federal Capital Territory. Also, four (4) Local Government Areas (LGAs) were randomly selected in Kaduna State. In the second stage two (2) wards were randomly selected in the four (4) LGAs selected in Kaduna State and in the 4 Area Councils selected in Federal Capital Territory making a total of sixteen (16) wards. In the final stage, equation (1) was used to select a proportionate and random sample of one hundred and eighty-five (185) small-scale rice farmers from the total sample frame of three hundred and forty-four (344) small-scale rice farmers in the study area. The study used Yamane (1967) for estimating sample size:

$$\text{n} = \frac{N}{1 + N(e^2)} = 185 \qquad (1)$$

Where,

n = Sample Size (Units)
N= Sample Frame/Population size (Units)
e = Level of Precision (5%)

### 1.1.2 The Multiple Regression Model

This study follows the model used by Justice et al. (2016); the multiple regression model is explicitly stated as follows:

$$Q_{ij} = \emptyset_0 + \sum_{n=1}^{11} \emptyset_i X_i + \mu_i \quad (2)$$

Where;

$Q_{ij}$ = Quantity of Output (Kg)

$X_1$ = Age of the Farmer (number),

$X_2$ = Number of years spent in schooling (Years),

$X_3$ = Marital Status of the Farmer (1, Married; 0, Otherwise),

$X_4$ = Households Size (Total Number of Persons),

$X_5$ = Access to Credit (1 = Access, 0 Otherwise),

$X_6$ = Member of Cooperative Society (1 = Member, 0 Otherwise),

$X_7$ = Change in Temperature (1 = Yes, 0 Otherwise)

$X_8$ =Loss of farmland as a result urbanization (Number)

$X_9$ = Rainfall variation (Number)

$X_{10}$ = Conflicts (farmers-herders clashes) (Number)

$X_{11}$ =Heat waves (Number)

$\emptyset_0$= Constant Term

$\emptyset_i$= Coefficients of the Explanatory Variables

$\mu_i$ = Random Error Term

I = Rice Farmers

### 1.1.3 Propensity Scoring Matching

This formula follows the study of Ali et al. (2018), the most common evaluation parameter of interest is the Average Treatment Effect on the treated (ATT) which is defined as: -

$$ATT_{ij} = E\left(\frac{\vartheta_1 - \vartheta_0}{\rho = 1}\right) - \left(\frac{\vartheta_1}{\rho = 1}\right) \quad (3)$$

.

$$\rho(X) = \rho_r\left(\frac{\rho = 1}{\theta = \theta_{ij}}\right) \quad (4)$$

$$ATT_{ij} = \frac{1}{N_1}[Y_1 - Y_0] \quad (5)$$

Where;

ATT = Average Impact of Treatment on the Treated,

$N_1$= Number of Matches (From Regression Model),

$Y_1$= Output Index by Participants, and

$Y_0$= Output Index by Non-Participants.
$i$ = Rice Farmers,
A positive (Negative) value of ATT will usually suggest that participants in a programme have higher (lower) outcome variable than non-beneficiaries.

## RESULTS AND DISCUSSION

**The socio-economic characteristics of rice farmers in the study area**
**Sex distribution**

Table 1 reveals that majority (76.22%) of the rice farmers are female, while (23.78%) of the farmers are male. This implies that women play a significant role in agricultural activities. Gender-targeted interventions might be necessary to support female farmers, ensuring they have access to resources, training, and support systems.

**Age distribution**
The result reveals that the mean age was 48.10 years, approximately 37.30% of the rice farmers were within 43-53 years, 25.41% were within 32-42 years, 22.16% were within 54-64 years, and 9.19% were greater than 65 years (65-75). The suggests that farming is predominantly undertaken by middle-aged farmers. This might indicate a lack of youth involvement in agriculture, which could impact the future sustainability of farming practices. Efforts may be needed to encourage younger generations to engage in farming through incentives, education, and modern agricultural technologies. This study agrees with the results of Alabi et al. (2022).

**Marital status**
Marital status of the farmers has direct relationship on the size of the household which will invariably influence the quantity of household labour that will be available for production activity. Marital status of the farmers also means commitment to the business because of the family needs that must be met. This result shows that the majority (88.11%) of the rice farmers are married, (7.03%) are single and 4.86% are divorced. A high percentage of married farmers could mean that farming is often a family-based activity. Policies and programs that support family farming could be beneficial, and social safety nets for family farmers might be important.

**Household size**
Household size and its composition are important factors to consider in describing households' pursuit for economic activities and welfare of the households most

especially as it affects the availability of family labour for economic activities such as farming. Household labour helps to mitigate/ cope with the issue of scarce and costly hired labour and help reduce the cost incurred in labour purchase. The result shows that majority (43.24%) of the rice farmers had 8-14 persons in their household and (42.16%) had 1-7 persons in their households. The mean household size of the rice farmers is 9. Large household sizes indicate a reliance on family labour for farming activities. This could also mean higher dependency ratios, with more non-working members in the household. Programs that focus on family labour management and productivity improvements could be beneficial. Household size significantly influences food demand and dietary patterns, as larger households consume greater quantities of staple foods, while also facing higher food insecurity risks (Omonona & Agoi, 2007).

**Number of years spent schooling**

The adoption capacity of a farmer about an innovation, practice or technology requires that he/she is well educated. The result shows the majority (69.77%) of the rice farmers spent 1-7 years in school, (18.02%) had 8-14 years in school, while (9.3%) spent 15-21 years in school education. The mean years of schooling is 6 years. The low average years of schooling suggest limited formal education among the rice farmers. This could affect their ability to adopt new technologies and practices such as adaptive and mitigation strategies which can influence their productivity, efficiency and income. Educational programs and training sessions tailored to this demographic could help improve their farming skills and productivity.

**Farm experience**

The number of years a farmer spent in farming gives an indication of the practical knowledge he\she has gained on how to cope in production, since experience farmers are better risk managers than inexperienced ones. When experience is channeled it can lead to higher productivity, efficiency and higher income this can translate to higher economic well-being of the farmer and the farm family. The result shows that majority of the rice farmers (38.92%) had 22-32 years of experience, (35.14%) had between 11- 21 years of experience, (24.86%) had 1-10 years of experience, while (1.08%) had 33 years or more years of experience. The mean years of farm experience is 18 years. This implies that most of the farmers are well experienced about rice production and it may have positive influence in their productivity, efficiency and income and invariably in their welfare. Furthermore, with considerable farming experience, these farmers likely have a wealth of traditional knowledge and skills. However, integrating this experience with modern agricultural practices could enhance productivity and sustainability. Extension services and training programs can play a critical role in this integration.

**Access to credit**

Access to credit facilities may enable farmers adopt new adaptation and mitigation strategies to enhance their production. The result showed that the majority (91.35%) could not access credit, while (8.65%) were able to access credit. The mean volume to access to credit is (₦22,515.96), this is an indication that access to credit is a problem which is likely to affect productivity. More so, limited access to credit is evident, with a significant portion of farmers not accessing credit facilities. This could hinder their ability to invest in better farming inputs and technologies. Enhancing credit facilities and financial literacy programs for farmers could improve their productivity and economic stability.

**Monthly income**

The amount of income coming into the household is dependent on the output and ability of the farmer to diversify into off-farm and non-farm activities. This will probably influence the welfare of the farmer, adaptation and mitigation strategies adopted by the farmers. The result shows that the majority (68.26%) of the farmers realized less than ₦25,000 from their secondary occupation, while (8.98%) of the farmers realized above ₦52000 as monthly income from secondary occupation. The mean monthly income (₦36,189.87) suggests that most of the rice farmers are smallholder farmers. The results show that there should be more efforts to improve market access, value addition, and diversification of income sources could help improve their livelihoods.

**Extension contact**

Majority of the farmers (61.08%) have extension contact, while (38.92%) had no extension contacts. This indicates that while a majority have contact with extension services, a significant portion does not. Improving the reach and effectiveness of agricultural extension services can help disseminate best practices and new technologies to more farmers.

**Membership in farm-based organizations**

Cooperative association may enable farmers mobilize resources to enjoy economies of scale; it provides information to enhance effective production and acquisition of better and more innovative skills to boost production. The result shows that 51.89% of the farmers are members of farm-based organizations, while 48.11% are not members of farm-based organization. These organizations can play a crucial role in providing support, collective bargaining, and knowledge sharing. Encouraging more farmers to join such organizations could strengthen community-based agricultural development.

**Table 1. The socio-economic characteristics of rice farmers**

| Variable | Frequency | Percentage | Mean Value |
|---|---|---|---|
| **Sex** | | | |
| Female | 141 | 76.22 | |
| Male | 44 | 23.78 | 48.10 |
| **Age (Years)** | | | |
| 21 – 31 | 11 | 5.95 | |
| 32 – 42 | 47 | 25.41 | |
| 43 – 53 | 69 | 37.30 | |
| 54 – 64 | 41 | 22.16 | |
| 65 – 75 | 17 | 9.19 | |
| **Marital Status** | | | |
| Single | 13 | 7.03 | |
| Married | 163 | 88.11 | |
| Divorced | 9 | 4.86 | |
| **Household Size (Number)** | | | |
| 1 – 7 | 78 | 42.16 | |
| 8 – 14 | 80 | 43.24 | 9 |
| 15 – 21 | 23 | 12.43 | |
| 22 – 28 | 4 | 2.16 | |
| **Number of Years Spent Schooling** | | | |
| 1 – 7 | 120 | 69.77 | |
| 8 – 14 | 31 | 18.02 | 6 |
| 15 – 21 | 16 | 9.30 | |
| 22 – 28 | 5 | 2.91 | |
| **Farm Expérience (Years)** | | | |
| 1 – 10 | 46 | 24.86 | |
| 11 – 21 | 65 | 35.14 | 18 |
| 22 – 32 | 72 | 38.92 | |
| 33 – 43 | 2 | 1.08 | |
| **Access to Credit** | | | |
| Yes | 16 | 8.65 | |
| No | 169 | 91.35 | ₦22, 515.96 |
| **Monthly Income (Naira)** | | | |
| ≤ 25, 000 | 114 | 68.26 | |
| 26, 000 – 51, 000 | 38 | 22.75 | 36, 189.87 |
| ≥ 52, 000 | 15 | 8.98 | |
| **Extension Contact** | | | |
| Yes | 113 | 61.08 | |
| No | 72 | 38.92 | |
| **Membership of Farm-Based Organizations** | | | |
| Yes | 96 | 51.89 | |
| No | 89 | 48.11 | |
| **Total** | 185 | 100.00 | |

Source: Field Survey Data (2025)

**The effects of socio-economic and environmental factors on the output of rice farmers**

Table 2 presents the effects of socio-economics and environmental factors on the output of rice farmers. Below is a discussion of each socio-economic and environmental factors and its implications:

**Socio-economic factors**

**Age of the Farmers:** The negative coefficient ($\emptyset_1$ = -0.0311, p = 0.060) suggests that as farmers' age increases, rice output tends to decrease slightly. This coefficient is significant at the 10% probability level. This implies that older farmers might have lower productivity, possibly due to less physical ability or reluctance to adopt new techniques.

**Household size:** The negative coefficient ($\emptyset_4$ = -0.7655, p = 0.021) was significant at the 5% probability level. This indicates that larger household sizes are associated with lower rice output. This might be due to increased consumption demands that reduce the resources available for farming.

**Cooperative membership:** The positive coefficient ($\emptyset_6$ = 3.1057, p = 0.000) was significant at 1% probability level. This indicates that being a member of a cooperative organizations significantly increases rice output. Farm-based organizations may likely provide resources, information, and support that enhance productivity.

**Environmental factors**

**Rainfall variation:** The positive coefficient ($\emptyset_9$ = 0.2695, p = 0.098) was significant at 10% probability level. This suggests that rainfall variations might have a positive effect on rice output. This could indicate that variability in rainfall, perhaps increased or more evenly distributed rain, benefits crop growth.

**Heat waves:** The negative coefficient ($\emptyset_{11}$ = -2.4752, p = 0.000) was significant at 1% probability level. This indicates that heat waves drastically reduce rice output. This highlights the severe impact of extreme heat on agricultural productivity.

The R-squared value was 0.587,i.e. the model explains approximately 58.7% of the variance in rice output, suggesting a moderately good fit.

Akaike Criterion (AIC = 858.796)- a measure used for model comparison, with lower values indicating a better fit.

**Table 2. The effects of socio-economic and environmental factors on the output of rice farmers**

| Variable | Parameters | Coefficient | Standard Error | t-Value | *p-Value* |
|---|---|---|---|---|---|
| Constant | $\emptyset_0$ | 11.2104 | 1.99985 | 5.61 | 0.000 |
| Age | $\emptyset_1$ | - 0.0311* | 0.0164 | -1.89 | 0.060 |
| Number of Years Spent Schooling | $\emptyset_2$ | -0.0199 | 0.0329 | -0.60 | 0.546 |
| Marital Status | $\emptyset_3$ | -0.4900 | 0.5297 | -0.93 | 0.356 |
| Household Size | $\emptyset_4$ | -0.7655 | 0.3278 | -2.34 | 0.021 |
| Access to Credit | $\emptyset_5$ | 0.2821 | 0.4442 | 0.64 | 0.526 |
| Cooperative Membership | $\emptyset_6$ | 3.1057*** | 0.6152 | 5.05 | 0.000 |
| Change in Temperature | $\emptyset_7$ | -0.1129 | 0.1775 | -0.64 | 0.526 |
| Loss of Farmland due to Urbanization | $\emptyset_8$ | 0.4224 | 0.3681 | 1.15 | 0.253 |
| Rainfall Variation | $\emptyset_9$ | 0.2695* | 0.1620 | 1.66 | 0.098 |
| Conflict | $\emptyset_{10}$ | 0.1295 | 0.3709 | 0.35 | 0.727 |
| Heat Waves | $\emptyset_{11}$ | -2.4752*** | 0.5958 | -4.15 | 0.000 |
| R-Square | | 0.587 | | | |
| Akaike Crit (AIC) | | 858.796 | | | |
| F-Statistics | | 3.613 | | | |
| Prob(F-Statistics) | | 0.000 | | | |

**Source**: Field Survey Data, 2025
*** = significant. @ 1%, ** = significant @ 5% and * = significant @ 10%

**Model fit and overall implications**

**The economic impact of environmental change on the output of rice farmers:** The Table 3 presents the results of a propensity-score matching (PSM) estimation that examines the impact of various environmental changes on the output of rice farmers. Below is an interpretation of the results for each of the treatment variables (environmental factors) on crop output, focusing on the average treatment effect on the treated (ATT), the corresponding z-values, and the significance levels:

**The economic impact of environmental change on the output of rice farmers in Kaduna state**

**Heat wave**

The negative ATT of -0.2680 implies that heat waves are associated with a decrease in rice output. This effect was also significant at the 10% probability level, suggesting that heat waves negatively impact rice productivity. Heat waves can damage crop directly by inducing heat stress and disrupting water availability (Lesk et al., 2016). Additionally, heat wave also one of the most detrimental forms of environmental stress on agriculture especially heat sensitive crops.

**Migration**

Migration has a positive coefficient and was significant at 5% probability level with ATT of 0.3007 on rice output. This means that there is strong evidence that migration affects rice output in this context. Migration affects productivity and also leads to labour shortages (Gray & Mueller, 2012).

**Change in temperature**

A significant positive coefficient at 1 % probability level with ATT of 0.2300. This indicates that changes in temperature are strongly associated with an increase in rice output. This suggests an impact of temperature change on rice productivity. This shows that adaptation strategies such changing in planting dates, multiple planting dates or use improved varieties to cope with recent increase or changes in temperature (Lobell & Burke, 2010). Furthermore, according to Rosenweig et al. (2014) who reported that rising temperature benefits crop production especially in cool regions where hotter conditions increases the growing season.

**Reduction in size of water bodies**

The ATT for the reduction in the size of water bodies is 0.2941, which is positive and statistically significant at 10% probability level. This suggests a strong evidence of its impact on rice output. Furthermore, Molden et al. (2007) reported that reduction in water bodies especially in the long run may have detrimental effect on agriculture especially for water intensive crops.

**The economic impact of environmental change on the output of rice farmers in FCT**

**Heat wave**

The negative ATT of -1.3811 implies that heat waves are associated with a decrease in rice output. This effect is also significant at the 5% probability level; this suggests that heat waves negatively impact rice productivity. Heat waves can damage crop directly by inducing heat stress and disrupting water availability (Lesk et al., 2016). Additionally, heat wave also one of the most detrimental forms of environmental stress on agriculture.

### Change in temperature

A significant positive ATT of 1.4681 indicates that changes in temperature are strongly associated with an increase in rice output, with high statistical significance ($p < 0.05$). This suggests a robust impact of temperature change on rice productivity. This shows that adaptation strategies such changing in planting dates, multiple planting dates or use improved varieties to cope with recent increase or changes in temperature (Lobell & Burke, 2010). Furthermore, according to Rosenweig et al. (2014) who reported that rising temperature benefits crop production especially in cool regions where hotter conditions increases the growing season.

### The economic impact of environmental change on the output of rice farmers for pooled

### Loss of crop due to soil degradation

The positive ATT of 1.2880 suggests that the loss of crops is associated with an increase in rice output among farmers who experienced this environmental change, compared to those who did not. This result is significant at the 10% probability level. This outcome is in agreement with assertions of Di Falco et al. (2011) who posited that farmers after facing crop loss intensify effort or adopt new coping strategies to increase output.

### Heat wave

The negative ATT of -0.7338 implies that heat waves are associated with a decrease in rice output. This effect is also significant at the 10% probability level; this suggests that heat waves negatively impact crop productivity. Heat waves can damage crop directly by inducing heat stress and disrupting water availability (Lesk et al., 2016).

### Change in temperature

A significant positive ATT of 1.4301 indicates that changes in temperature are strongly associated with an increase in rice output, with high statistical significance ($p < 0.01$). This suggests a robust impact of temperature change on crop productivity. This shows that adaptation strategies such changing in planting dates, multiple planting dates or use improved varieties to cope with recent increase or changes in temperature (Lobell & Burke, 2010). Furthermore, according to Rosenweig et al. (2014) who reported that rising temperature benefits crop production especially in cool regions where hotter conditions increases the growing season.

**Table 3. Propensity-score matching estimation for the impact of environmental change on the output of rice farmers**

| Treatment | Variables | Kaduna | | FCT | | Pooled Data | |
|---|---|---|---|---|---|---|---|
| | | ATT | Z-Value | ATT | Z-Value | ATT | Z-Value |
| Crop Output | Loss of Crop due to Soil Degradation | -0.1001 (0.2012) | -0.71 | -1.3231 (0.3221) | -1.06 | 1.2880 (0.6859) | 1.88* |
| | Heat Wave | -0.2680 (0.1611) | -1.66* | -1.3811 (0.6856) | 2.01** | -0.7338 (0.4124) | -1.78* |
| | Migration | 0.3007 (0.1426) | 2.11* | 0.3011 (0.4200) | 0.41 | 0.2917 (0.4775) | 0.61 |
| | Conflict | -0.2066 (0.1775) | -1.16 | 0.9316 (0.7377) | 0.207 | 0.4071 (0.3768) | 1.08 |
| | Change in Temperature | 0.2300 (0.0716) | 3.21*** | 1.4681 (0.6612) | 2.22** | 1.4301 (0.3925) | 3.64*** |
| | Urbanization | 0.2339 (0.1665) | -1.40 | 0.6667 (0.6549) | 1.02 | 0.2999 (0.3815) | 0.79 |
| | Soil Infetility | 0.5102 (0.3382) | 1.03 | 0.7147 (0.6722) | 1.06 | -0.0024 (0.4077) | -0.01 |
| | Reduction in Size of Water Bodies | 0.2941 (0.1608) | 1.83* | 0.4334 (0.7846) | 0.55 | 0.3352 (0.4487) | 0.75 |

*** = significant. @ 1%, ** = significant @ 5% and * = significant @ 10%. Standard errors are reported in parenthesis; **Source**: Computed from Field Survey Data (2025)

# CONCLUSION

The socio-economic factors that significantly influenced the output of rice included age, household size, and cooperative membership. The environmental factors that influence the output of rice include rainfall variations and heat waves. The environmental changes had significant impact on the output of rice farmers in the study area. In the pooled data for example the environmental change that had significant impact with their corresponding average treatment effect (ATT) included heat waves (0.4124), change in temperature (1.4301), and loss of crop due to soil degradation (1.2880).

An increase in temperature negatively affects welfare, with a coefficient of (-0.3596). This factor was statistically significant at the 1% probability level; this implies that temperature changes may not favor certain crops or farming conditions.

The negative and highly significant coefficient ($\beta_{11}$ = -0.0650, z = 2.27) indicates that heat waves drastically reduce crop output. This highlights the severe impact of extreme heat on agricultural productivity.

The result indicated that the coefficient is negative and statistically significant ( $\beta_8$= -0.2356, z = 1.76) at 10% probability level. This implies that as a unit increase in reduction in the size of water bodies, while keeping all other variables constant will lead to 0.2356 unit reduction in the welfare status of crop farmers.

# RECOMMENDATIONS

- Farmers should be encouraged to use drought-resistant and early-maturing rice varieties (like the NERICA series) to mitigate the effects of shorter rainy seasons.
- The government should facilitate the construction of tube wells and wash-bores, particularly for lowland rice cultivation.
- Regular soil testing to determine specific fertilizer needs and the use of IPM to reduce the high cost of chemical pesticides.
- Government and financial institutions should provide low-interest loans specifically for smallholder rice farmers.
- There is a need for more extension officers to visit rural areas.
- Policies should specifically target female-headed households with land tenure security and tailored inputs.

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