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Vulnerability determinant of rice farmers to climate change in Ebonyi State, Nigeria

OSUJI EMEKA EMMANUEL[1,♥], OSUJI MARYANN NNENNA[2], BEN-CHENDO GLORY NKIRUKA[2], ANYIAM KELECHI HENRY[2], ORJI JEPHTER EBUKA[1], ECHEREOBIA CHRISTOPHER OGBUJI[3], EZIRIM KELECHI THANKGOD[4], TIM-ASHAMA AKUNNA CHINENYENWA[5], NWACHUKWU ESTHER UGOCHUKWU[2], UGWUNALI EMEKA JERRY[6], NZEAKOR FELIX CHIBUEZE[7]

[1]Department of Agriculture, Alex Ekwueme Federal University. P.M.B 1010 Abakaliki, Ebonyi State, Nigeria. ♥email: osujiemeka2@yahoo.com
[2]Department of Agricultural Economics, Federal University of Technology. Owerri, Imo State, Nigeria
[3]Department of Crop Science and Technology, Federal University of Technology Owerri. Imo State, Nigeria
[4]Department of Mechatronics Engineering, Federal University of Technology. Owerri, Imo State, Nigeria
[5]Department of Agricultural Science, Alvan Ikoku Federal University of Education. Owerri, Nigeria
[6]Department of Cooperative and Management, Federal College of Land Resources and Technology. Owerri, Imo State, Nigeria
[7]Department of Agricultural Extension and Rural Development, Michael Okpara University of Agriculture. Umudike, Abia State, Nigeria

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Abstract. *Emmanuel OE, Nnenna OM, Nkiruka B-CG, Henry AK, Ebuka OJ, Ogbuji EC, Thankgod EK, Chinenyenwa T-AA, Ugochukwu NE, Jerry UE, Chibueze NF. 2024. Vulnerability determinant of rice farmers to climate change in Ebonyi State, Nigeria. Asian J Agric 8: 23-30.* Climate change has become a reoccurring nightmare regarding agricultural production with negative impacts. The study researched the vulnerability determinants of rice farmers to climate change in Ebonyi State, Nigeria. Rice farmers numbering 80 were picked using the purposive sampling method. A structured questionnaire was used for data collection, and mean, frequency counts, percentage, and probit regression models were employed in data analysis. Results show that the rice farmers were in their productive age, male, married, experienced, and relatively educated. Late onset of rainfall (98.8%), increased temperature (97.5%), prolonged drought (95.0%), severe windstorm (95.0%), and high evaporation rate (92.5%) were the most perceived climate change occurrences in the state. The use of improved varieties of seeds (100%), effective use of pesticides (96.3%), efficient application of fertilizers (95.0%), and diversification of crops (90.0%) were the primary adaptation measures to climate change. Age, education, access to capital, farming experience, access to climate change information, gender, and extension contacts were major determinant factors in the climate change vulnerability of rice farmers. High cost of fertilizer (100%), lack of timely access to inputs (97.5%), inadequate capital (97.5%), poor extension service (96.3%), and inadequate lands (90%) constrained rice production in the state. Farmers should practice more climate-smart agriculture to overcome the adverse effects of climate change on rice production.

Keywords: Climate change, determinants, probit model, rice farmers, vulnerability

INTRODUCTION

In Nigeria and other nations worldwide, rice (*Oryza sativa* L.) is a crucial crop that contributes significantly to food security, employment development, and income generation (FAO 2023). It is the most cereal crop consumed globally across all continents (Africa, Asia, Europe, America, etc.) (FAO 2022). Sub-Saharan Africa, Bangladesh, Cambodia, Myanmar, Laos, and Vietnam consume more than 50% of their calories from rice. In contrast, Thailand, the Philippines, Malaysia, India, Nepal, and Sri Lanka consume 20-44% of calories from rice. Nigeria, Africa's leading rice producer, consumes over 20% of its calories from rice intake (FAO 2022). As a staple food, rice cultivation is significant in African countries, including Nigeria. Rice cultivation employs unemployed youths, is a source of household income, food intake, and energy, and contributes to about 15% of agriculture's gross domestic product in Nigeria (NBS 2023). It equally serves as a source of raw materials for manufacturing industries in Nigeria. Rice production is predicted to rise in Nigeria due to the recent government restrictions on cereal imports, including rice (Bichi et al. 2023). The rules were imposed in good faith to encourage and boost local rice production in the country to meet the growing demand for grain foods. However, the above objective of the Nigerian government is still far-fetched owing to several factors and climate change issues that are prevalent in the country with its attendant consequences (FAOSTAT 2024). Nigeria is particularly vulnerable to climate change due to its excessive reliance on rain-fed agriculture, which distorts crop yield and causes farmer poverty (Onyeneke 2021). Extreme weather events and climate change negatively impact rice production, causing poor yields and harvest. Delays in food production and delivery caused by a rise in the frequency and intensity of extreme weather events drive food prices (Ho et al. 2022). Interestingly, food insecurity is rising in Nigeria due to crop growers' vulnerability and susceptibility to climate change (FAO 2022). Nigerian rice farmers are currently dealing with several challenges, including vulnerability to climate change, which affects crop farming operations and agricultural productivity. The worrisome development has decreased rice productivity and yield, resulting in low income, starvation, hunger, and poverty (Van-Oort and Zwart 2018). Extreme weather events like droughts, floods, temperature swings, windstorms, rainfall, evaporation, relative humidity, etc., threaten rice cultivation and result in significant output losses. High temperature reduces rice plant yields while simultaneously promoting the growth of pests, weeds, and insects that prey on rice crops (Onyeneke et al. 2021). Rising temperature distorts the root and development of rice, causing poor yields. For instance, a temperature of 25 to 28°C is ideal for rice seedling growth; any higher temperature would result in losses for rice growers. Variations in precipitation trends raise the risk of short-term crop failure and long-term production drops (Arifah et al. 2022). High precipitation lowers rice plants' capacity for photosynthetic activity, leading to low yields.

Consequently, high rains cause flooding of rice fields, leading to rice seedling erosion and soil nutrient depletion. As the soil gets hotter, evapotranspiration decreases, resulting in low moisture levels that impede rice growth and development (Saud et al. 2022). A high evaporation rate produces rice of lesser quality and quantity, negatively impacting yield and market value. During a drought, the rice field becomes dry, which damages the planted seedlings and results in yield losses. Planting rice seedlings in an environment with high relative humidity hinders their germination and growth. Elevated relative humidity leads to a rise in water loss and yellowing of rice plants, which impacts photosynthetic functions (Tang et al. 2023). In recent times, rice farmers in Ebonyi State have suffered from adverse effects of climate change and have become more vulnerable to the changing climate with attendant evidence of poor yield and low economic returns, which have devastated the farmers and plunged them into abject penury (Osuji et al. 2023). Before now, the Ebonyi State was reputed as the rice hub of the nation and in Sub-Saharan Africa, but surprisingly, its status regarding rice production is fast declining due to rice farmers' vulnerability to climate change and extreme weather conditions (Onyeneke et al. 2021).

Previous studies (Ojo and Baiyegunhi 2020; Sharma et al. 2022; Habib-Ur-Rahman et al. 2022; Chen et al. 2023a; Joseph et al. 2023; Dar et al. 2024) have examined the impacts of climate change on cereal crops such as rice using both primary and secondary data and these studies focused mainly on direct and indirect impacts of climate change on rice crops. However, interestingly, it has yet to explore the vulnerability determinants of rice farmers to climate change in Nigeria, thereby making this study the first to consider and explore this aspect of study in Nigeria's context. The study considered the socio-economic factors and their relationship with farmers' vulnerability to climate issues. The study also contributed to the body of literature by adding new scientific knowledge to the existing literature, making the study of greater significance. The study set out to achieve the following objectives: the socio-economic characteristics of rice farmers, the perceived climate change occurrences encountered by rice farmers, the adaptation mechanisms of rice farmers to climate change, determinants of the vulnerability of rice farmers to climate change, and factors impeding rice production of farmers in the State.

MATERIALS AND METHODS

Study area

The research was done in Ebonyi State, Nigeria (Figure 1). The state has its location in South-East region with an estimated population of 3,242,500 persons (NPC 2023). The state practice agriculture on large scale and is reputed as the rice hub of the nation. The state is made up of 13 Local Government Areas (LGAs) (Abakaliki, Izzi, Ezza-North, Afikpo-South, Ohaukwu, Ebonyi, Oniocha, Ishielu, Ezza-South, Ikwo, Afikpo-North, Ohaozara and Ivo) with total land area of 5,533 km^2 and Latitude: 6°10' 40.7028" and Longitude: 7°57' 33.4296". The state experiences two seasonal vegetation; the rainy and dry seasons which influence agricultural activities in the state. Rainfall is around 1200 mm, while temperature ranges between 27^{o}C to 28^{o}C.

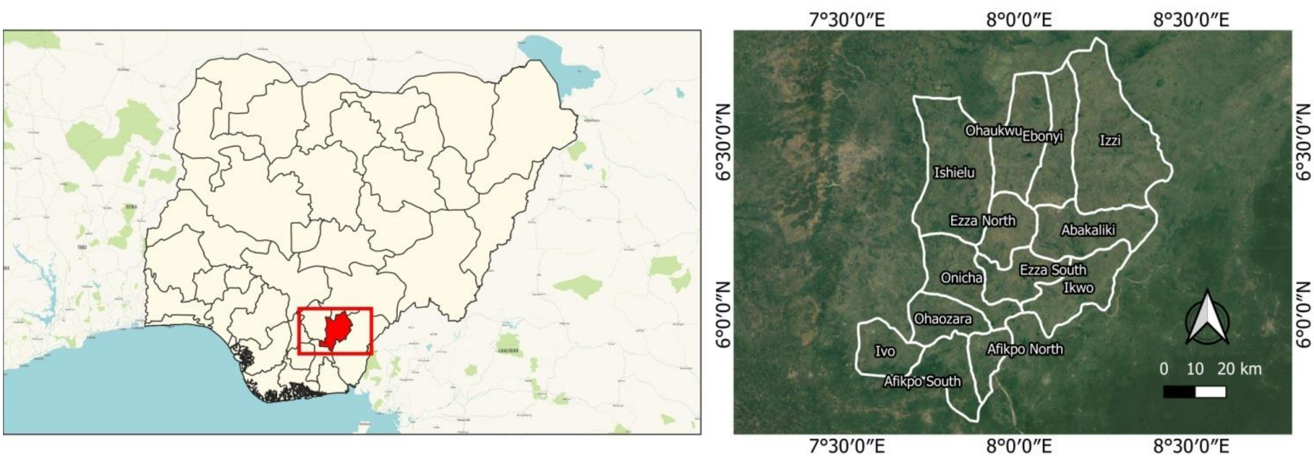

Figure 1. Map of Ebonyi State, Nigeria showing the study locations

Sampling techniques

A purposive sampling technique was used for this study. In the first instance, four Local Government Areas (LGAs) (Ikwo, Izzi, Ezza-North, and Ezza-South) were picked from the 13 LGAs in the state. These were selected based on their predominant rice cultivation, which distinguishes them from other LGAs (ESMANR 2023). The second stage involved another purposive selection of six communities out of the four LGAs, resulting in 24 communities. The six communities were noted for extensive rice cultivation in the state (ESMANR 2023). From the total registered rice farmers in the 24 communities, four independent rice farmers were selected to sum up 96 farmers. The four rice farmers were selected based on their extensive scale rice cultivation, primarily for commercial purposes.

Method of data collection

Primary data were collected from the 96 rice farmers using structured questionnaire designed for the study and out of the selected 96 rice farmers, only 80 rice farmers provided useful information for data analysis. Sixteen (16) questionnaires were dropped due to inconsistent and incomplete information required for the study.

Method of data analysis and model specification

Data were analyzed using descriptive statistics (mean, frequency count, and percentage) and the probit regression model. The probit regression model is a scientific analytical tool used to model dichotomous dependent variables with multiple input variables (Ismael and Duleba 2023). It has an advantage over other analytical tools in that it produces precise results with good statistical degrees that are not spurious or erroneous, hence its suitability for the study. The probit model was used to model the vulnerability determinants of rice farmers to climate change. Note that the vulnerability of the rice farmers to climate change was measured using the climate vulnerability criterion (Kim and Kwon 2022), which is expressed as climate sensitivity plus exposure minus adaptation. In this study, the farmers' susceptibility to climate risks with adaptation equals one and otherwise equals zero (0). Hence, the probit model accommodates dichotomous dependent variables (1 and 0) (Ismael and Duleba 2023).The probit model is explicitly expressed follows;

$$Pi = Pr(Y = 1/X) = Pr(I_i \leq I_i) = Pr(Z_i \leq B/X_i) = F(BX_i)$$

$$F(I_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{BXi} e - z^{2/2}\, dz$$

Where:

Pi = Pr = {Probability of ith farmers' climate sensitivity plus exposure minus adaptation= 1 and otherwise = 0}

F = Standard normal cumulative distributed function

B = Coefficients

X_i= represents the independent variables such as;

X_1 = Age (years)

X_2 = Education (No. of years spent in school)

X_3 = Household size (No. of persons)

X_4 = Farm size (Ha)

X_5 = Farming experience (No. of years)

X_6 = Participation in climate change workshops (No. of times participated)

X_7 = Access to climate change information {Accessed = 1, otherwise = 0}

X_8 = Extension contacts (No. of visits)

X_9 = Farm income (Naira)

X_{10} = Adaptation to climate change {Adapted = 1, otherwise = 0}

RESULTS AND DISCUSSION

Socio-economic characteristics of rice farmers

Table 1 presents the socio-economic characteristics of rice farmers. The majority of the farmers were within the age of 41-50 years with a mean age of 48 years. This implies that the rice farmers were young and in their most productive age which could enhance rice production in the area. Increase in age is associated with increase in farm production experiences which aid farm operations and other related activities (De-Vos et al. 2023). The majority of the rice farmers were male (86.3%), in comparison to the female (13.8%). This implies that rice production was dominated by the male farmers. This supports the fact that men are breadwinners and tend to be involved in crop production to fend for their families (Chen et al. 2023b). The majority of the farmers were married (51.3%), the singles (26.3%) and widowed (22.5%). This implies that the married farmers dominated rice production. The table shows that 32.5% of the rice farmers had primary education, 11.3% tertiary education, 15.0% had non-formal education. Thus the majority of the farmers 41.3% had secondary education. This implies that the rice farmers were relatively educated to understand rice cultivation and production principles (Arifah et al. 2023). The majority of the rice farmers, 63.8% had household sizes between 5-8 persons with a mean household size of 7 persons. This implies that the household size regarding the rice farmers was relatively large and could support their farming strength and production activities. The majority of the rice farmers, 73.7% were involved with farming and other non-farming activities while about 26.3% of them were fully engaged in farming activities only. This shows that the rice farmers combined rice cultivation with other production activities to raise farm income and livelihood sustenance (Kobayashi et al. 2023). The majority of the farmers, 47.5% had farm sizes within 1.1-2.0 hectares with a mean hectare of 1.8. This implies the prevalence of small farm holdings in rural communities. This is partly due to land tenure systems and land scarcity which limit large scale agricultural production. The table shows that about 20% of the rice farmers had extension contacts between 1-2 times, 10% had extension contacts between 3-4 times while the majority of the rice farmers, 70% had no extension contacts. The mean extension contact was approximately 2 contacts, which implies that the rice farmers had relatively low contacts with extension agents, which shows that the rice farmers did not benefit much from the extension agents (Chen et al. 2023a). The majority of the farmers, 87.5% do not belong to cooperative society while 12.5% belongs to cooperative societies. This implies that a lower percentage of the rice farmers benefited from cooperative societies. The mean participation in workshop/training was 1.3 times per cropping year. This means that the rice farmers had a low participation in workshop/training regarding rice cultivation and production principles. The majority of the rice farmers, 67.5% had farming experience ranging between 11-20 years. The mean farming experience of the rice farmers was 18 years, proving that the rice farmers had experience in rice production. Farming experience helps farmers to improve on their production capacity and overcome inherent farm problems and challenges besetting farmers (Lansing et al. 2023). Table 1 shows that the rice farmers obtained their capital from banks (10%), friends/relatives, (41.3%), while a higher percentage (48.7%) accessed their capital from personal savings. This shows that majority of the rice farmers started their rice cultivation from their own personal savings which is common in rural societies. The table shows that the land for rice farming was acquired through pledge (7.5%), purchase (13.8%), through gifts (18.8%), through lease/rent (23.8%) and majority (36.3%) via inheritance. This implies that the land used for rice farming was obtained via inheritance as this is common in rural societies (Yin et al. 2021). The majority of the farmers (37.5%) made use of family labour, while (31.2%) made use of hired labourers. This implies that the labour used in rice cultivation came majorly from family labour than hired labour. This could be due to the cheap source of family labour.

Perceived climate change occurrence encountered by rice farmers

Table 2 presents the perceived climate change occurrences encountered by rice farmers. The table shows that 95% of the rice farmers acceded to prolonged drought. This implies the long absence of water or delayed rainfall, negatively affecting crop production. Prolonged drought causes stunted growth in rice farming, affecting yield (Chen et al. 2023b). The result shows that 90% indicated increased rainfall intensity. This implies overbearing rainfall, which could lead to the erosion of newly planted rice seedlings and the washing away of soil nutrients and vegetative soil supports, causing total crop failure and poor performance (Sharma et al. 2022). About 97.5% of the rice farmers identified increased temperature; this implies that the rice farmers experienced increasing temperature, and this could lead to dryness of the soil moisture contents, which limits rice production and increases disease and pest infestations, which attacks rice plants, leading to poor yield and low harvest (Joseph et al. 2023). High temperatures oppose rice cultivation by destroying soil microorganisms, which support soil efficacy and soil-fauna microbial activities. About 95.0% assented to severe windstorms; severe windstorm implies fierce, destructive, and unfavorable wind patterns that cause severe havoc on rice plants (Dar et al. 2024). Excessive wind destroys rice planted in the field, leading to poor growth and yield performance. In addition, severe windstorms uproot newly planted and already growing rice seedlings, causing total crop damage and failure. High relative humidity was identified by 80% of the rice farmers. High relative humidity promotes the growth and emergence of rice pests and diseases that feed on rice plants, causing crop failure and low yield (Ojo and Baiyegunhi 2020). It affects the photosynthetic processes of rice plants, leading to stunted growth and poor root and shoot development. About 98.8% of the rice farmers indicated a late onset of rainfall; this implies a delay in rainfall, which leads to a prolonged drought season, thereby negatively affecting rice production. Late onset of rainfall distorts farming activities and the calendar, affecting the yearly planting of crops—delayed rains cause land dryness, which does not support rice cultivation (Habib-Ur-Rahman et al. 2022). Early cessation of rainfall was identified by 87.5% of the rice farmers. This implies the sudden and unexpected cessation of rainfall which severely affects rice production. Early rain cessation is inimical to rice cultivation as it distorts rice growth and overall development causing poor yield and harvest. It makes already planted rice seedlings to lose support of soil moisture and causes yellowing of rice leaves (Bichi et al. 2023). High evaporation rate was indicated by 92.5% of the farmers. High evaporation rate implies the quick loss of water to the atmosphere thereby depleting soil-moisture contents and soil-water needed for overall growth rice crop growth and development. The sudden losses of soil-water causes rice field dryness mostly in the vegetative soil-layers which debase rice yield. About 81.3% of the rice farmers' experienced high atmospheric pressure, high atmospheric pressure prolongs rice crop germination time, delays the growth rate of young rice plants and impede root and shoot development in rice plants (Saud et al. 2022). It also affects soil microbial organisms responsible for soil build-up sand other soil-activities needed for optimal rice growth. It equally distorts the photosynthetic activities in rice plants leading to low yield and economic losses.

Adaptation mechanism of rice farmers to climate change

Table 3 presents the adaptation mechanisms of rice farmers to climate change. The table shows 88.8% of rice farmers adopted the irrigation methods. This implies the artificial or alternate water provisions during drought periods. Our agricultural system is dependent on rain fed agriculture making rice farmers vulnerable to climate change (Ali et al. (2021). Adoption of irrigation method substitute for rain absence by providing rice farmers with the needed water required for rice production throughout the cropping season and this ensures maximum rice yield. Use of improved seed varieties was adopted by all the rice farmers (100%). This implies the use of proven rice seedlings that is resistant to rice pests and diseases and adverse climatic and weather conditions (Amadu et al. 2020). These improved rice seedlings ensures improved rice yield, performance and optimal harvest. Use of developed farm machineries was adopted by 12.5% of rice farmers. This implies the deployment of modern farm machines such as tractors, planters, harrowers, ridgers, etc. in rice cultivation. These developed implements facilitate rice cultivation in the face of climate change and adverse weather conditions (Arifah et al. 2022).Its usage enhances rice yield and improved land productivity while displacing the use of crude implements which retards yield. Effective use of pesticides on farm was adopted by 96.3% of the rice farmers. Efficient and effective use of pesticides assists in controlling rice pests and diseases caused by high temperatures and frequent rainfalls. Most indigenous rice varieties are vulnerable to pest infestations and disease and thus the use of pesticides which should be properly applied based on specifications (Adekunmi et al. 2022). Efficient application of fertilizers on farm was adopted by 95.0% of rice farmers. Due to negative impacts of climate change on rice field, farmers' experiences low yields and poor harvest leading to economic losses and time invested in cultivation. As a result the use of inorganic fertilizers seems appropriate and efficient in remedying these ugly impacts of climate change on rice fields. The use of fertilizers improves rice production and enhances better performance both in land yield and productivity (Yakubu et al. 2021). The table further reveals that 96.3% of the rice farmers adopted the use of crop rotation. Crop rotation refers to a proven and verified land management system used to mitigate the negative impacts of changing climate and ensures sustainable crop yield with other crops inclusive. It helps to break pest and disease cycles caused by adverse weather condition and reinforces nutrient supply required for optimal rice yields. About 88.8% of rice farmers adopted changing of cultivation date. The change of cultivation dates is necessary considering climate change negative effects on rice production (Gbemavo et al. 2022). Changing of cultivation date are effective strategies in dealing with continued variations of precipitation and temperature. Change of dates allows farmers to suit their cropping in respect to variations in climate change per time. Adoption of plant spacing was adopted by 81.3% of rice farmers. Crop spacing assist in the development of rice roots, shoots, and overall crop growth. It helps in effective distribution of light, water, and nutrients required in rice plants (Akanbi et al. 2022). Crowding of rice plants in the face of climate change leads to overall crop failure and input-resource sabotage. The use of improved soil conservation methods was adopted by 80% of rice farmers. This connotes that the rice farmers practiced improved soil conservation methods such as mulching, erosion control, use of drainage systems, etc. in mitigating climate change and improving rice production (Khan et al. 2022a). Improved soil conservation methods helps to maintain soil fertility, biodiversity and aid in soil developmental processes and nutrient capacity of soils leading to improved yields. Diversification was adopted by 90% of the rice farmers. Diversification is a multi-level processes in which crop farmers engage in other income yielding occupation to guard against the negative effects of climate change on agriculture and crop production. Diversification allows crop farmers to explore other areas and engage productively should there be any climate eventualities (Ocheni et al. 2021).

Table 1. Socio-economic characteristics of rice farmers

Variable	Frequency	Percentage
Age		
20-30	15	18.8
31-40	22	27.5
41-50	35	43.8
51 and above	08	10.0
Mean	48	
Sex		
Male	69	86.3
Female	11	13.8
Marital status		
Single	21	26.3
Married	41	51.3
Widowed	18	22.5
Level of education		
Primary	26	32.5
Secondary	33	41.3
Tertiary	09	11.3
Non formal	12	15.0
Household size		
1-4	22	27.5
5-8	51	63.8
9-12	07	8.8
Mean	07	
Occupation		
Farming only	21	26.3
Farming and others	59	73.7
Farm Size		
0.1-1.0	35	43.8
1.1-2.0	38	47.5
2.1-3.0	07	8.7
Mean	1.8	
Extension contact		
1-2	16	20.0
3-4	08	10.0
None	56	70.0
Mean	1.6	
Cooperative membership		
Yes	10	12.5
No	70	87.5
Participation in workshop/training		
1-2	13	16.3
3-4	06	7.5
None	61	76.2
Mean	1.3	
Farming Experience		
1-10	18	22.5
11-20	54	67.5
21-30	08	10.0
Mean	18	
Source of Capital		
Banks	08	10.0
Friends/relatives	33	41.3
personal savings	39	48.7
Source of land		
Inheritance	29	36.3
Lease/rent	19	23.8
Gift	15	18.8
Purchase	11	13.8
Pledge	06	7.5
Source of labour used		
Family	30	37.5
Hired	25	31.2
Both	25	31.2

Table 2. Perceived climate change occurrence encountered by rice farmers

Perceived climate change occurrence	*Frequency	Percentage (%)
Prolonged drought	76	95.0
Increased intensity of rainfall	72	90.0
Frequent floods	67	83.8
Increased temperature	78	97.5
Severe windstorm	76	95.0
High relative humidity	64	80.0
Late onset of rainfall	79	98.8
Early cessation of rainfall	70	87.5
High evaporation rate	74	92.5
High atmospheric pressure	65	81.3

Note: *Multiple Responses

Table 3. Adaptation mechanism of rice farmers to climate change

Adaptation mechanism of rice farmers	*Frequency	Percentage
Adoption of irrigation methods	71	88.8
Use of improved varieties of seeds	80	100.0
Use of developed farm machineries	10	12.5
Effective use of pesticides on farm	77	96.3
Efficient application of fertilizers on farm	76	95.0
Adoption of crop rotation system	77	96.3
Changing of cultivation date	71	88.8
Adoption of plant spacing	65	81.3
Adoption of improved soil conservation methods	64	80.0
Diversification of crops	72	90.0

Note: *Multiple Responses

Table 4. Determinants of vulnerability of rice farmers to climate change

Variable	Coefficient	t-value	S.E
Constant	0.762	1.901**	0.400
Age	-6.436	-3.951***	1.629
Education	9.540	3.351***	2.847
Household size	-16.853	-0.702ns	24.007
Access to capital	-0.967	-2.821**	0.342
Farming experience	-3.601	-4.843***	0.743
Farm size	0.841	-0.788ns	1.067
Access to climate change information	-10.421	-3.902***	2.671
Participation in climate change workshops	0.562	-1.001ns	0.561
Gender	-0.887	-1.990**	0.446
Extension contacts	-13.742	-2.002**	6.864
R^2	0.881		
F-value	42.099		
N	80		

Note: ***, ** indicates significant at 1 and 5% levels

Table 5. Identified factors impeding rice production of farmers

Identified factors	*Frequency	Percentage
Lack of timely access to inputs	78	97.5
Inadequate lands	72	90.0
High cost of fertilizers	80	100.0
Increased water flooding	57	71.3
Incidence of pests and diseases	71	90.0
Inadequate capital	78	97.5
High cost of labor	69	86.3
Poor extension service	77	96.3
Inaccessibility of climate change information	66	82.5
Poor storage facilities	70	87.5
Crude processing equipment	80	100.0

Note: *Multiple responses

Determinants of vulnerability of rice farmers to climate change

Table 4 presents the determinants of vulnerability of rice farmers to climate change. The R^2 value of 0.881 explained about 88.1% of the total variations in the vulnerability of rice farmers to climate change. The F value of 42.099 was significant and further indicates the goodness of fit of the model used. Age coefficient was negative at 1% and significant; this implies that aging farmers tend to be more vulnerable to climate change compared to younger farmers. This could also mean the inability of aging farmers to access vital information on climate change ahead of time to mitigate its negative effects on rice production. Typically age of a farmer is very important in agricultural production and climate change mitigation (Khan et al. 2022b). Education coefficient was significant at 1% and was statistically positive; indicating that the higher the educational level of the rice farmers, the less vulnerable they will be to climate change issues. Education is known to empower farmers with the requisite knowledge and understanding of variations in climate and weather conditions. It exposes farmers in accessing vital information regarding climate change and its adverse effects (Osuji et al. 2023). Access to capital was significant at 5% and was negative, indicating that access to capital determines the vulnerability of rice farmers to climate change. Inability of the rice farmers to access capital limits the purchase of planting materials such as improved and resistant seed varieties, chemicals for pests and disease control, fertilizers, etc. which is essentially used in mitigating climate change adverse impacts on crop production. In addition, this further implies that failure of the rice farmers to access capital makes them more vulnerable to climate change (Onyeneke et al. 2021). Farming experience was significant at 1% and statistically negative. This implies that inexperienced farmers suffers most from the negative consequences of climate change and are more vulnerable to climate change adverse effects. More so, while experienced farmers are better-off with changes in climate, inexperienced ones are at a loss and are faced with severe climate change impacts which affects their crop yield and outputs (FAO 2022). Access to climate change information was significant at 1% and statistically negative; indicating that access to climate change information could lead to the vulnerability of the rice farmers to climate change. Inability of the rice farmers to access climate change information makes them more vulnerable to climate change negative effects. Failure to access climate change information exposes farmers to the dangers associated with climate change which manifests in crop failures and poor yields (Ho et al. 2022). Gender was significant and statistically negative at 5%, this implies that the female farmers are more vulnerable to climate change than the male farmers. This could be due to their feminine nature and inability to observe climate change variations and undue weather conditions per cropping season. This also could imply inability of the female farmers to take proactive measures to mitigate negative effects of climate change upon observations and access to information (Van-Oort and Zwart 2018). Extension contacts was significant and statistically negative at 5%, indicating that rice farmers with no extension contacts becomes more vulnerable to climate change when compared with farmers with good exposure to extension contacts. Furthermore, poor extension contacts limits diffusion and accessibility of climate change information and thus exposes the farmers to vulnerability of climate change. Extension service is a vital tool in overcoming climate change incidence and occurrence regarding crop production (Arifah et al. 2022).

Identified factors impeding rice production of farmers

Table 5 presents the factors impeding rice production of farmers. The table shows that 97.5% of rice farmers perceived lack of timely access to inputs to be a limiting factor in the production of rice. This implies that inability of the farmers to access farming inputs on time constrained rice production (Chen et al. 2023a). Inadequate lands were identified by 90% of the rice farmers. This shows that the rice farmers cultivated on small portions of lands. This could be due to land tenure systems and land scarcity which limit large scale rice production (Sharma et al. 2022). High cost of fertilizer was indicated by 100% of the rice farmers. This implies that high cost of fertilizer contributed to low rice production. Most of the rural farmers are resource poor and may not be able to afford the high cost of fertilizers, and this could be a serious challenge for the farmers. Increased water flooding was identified by 71.3% of rice farmers. This implies that the issue of climate change contributing to water flooding of rice field can be devastating leading to total crop failure (Joseph et al. 2023). About 90% of the rice farmers indicated incidence of pest and diseases to be a limiting factor in rice production. This shows the prevalence of pests and disease attacks on rice plants which reduce rice yields. Inadequate capital was identified by 97.5% of the rice farmers. Inadequate capital is a major challenge facing rural farmers, inability of the farmers to access capital from banks and other micro-finance institutions limits large scale production (Dar et al. 2024). High cost of labor was identified by 86.3% of the rice farmers. This connotes that inability of the rice farmers to afford high labour fares could be a huge constraints to rice production. This stems from rural-urban migration of youths to cities in search of greener pastures. Poor extension service was identified by 96.3% of rice farmers. This means that lack of access to extension services impeded rice production. Poor extension services limit the dissemination of farm information, innovation and technical know-how regarding crop production (Ojo and Baiyegunhi 2020). Inaccessibility of climate change information was indicated by 82.5% of rice farmers. This implies that inability of the rice farmers to access climate change information constrained rice production. Issues of climate change relating to high temperature, irregular rainfall, high evaporation rate, relative humidity, etc. are remarkable impediments to rice production (Habib-Ur-Rahman et al. 2022). Poor storage facility was indicated by 87.5% of the rice farmers. Issue of storage facilities limits large scale cultivation of rice, as harvested rice is prone to grain losses and spoilage and further resulting in economic losses. Crude processing equipment was identified by 100% of the rice farmers. This means that the farmers encountered so many losses during the processing of rice resulting from the use of crude processing equipments. This further connotes that value addition in rice processing is jeopardized via the use of crude processing tools.

In conclusion, the study's findings show that the rice farmers were more male, married, experienced, and productive age, with a household size of 7 persons. Notable perceived climate change occurrences were prolonged drought, increased intensity of rainfall, frequent floods, increased temperature, and severe windstorms. To mitigate climate change, the farmers employed some adaptation measures such as adopting irrigation methods, improving varieties of seeds, developing farm machinery, effective use of pesticides, efficient application of fertilizers, and adopting a crop rotation system. Age, education, access to capital, farming experience, access to climate change information, gender, and extension contacts appeared to be significant determinants of climate change vulnerability for rice farmers. Lack of timely access to inputs, inadequate lands, high cost of fertilizers, increased water flooding, pests and diseases, and inadequate capital-constrained rice production of farmers. Farmers should practice more climate-smart agriculture to overcome the adverse effects of climate change on rice production. Farmers should seek early climate change information to mitigate the adverse effects of climate change on rice production.

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