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Impact of Climate Information Services on Crop Yield in Ebonyi State, Nigeria

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Abstract: This paper assessed crop farmers' access and utilization of climate information services (CIS) and impact of CIS use on crop yields in Ebonyi State, Nigeria. The multi-stage sampling procedure was used to select 405 farmers from the State, and data were collected through a survey of the farmers using a questionnaire. We employed descriptive statistics, endogenous treatment effect, and Heckman probit selection model to analyze the data collected. The result indicates that a majority (89%) of the farmers accessed climate information and that the common sources of climate information include agricultural extension officers, fellow farmers, and radio. This study shows that 88% of the farmers used climate information services in making farming decisions. Farmers' age, household size, marital status, farming experience, income extension contact, ownership of television, ownership of radio, ownership of mobile phone, proximity to the market, workshop/training participation, climate events experienced, and knowledge of appropriate application of fertilizer significantly influenced both access and utilization of CIS. The use of CIS in planning for farming activities significantly increased rice, maize, and cassava yields. The study demonstrates the important contribution of climate information services in crop production. We therefore recommend that access and use of climate information services in agricultural communities should be increased.

Keywords: access; use; climate information services; cross sectional survey; heckman probit selection model; endogenous treatment effect

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1. Introduction

Climate change presents a major challenge to Africa and the rest of the world's agricultural and economic systems. The IPCC and WMO observed that rising sea level, increasing temperature, extreme climate events, and changing rainfall pattern and distribution are negatively impacting agriculture on the continent [1,2]. These climate risks have led to different degrees of drought and floods on the continent, with serious negative impacts on food and livelihood security and gross domestic product (GDP) [2,3]. Because most Africans have little adaptive ability and rely largely on climate-sensitive sectors, the continent is more prone to climate change consequences than other parts of the world [4,5]. This will undoubtedly exacerbate the continent's already dire food insecurity and poverty issues, with over 25% of the population (particularly in sub-Saharan Africa) suffering from acute food insecurity [6]. Various crop models have predicted decline in the yields of different crops and net revenue from crop production in different countries in the continent [7–12]. The National Adaptation Strategy and Plan of Action on Climate Change for Nigeria document estimates that climate change will reduce Nigeria's GDP by 6 to 11 percent if no action is taken to adapt to the effects of the changing climate [13]. Boko et al. [14] also predicted a major decline in the contribution of agriculture to sub-Saharan GDP by as much as 2 to 7 percent in 2100.

Nigerian agriculture is critical to the country's economic success. Between 2010 and 2019, agriculture employed around 70 percent of the country's workforce and generated an average of 22% of GDP [15]. Following the challenges of climate change on agriculture and other sectors of the economy, Nigeria has developed several policies and plans to enhance and coordinate an adaptation response. Enhancing climate action (including adaptation) is the thirteenth goal of the Sustainable Development Goals (https://www.undp.org/sustainable-development-goals#climate-action, accessed on 18 December 2022).

The term "adaptation" refers to changes or readjustments made to a system in order to mitigate the effects of, or get ready for, future climate change hazards. In other words, the goal of agricultural adaptation is to protect farmers from climate-related hazards as much as possible. Exposure, sensitivity, and adaptive capacity are the three factors that contribute to systems' and sectors' vulnerability to climate threats [16]. One can find several adaptation actions in the crop sub-sector reported in the literature, and most such strategies are determined by socioeconomic, farm, institutional, and location-specific characteristics [17–19]. Nigerian policies and strategies such as the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria, the Nationally Determined Contribution, National Agricultural Technology and Innovation Policy, and the Agriculture Promotion Policy (APP) consider climate smart agriculture, techniques for better resource management, and crop production systems to be priority adaptation actions for agriculture in the country [13,20–22].

Strategies for successfully adapting to climate change could be hampered by inadequate appropriate climate information [23]. Having accurate climate information provided in a timely manner is a sine qua non for effective adaptation planning in agriculture [3,24]. Climate information is simply the provision and translation of useful climate data and knowledge (such as past climate, short-term and long-term forecasts/projections of weather, and climate parameters) for decision making and planning [25–27]. Climate information alone cannot be sufficient in influencing farm decision making because of the highly technical nature of climate forecasts/projections, which farmers often find difficult to understand. Therefore, providers of such information should accompany it with appropriate agricultural advice to farmers to adequately equip them tomanage the projected/anticipated hazards [28]. Climate information services (CIS) refer to agricultural advisories integrated in climate information, and these assist crop farmers in determining which practices to use to manage the predicted/anticipated climate risks [29–31]. The application of climate information services accessed in farm planning and decision making entails their use [32]. Nigerian agriculture systems are largely rain-fed [33]; therefore, farmers in Nigeria need climate information to manage climate risks, which in turn would enhance their productivity.

In Nigeria, the Nigerian Meteorological Agency (NiMET) provides periodic climate information services (CIS) through its networks found in different states in the country and collaborates with other agencies to ensure CIS gets to end users. Furthermore, CIS is disseminated through several channels and media, including televisions, radios, agricultural workshops/shows, bulletins, other publications (such as seasonal rainfall prediction reports), extension agents, social media platforms, cell phones, and farmer groups. Climate information services will achieve its cardinal objective in agricultural production only if it is available, timely, accurate, and provided through appropriate institutions and channels to farmers and used by the farmers to reduce climate impacts [34]. CIS provision in Nigeria is gradually gaining momentum, but the accessibility and utilization especially by farmers is still limited [35,36]. In addition to providing climate information and dissemination with agronomic advisories, efforts should also be made to track how farmers use the CIS for informing farm decisions [37,38]. However, many factors constrain the accessibility and utilization of CIS by farmers [39]. Understanding farmers' access to and utilization of CIS, the factors shaping them, the impact of CIS on crop yield, as well as the challenges to the utilization of CIS in making agricultural production decisions are therefore critical in climate change response in crop production in Nigeria in general and Ebonyi State in particular. Interest in these issues is the core motivation of this paper.

Farmers and other end users in Africa have limited access to and use of CIS [36,39–44]. Additionally, there is a dearth of understanding on the use of CIS for managing climate risks in crop production [34]. This is largely caused by inaccessibility of climate information services by farmers [45]. Furthermore, a dearth of information on the effective dissemination channels, the level of uptake by farmers, and the disconnect between producers of CIS and end users are also responsible for the low uptake and use of CIS in many developing countries, including Nigeria [40,41,46–48].

Furthermore, the important role of climate information services in assisting with adaptation and mitigation efforts cannot be overstated. Climate information services invariably contribute to mitigating the negative consequences of climate change and, by extension, to the agriculture sector's resilience. However, there is limited research on CIS access and use in Nigeria, as well as the impacts on agricultural yield. The focus of most existing studies is on the description of climate information [35,36,39,47] without attention to the determinants of access and use of CIS. Furthermore, there is a dearth of research on the effect of climate information services on yield and, by extension, food security in Ebonyi State in particular and in Nigeria, Africa's most populous country, where agriculture is the mainstay. In Nigeria and sub-Saharan Africa, agriculture contributes to a large portion to the inhabitants' occupations and livelihoods. Conventional rain-fed agriculture is a major feature of the farming communities, and CIS is needed to adapt. A dearth of knowledge of existing climate information services would logically limit its usage otherwise. Therefore, there should be certain distinguishing features that inform what decisions farmers make in changing climatic conditions in Africa. As a result, this research provided explanations to the following research questions: Do farmers have access to climate information? Do farmers utilize climate information services in making farming decisions? What are the determinants of crop farmers' access and use of CIS in Ebonyi State? What is the impact of CIS on crop yields?

2. Methodology

2.1. Study Area

The survey was conducted in Ebonyi State, Nigeria. Ebonyi State is particularly vulnerable to the adverse impacts of climate change due to recurring floods, rising temperature, rainfall variability, and extreme weather events [49–51]. In 2016, the population increased to 2,880,383 persons [52]. Ebonyi is one of the states in southeastern Nigeria and is divided into three agricultural zones—Ebonyi north zone, Ebonyi south zone, and Ebonyi central zone—and thirteen local government areas (see Figure 1). Smallholder crop farmers dominate agricultural production in the state and cultivate food crops such as rice, cassava, yam, potato, maize, plantain, and vegetables. The major means of livelihood of the inhabitants of the area is rainfed agriculture.

2.2. Research Design and Type of Climate Information Disseminated

2.2.1. Research design

This study adopted the multistage sampling procedure in selecting respondents for the survey. The three agricultural zones of the state were involved in the study. In the first stage, three local government areas (LGAs) in each agricultural zone were selected. In each zone, the study selected three LGAs. In each selected LGA, three communities were randomly selected. At the third stage, the study selected fifteen crop farmers in each community. This made the sample size for the study four hundred and five (405) crop farmers. The main instrument for data collection was a structured questionnaire. The questionnaire was administered to the farmers by recruited and trained enumerators. The paper used a questionnaire that captured the data required to answer the research questions and administered the questionnaire to the respondents. Data collected were analyzed using descriptive statistics, factor analysis, and the Heckman probit model. Describing the socioeconomic characteristics of the farmers, their access and utilization of climate information services were analyzed using descriptive statistics. We used the

Heckman probit model to analyze the determinants of access and the utilization of climate information services. The implicit form of the Heckman probit model is written as:

Y_1 (access to CIS; 1 if farmer had access to CIS, 0 if farmer had no access to CIS)

Y_2 (use of CIS in farm decision-making; 1 if farmer used CIS, 0 if farmer did not use CIS)

$$Y_1 = \alpha W_i + \mu_{1i} \text{ Selection equation} \quad (1)$$

$$Y_2 = \delta X_i + \mu_{2i} \text{ Outcome equation} \quad (2)$$

$$Y_2 = \delta X_i + \delta_\lambda \pi_i + \mu_{2i} \text{ Latent equation} \quad (3)$$

μ_1 and μ_2 ~ N[0,1]

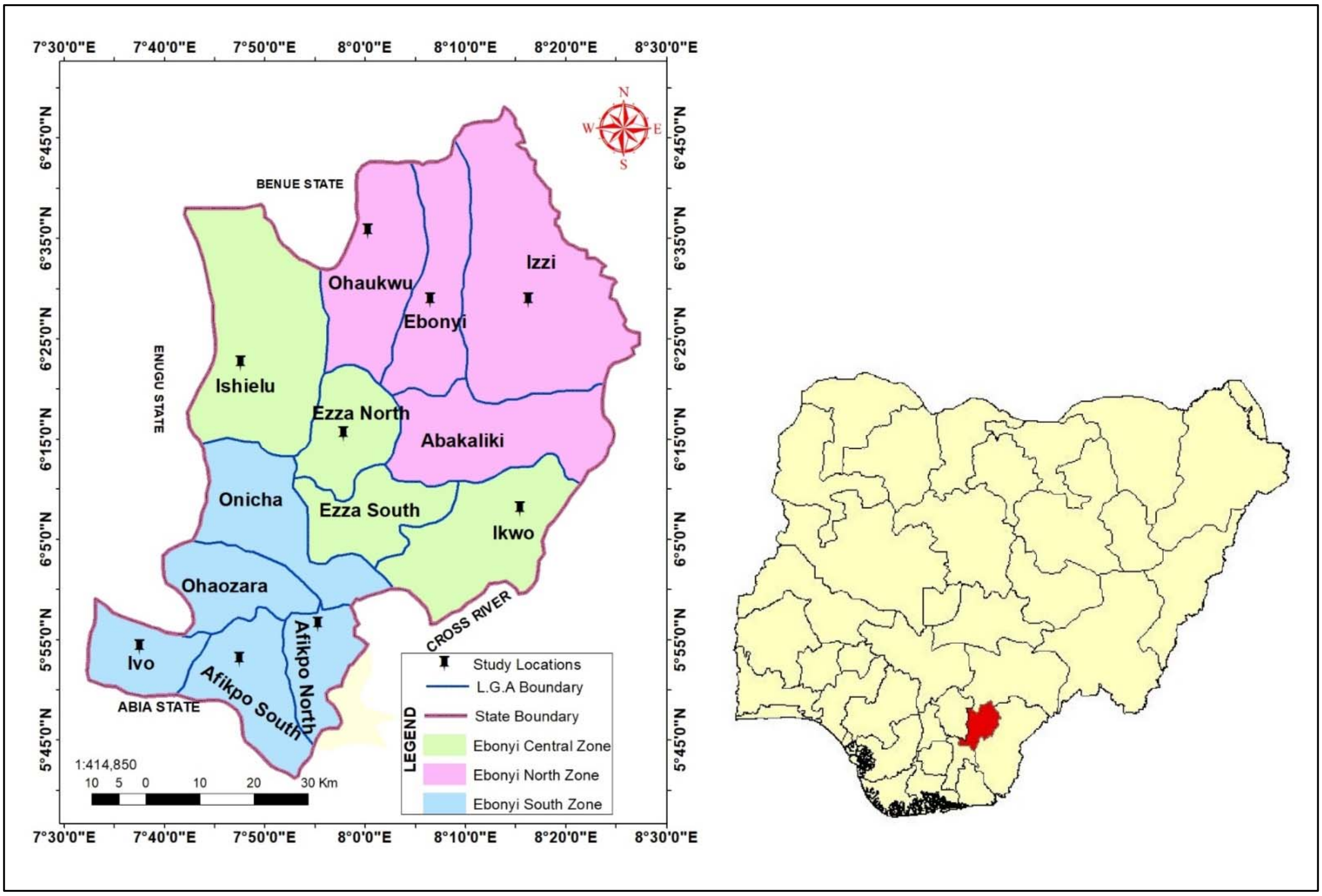

Figure 1. Map of Ebonyi state showing the agricultural zones and local government areas.

To correct the problem of selectivity bias, an additional independent—inverse Mills ratio—is added to Equation (2) to generate Equation (3). This is because the decision to utilize CIS in farming (Y_2) was endogenously determined because farmers had to access CIS (Y_1) before utilizing it. In this case, the Heckman probit selection model is most appropriate to analyze the determinants of access and use of CIS because of its ability to correct for potential selectivity bias [53,54]. α and δ are the vector of the parameter estimates of the explanatory variables, and W_i and X_i represent the independent variables that influence Y_1 and Y_2, respectively. μ_{1i} and μ_{2i} are the respective error terms with normal distributions, zero mean, and unit variance. We followed the scholarly work of Muema et al. [32] in measuring access and utilization of CIS. In their paper, farmers who reported accessing CIS were given a score of 1, while those who reported not accessing CIS were given a score of 0; furthermore, farmers who reported utilizing CIS in farm decision making were given a score of 1, while those who reported not utilizing CIS were given a score of 0.

The explanatory variables for the selection equation (access to CIS) include:
W_1 = gender (dummy variable; male = 1, female = 0)
W_2 = age (years)
W_3 = education (years spent in school)
W_4 = household size (number of persons)
W_5 = marital status (married = 1, not married = 0)
W_6 = farming experience (years)
W_7 = income (Naira)
W_8 = contact with extension agents (number of extension visits/contacts per year)
W_9 = access to credit (dummy variable; yes = 1, no = 0)
W_{10} = ownership of television (dummy variable; yes = 1, no = 0)
W_{11} = ownership of mobile phone (dummy variable; yes = 1, no = 0)
W_{12} = ownership of radio (dummy variable; yes = 1, no = 0)
W_{13} = farm size (ha)
W_{14} = proximity to the market (dummy variable; yes = 1, no = 0)
W_{15} = membership of farmer groups/cooperatives (dummy variable; yes = 1, no = 0)
W_{16} = participation in workshop/training on climate risk management/crop production (dummy variable; yes = 1, no = 0)
W_{17} = climate event experienced (dummy variable; 1 if the farmer had experienced climate events, 0 otherwise)
W_{18} = relied on government for support when experiencing a climate event (dummy variable; yes = 1, no =0)
W_{19} = access to improved crop varieties (dummy variable; yes = 1, no = 0)
W_{20} = knowledge of appropriate application of fertilizer (dummy variable; yes = 1, no = 0)
W_{21} = access to irrigation (dummy variable; yes = 1, no = 0).
The explanatory variables for the outcome/latent equation (utilization of CIS) include:
X_1 = gender (dummy variable; male = 1, female = 0)
X_2 = age (years)
X_3 = education (years spent in school)
X_4 = household size (number of persons)
X_5 = marital status (married = 1, not married = 0)
X_6 = farming experience (years)
X_7 = income (Naira)
X_8 = contact with extension agents (number of extension visits/contacts per year)
X_9 = access to credit (dummy variable; yes = 1, no = 0)
X_{10} = ownership of television (dummy variable; yes = 1, no = 0)
X_{11} = ownership of mobile phone (dummy variable; yes = 1, no = 0)
X_{12} = ownership of radio (dummy variable; yes = 1, no = 0)
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X_{18} = relied on government for support when experiencing a climate event (dummy variable; yes = 1, no =0)
X_{19} = access to improved crop varieties (dummy variable; yes = 1, no = 0)
X_{20} = knowledge of appropriate application of fertilizer (dummy variable; yes = 1, no = 0)
X_{21} = access to irrigation (dummy variable; yes = 1, no = 0).

One major challenge in impact estimation is addressing hidden (unobservable factors) and overt (observable factors) biases [55–57]. We used a coherent framework to measure how farm households' utilization of climate information service decision impacts their crop yield. To address possible confounding issues in our dataset, we used the endogenous treatment effect model. The endogenous treatment effect model accounts for both observable and unobservable factors that affect the use of climate information services and its impact on crop yield [58–60].

Farmers weigh the expected net benefits from utilizing CIS in farm decision making; thus, if the expected benefits of utilization CIS are greater than the benefits of non- utilization CIS, farmers prefer to utilize it. The CIS utilization decision is expected to affect crop yield. We considered the use of CIS in farm decision making as non-randomly assigned among farmers because they endogenously self-select into use and non-use decisions. Thus, decisions can be influenced by unobservable variables/confounders that may correlate with the crop yield of interest in this study. Therefore, the impact of CIS use on crop yield can be modelled as a function of farmers' observable and unobservable characteristics. Consequently, we used the endogenous treatment effect to model the impact of CIS use on crop yield and the model is stated as follows:

$$ATE(X_i) = E(y_{i1} - y_{i0}\ |X_i) \tag{4}$$

$$ATET(X_i) = E(y_{i1} - y_{i0}\ |X_i,\ T_i = 1) \tag{5}$$

$$ATENT(X_i) = E(y_{ik1} - y_{i0}\ |X_i,\ T_i = 0) \tag{6}$$

where;

E = the mean operator.

T_i = treatment taking only two values, 1 and 0. It takes a value of 1 for farmers using CIS in farm decision making and 0 for farmers not using CIS in farm decision making.

X_i = vector of control variables such as gender, age, education level, household size, marital status, farming experience, income, extension contact, access to credit, ownership of television, phone, radio, farm size, proximity to the market, membership of cooperatives, workshop participation, climate event experienced, reliance on government support, access to improved varieties, knowledge of fertilizer application, and access to irrigation facilities.

y_{i1} = rice, maize, and cassava yield in the subpopulation of farmers using CIS in farm decision making.

y_{i0} = rice, maize, cassava yield in the subpopulation of farmers not using CIS in farm decision making

ATE = average impact of CIS use on rice, maize, and cassava yields in the population.

ATT = average impact of CIS use on rice, maize, and cassava yields in the subpopulation of farmers using CIS in farm decision making.

ATT0 = average impact of CIS use on rice, maize, and cassava yields in the subpopulation of farmers not using CIS in farm decision making.

2.2.2. Type of Climate Information Disseminated

The climate information accessed by the farmers include seasonal forecasts, daily weather forecast, weekly forecast, seasonal rainfall prediction, and others. These information are usually provided by the Nigerian Meteorological Agency and disseminated to end users through various media—television, radio, social media platforms, bulletins, and so on. Other stakeholders play roles in the dissemination process by making the climate information available and accessible to farmers and other agricultural producers. The frequency of dissemination of the climate information is not constant but varies according to the platform through which the information is being disseminated.

3. Results and Discussion

3.1. Climate Information Services Accessed by Crop Farmers

3.1.1. Access to Climate Information

The result on access to climate information presented in Figure 2 shows that the majority (89%) of the farmers had access to climate information. Accessing climate information is very necessary in this era of climate risks. Efforts towards helping the farmers in this regard should be geared towards an easy access, so that the shocks and climate events they have been witnessing could be handled easily. The result agrees with the finding of Muena et al. [32] who found that 94% of sampled farmers in Makueni County in Kenya accessed climate information services.

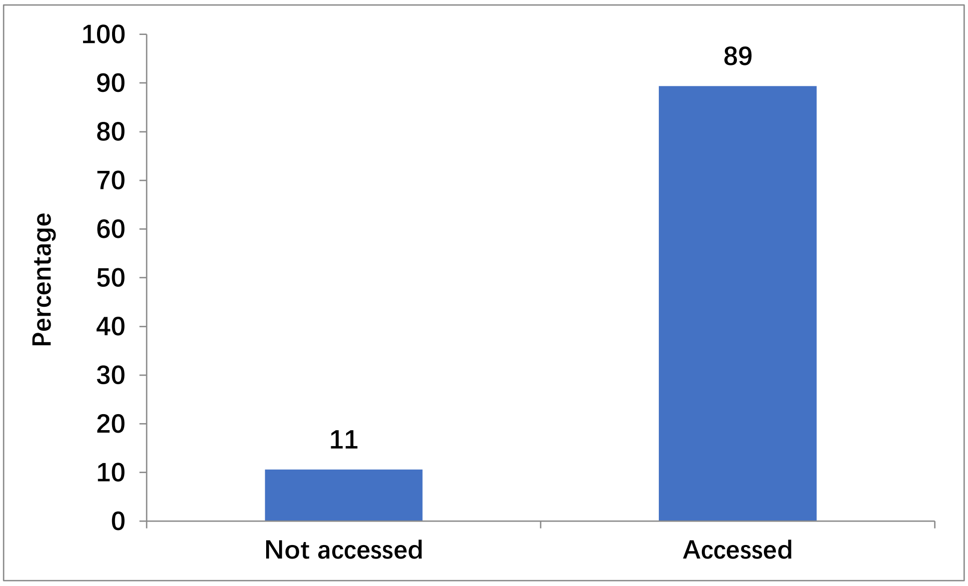

Figure 2. Percentage distribution of farmers according to access to climate information.

3.1.2. Sources of Climate Information

The result on the sources of climate information presented in Table 1 indicates that the majority (82%) of the farmers accessed climate information through the radio medium. The implication of this is that radio is a cheap and easy medium through which climate and other agricultural information can be passed to the farmers. This is followed by information through fellow farmers (55%). According to Adio et al. [61], fellow farmers are another easy medium through which farmers gain access to information. Whether on the farm or during meetings or at any gathering, farmers feel free to share information with fellow farmers for mutual benefits. Another major source (55%) was through extension agents. In Table 1, the majority of the farmers had contact with extension agents. These were the most common means/channels of delivering climate information to farmers. Farmers also received climate through television (45%), family members and friends (41%), donor-funded projects (40%), and internet (34%), among others.

3.2. Utilization of Climate Information Services in Farming

The analysis of the utilization of climate information services in farming presented in Figure 3 shows that the majority (88%) of the farmers utilized climate information services, and this is largely due to the need for this information for agricultural production in this era of climate change. The majority of the farmers utilizing climate information, however, confirms the work of Hansen et al. [62], which asserted that the increasing recognition of climate information services is due to its importance in the adaptation to climate change in the agricultural sector through the provision of local climate knowledge, supporting interventions building the resilience of farmers, and creating a welcoming space to enhance the adoption of agricultural practices that are smart for climate.

Table 1. Frequency distribution of farmers according to sources of climate information.

Source of Climate Information	Frequency	Percentage
Radio	333	82
Fellow farmers	223	55
Agricultural extension services	221	55
Television	182	45
Family members/friends	165	41
Donor-funded projects	162	40
Internet/social media	139	34
Nigerian Meteorological Agency (NIMET)	129	32
Farmers associations/cooperatives	128	32
Phone	117	29
Community-based organizations	114	28
Newspaper	108	27
Research institutions/universities	107	26
Community/village leaders	92	23
Non-governmental organizations (NGOs)	76	19
Social gathering	74	18
Religious organizations	51	13
Printed materials	35	9
Age grades	14	3

Note: Multiple responses recorded.

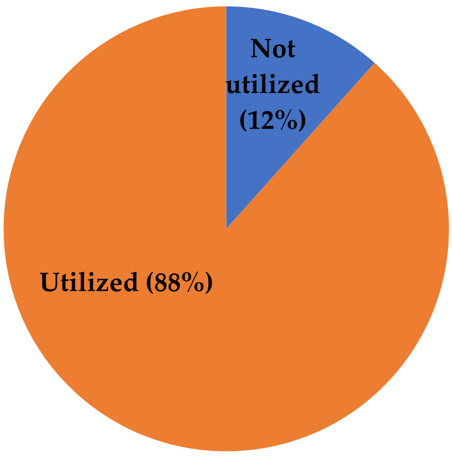

Figure 3. Percentage distribution of farmers according to use of climate information services.

3.3. Determinants of Farmers' Access and Utilization of Climate Information Services

The Heckman probit model was used to analyze the determinants of access and the utilization of CIS, and the result is presented in Table 2. We used the likelihood ratio chi square and the likelihood ratio test of independent equations to determine the significance and appropriateness of the model. The likelihood ratio chi square (LR chi2(21)) had a value of 186.29, which was significant at the 1% level, while the likelihood ratio test of independent equations had a 3.35, which was significant at the 10% level. These results indicate the overall significance of the Heckman probit model and its high explanatory power and appropriateness for modeling the determinants of farmers' access and use of climate information services.

Table 2. Heckman probit selection estimates of the determinants of crop farmers on access and utilization of climate information services.

Variables	Access to Climate Information Services	Utilization of Climate Information Services
	Coefficients	Coefficients
Gender	−0.18 (−0.92)	0.52 (2.19) **
Age	−0.04 (−2.66) ***	−0.02 (−2.43) **
Educational level	0.03 (1.19)	−0.01 (−0.38)
Household size	0.23 (5.49) ***	−0.06 (−1.57)
Marital status	0.86 (1.68) *	0.97 (2.03) **
Farming experience	0.04 (2.57) ***	0.04 (2.41) **
Income	7.74e−07 (1.79) *	3.14e−08 (2.11) **
Extension contacts	0.09 (7.03) ***	0.07 (2.45) **
Access to credit	0.01 (0.03)	0.19 (6.40) ***
Ownership of television	0.30 (2.42) **	0.41 (5.90) ***
Ownership of mobile phone	1.24 (2.55) **	0.86 (2.46) **
Ownership of radio	0.11 (2.42) **	0.02 (6.00) ***
Farm size	−0.07 (−1.25)	0.12 (2.05) **
Proximity to the market	1.81 (3.27) ***	1.30 (2.92) ***
Cooperative membership	−0.02 (−0.10)	0.21 (0.78)
Workshop participation	0.60 (2.65) ***	0.57 (1.66) *
Experienced climate event	1.32 (5.41) ***	0.43 (1.69) *
Relied on government support when experienced climate event	−0.26 (−1.14)	−0.16 (−0.56)
Access to improved crop varieties	0.09 (0.37)	1.16 (4.48) ***
Knowledge of appropriate application of fertilizer	0.69 (2.51) **	0.39 (2.64) ***
Access to irrigation	0.39 (1.02)	1.23 (2.24) **
Constant	−5.55 (−4.70) ***	−2.47 (−2.63) ***

Likelihood ratio Chi square (21) = 186.29; Prob > chi2 = 0.00. LR test of indep. eqns. (rho = 0): $chi^2(1)$ = 3.35; Prob > chi2 = 0.07. Note: *** $p \leq 0.05$, ** $p \leq 0.05$, * $p \leq 0.10$. Values in parentheses are z-values.

Table 2 shows that gender had a significant and positive influence on the utilization of CIS, meaning that men utilized CIS more than women in cropping decision. This could be attributed to the fact that men own/hold more agricultural land in the area than women and are more likely to make decisions on the utilization of CIS in the farms they control. This points to the gendered nature of CIS utilization in crop production and the need to close the gap. This is also pointing to the fact that more integration of gender into agricultural policy for the successful implementation of climate adaption interventions in crop farming becomes critical [63].

Age significantly decreased CIS access and utilization. This shows that younger crop farmers had more access to CIS and that they utilized it than their older counterparts. Age is related to farmers' productivity [64]. The significance of age as a determinant of CIS access and utilization by the crop farmers shows their burning interest in enhancing their productivity amid climate vagaries [65].

Household size significantly increased CIS access. This indicates that larger farm households have better chances of accessing climate information services than smaller farm households. Leonard et al. [66] affirmed that farmers' family size determines the extent of their involvement in farm operations. Deressa et al. [67] recorded the role of large farm households in climate adaption. Marital status generated a significant positive effect on CIS access and utilization. Married people have been known for a high sense of responsibility and the serious pursuance of means of income that invariably increase their productivity through accessing and utilizing CIS [68].

Farming experience had a significant positive influence on CIS access and utilization. This implies that the more experienced a farmer is the higher likelihood he/she has to access and utilize CIS. Farming experience has been identified as enhancing the better use of scarce farm resources by smallholder farmers in Nigeria [69].

Contacts with extension agents positively and significantly influenced CIS access and utilization. This implies that the more frequent farmers are visited by extension agents, the more their CIS access and utilization. Onyeneke [60] found that extension increases access and use of climate and agricultural information, which enhances climate resilience. Contact with extension agents is expected to enhance crop farmers' revenue, improve their productivity, and minimize farm loss by helping farmers to address farm problems [70].

Income had a positive and significant effect on CIS access and utilization. Wealthier crop farmers had better access to CIS than their poorer counterparts. Wealthier farmers also utilized CIS more than poorer farmers. Muema et al. [32] found similar result in Makueni County in Kenya, where monthly income increased CIS access and utilization. Lack of finance hinders farmers from accessing and utilizing CIS [71]. Access to credit significantly increased the likelihood of utilizing CIS. This means that the more farmers access credit facilities, the more likely their decision to utilize CIS accessed. Utilizing CIS is an agricultural investment and could enhance productivity and climate resilience, as confirmed by Ajah et al. [72]. Income and access to credit increase the uptake of innovations [73].

Furthermore, ownership of television, radio, and mobile phones had positive and significant influence on CIS access and utilization. Television, phones, and radio are all sources through which farmers access information [74,75], which increases their productivity, and enhances climate resilience. This result supports the findings of Oyekale [76] that ownership of television for instance increased access to weather forecast in South Africa. Furthermore, Hampson et al. [77] found that farmers trust and preferred climate information disseminated through radios and that disseminating climate information through radios using local languages would improve CIS utilization.

Farm size also significantly and positively influenced CIS utilization. This means that large-scale crop farmers would utilize CIS more than small-scale crop farmers. This is because large farmers would not want to take the risk of negligence on climate information, as the result can be serious. Larger farmers need more agricultural and climate information than their smallholder counterparts due to the magnitude of the expected loss by climate risks if not managed [78,79].

Proximity to the market significantly increased CIS access and utilization. The nearer a farmer's home to the market the better his/her CIS access and utilization. Farmers likely share important agricultural information with fellow farmers, possibly during market days when they bring their goods for sale [61]. Workshop participation significantly increased CIS access and utilization. The more a farmer participates in training/workshops on climate risk management and/or agricultural the better his/her CIS access and utilization.

Workshop participation increase farmers' resilience and output [74,80]. Climate events experienced significantly increased CIS access and utilization. Climate shocks experienced by the farmers make them more sensitive to information on averting climate risks. This result substantiates the findings of Onyeneke [60] and Onyeneke et al. [81], who observed that farmers previously exposed to climate risks understand the impacts and would make efforts not to allow the incurred risks/losses to repeat.

Access to improved varieties significantly increased the utilization of CIS. This implies that farmers with access to improved crop varieties would utilize CIS more than farmers without access to improved crop varieties. Improved crop cultivars aid in climate adaption and resilience, and any farmer with access to improved crop varieties is more likely to be more resilient and to possess higher ability to adapt than farmers without access to improved crop varieties. O'Brien et al. [82] and Patt et al. [83] also observed that access to improved crop seeds increases the benefits of CIS.

Access to irrigation facilities significantly increased CIS utilization. This implies that farmers with access to irrigation facilities would utilize CIS more than farmers without access to irrigation facilities. Irrigation promotes climate adaption, and any farmer with access to irrigation would be more resilient and possess higher adaptive capacity than farmers without access to irrigation. Access to irrigation is necessary for coping with a long drying season [84]. This finding corroborates the observations of Kitinya et al. [85] and Onyeneke [60], who noted the importance of irrigation in utilizing CIS and climate adaption.

Knowledge of the appropriate application of fertilizer significantly increased CIS access and utilization. This implies that farmers with appropriate knowledge of fertilizer application accessed and utilized CIS more than farmers without appropriate knowledge of fertilizer application. Farmers need accurate knowledge of the time and rate of fertilizer application to avoid loss and damage to the crop due to excessive use [86,87]. This finding corroborates the findings of Unique-Kulima [88] and Aryal et al. [89], who found that fertilizer application is important in climate resilience and that the appropriate knowledge of its application aids the efficient and effective use of it on the farm.

3.4. Effect of Use of Climate Information Services on Crop Yield

From Table 3, the use of climate information was identified as having significant effects on the yield of rice and cassava. Particularly, the use of CIS in farming is associated with increases in crop yields in the area. The average treatment effect results showed that using CIS in farming increased the yields of rice, maize, and cassava by 1608 kg/ha, 813 kg/ha, and 2658 kg/ha, respectively, in the population of farmers in the area. The average treatment effects on the treated results showed that using CIS in farming increased the yields of rice, maize, and cassava by 1541 kg/ha, 959 kg/ha, and 2928 kg/ha, respectively, in the sub-population of farmers using CIS in the area. The result of the average treatment effect on the control/untreated shows that CIS use would increase rice yield by 583 kg/ha, maize yield by 136 kg/ha, and cassava yield by 450 kg/ha in the non-users of CIS should they decide to use it in farm decision making. This significant yield increase was due to the interest of Ebonyi farmers in agricultural production [60,90] and their desire to avert climate shocks through the use of climate information services.

Table 3. Endogenous treatment effect estimates of the impact of use of climate information services on crop yield.

Outcome	Unit	Average Treatment Effect (ATE)	Average Treatment Effect on the Treated (ATT)	Average Treatment Effect on the Untreated (ATT0)
Rice yield	(kg/ha)	1608 (13.03) ***	1541 (11.05) ***	583 (7.74) ***
Maize yield	(kg/ha)	813 (26.97) ***	959 (37.99) ***	136 (3.45) ***
Cassava yield	(kg/ha)	2658 (39.35) ***	2928 (51.52) ***	450 (7.41) ***

Note: *** $p \leq 0.01$. Values in parentheses are z-values.

4. Conclusion

This study concludes that most crop farmers are literate, married, experienced, young male smallholders with access to extension services and improved crop varieties and who belong to cooperative societies. They also own radio, television, and phones as information and communication sources. The farmers received climate information via diverse sources including radio, fellow farmers, agricultural extension services, television, donor-funded projects, family members and friends, the internet, the Nigerian Meteorological Agency (NiMET), and farmers associations. The farmers also utilize climate information services.

Age, farming experience, extension contacts, ownership of television, ownership of mobile phones, ownership of radio, proximity to market, workshop participation, experienced climate event, and the knowledge of the appropriate application of fertilizer significantly affect both CIS access and utilization. Use of climate information services significantly increased rice, maize, and cassava yields in the population of farmers, as well as in the sub-population of farmers using CIS.

For more equitable access and utilization of climate information by farmers, the gender gap must be closed, as the result of this study revealed male dominance in accessing and utilizing climate information. Furthermore, more access to credit facilities should be given to farmers, as this would enhance access to climate information, and accessible support from the government should be rendered to farmers in the event of climate shocks, including more training on climate information, wherein the participation of farmers would be encouraged. Irrigation facilities should be made available to farmers for easy adaptability to the long dry season and increasing heat.

Based on the identified sources through which the farmers receive climate information services, it is recommended that the better involvement of religious organizations, age grades, social gathering, community/village leaders, non-governmental organizations, printed materials, community-based organization, and research institutions will enhance the access and utilization of climate information services. On account of the noted utilization of climate information on farm decision-making, area allocation across crops and when to sell farm produce demand more knowledge among farmers. In lieu of this, more sensitization and trainings by extension agents, NGOs, and other agencies is recommended.

Access to improved crop varieties and farm size increased the tendency to utilize accessed climate information in farm decision making. Based on this finding, making farm land more accessible to farmers, as well as enhancing their access to improved crop varieties, would promote the use of climate information services in farm decision making.

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