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Agricultural Extension Services and Climate Adaptive Capacity of Smallholder Farmers in Ebonyi State, Nigeria

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Abstract
Climate adaptive capacity of smallholder farmers through agricultural extension and climate information sources in Ebonyi State, Nigeria was evaluated. Sample sizes of 428 smallholder farmers were selected through multi-stage sampling procedure. Data collected using questionnaire were analysed using percentage, and multivariate probit model. Source of agricultural extension service of smallholder farmers includes; farmer-to-farmer extension (99.6%), mobile phones (96.4%), radio (90.7%) and organized workshops/seminars (88.4%). Source of climate information service were farmer-to-farmer networks (94.4%), radio (90.6%), community meetings (85.4%) and mobile phones (81.6%). Planting of drought-tolerant crops (P<0.05), soil-water conservation (P<0.05), modifying planting dates (P<0.05), and implementing crop rotation systems (P<0.05) were significant adaptive strategies engaged by the smallholder farmers. Agricultural extension and climate information services enhanced adaptive capacity of smallholder farmers. Farmers were advised to engage proven adaptation measures to mitigate adverse effects of weather conditions.

Introduction

Around the world, smallholder farmers make up the majority of farmers practicing agriculture. According to (Chiaka et al., 2022), 80% of smallholder farmers engaged in agriculture and grow staple food crops on small plots using available input resources. Smallholder farmers play a significant role in supplying food to African nations, especially in Nigeria. These groups of farmers are quite unique and are commonly characterised with small land size, labor constraints, inadequate resource endowment or capital, poor market orientation, and limited access to land (Michael, 2024). All of these reduce agricultural output and land productivity, making food availability and provision in the country a looming illusion and the population that depend on these foods more vulnerable to food insecurity. Nonetheless, it is impossible to overstate the value of extension services in assisting smallholder farmers in overcoming the difficulties associated with agricultural output (Loki and Mdoda, 2023). Agricultural extension provides farmer education, scientific research and new information in ameliorating smallholder farmers' agricultural issues. Services emanating from agricultural extension assist farmers in enhancing their farming methods and most especially in climate change mitigation and adaptations. It informs farmers and disseminates innovative concepts produced by agricultural research institutes (Pawera et al., 2024). Farmers and rural producers are assisted by agricultural extension through advisory services, new information, training, and connections to input markets and other resources. Extension services provide farmers

with relevant information and hands-on experience they need to make wise and informed decisions about their farming enterprises (Akinnagbe et al., 2024). Howbeit, increased extension services are expected to boost farm income and productivity, decrease poverty, lessen food insecurity, and proffer climate security, all these objectives are far-fetched due to the dearth of extension services in recent times (Ikoyo-Eweto et al., 2023).

Nigeria's agricultural growth and development have been threatened by climate change, as evidenced by rising temperatures, fluctuating rainfall, rising sea levels and flooding, drought and desertification, land degradation, more frequent extreme weather events, impacted fresh water resources, and biodiversity loss (Obada et al., 2024). The scarcity of food results from land degradation and soil impairments caused by extreme weather events. The timing and quantity of precipitation changes have a significant effect on field crops, influencing harvesting times and resulting in severe agricultural floods. Higher temperatures cause up rise of pests and diseases which attacks field crops reducing their yields and market value. Coastal agricultural towns are also under risk from storms and sea level rise, which can pollute water sources through erosion, loss of agricultural land, and saltwater intrusion (Donnell et al., 2024). Thus, Nigerian food security faces a serious danger from climate change, which impacts both commercial and subsistence farming. Climate information services (CIS) are being used in this context to address the excesses of extreme climate events and changing weather patterns (Mabhaudhi et al., 2025). It involves gathering, evaluating, compiling, and disseminating climate data on variables including temperature, precipitation, wind, soil moisture, ocean conditions, and extreme weather indicators. CIS assist smallholder farmers in making informed decisions over prevalent climate occurrences influencing agricultural operations. CIS aid smallholder farmers in risk management, adaptation, and mitigation of climate change (Zagre et al., 2024).

Adaptive capacity is the competence of smallholder farmers in responding to the adverse effects of climate change. Building adaptive capacity involves meeting the requirements and acquiring the skills necessary to mobilize and integrate various system components in order to address the environmental, social, and economic effects of climate change. Climate adaptation strategies include regenerative agriculture and the planting of drought-tolerant crop types, better water storage and usage, land management to lower the danger of wildfires, and the construction of more robust defences against extreme weather events like heat waves and floods (Grigorieva et al., 2023). Others includes; modifying planting dates, implementing crop rotation and diversification, improving irrigation systems, rainwater harvesting, water conservation practices, reforestation efforts, ecosystem restoration, wetland management, early warning systems, growing resilient infrastructure, and putting community-based preparedness plans into action (Osuji et al., 2023). Addressing the above issues created a research gap in knowledge and literature, thus improved adaptive capacity via climate information and extension service have the potential in mitigating climate occurrences and reducing food insecurity in Nigeria.

Hence, the research identified source of agricultural extension service of smallholder farmers; source of climate information service of smallholder farmers; and analysed the effect of agricultural extension and climate information sources on climate adaptive capacity of smallholder farmers.

Methodology

The research was done in Ebonyi State, Nigeria. The agricultural land mass measuring up to 5,533 km^2 and has *Latitude*: 6°10' 40.7028N" and *Longitude*: 7°57' 33.4296E" with an estimated population of 3,242,500 people. Multi-stage sampling procedure was engaged in selecting the household farmers. In first instance, 5 LGAs were selected randomly from the 13 LGAs and the second stage had 5 rural communities selected from the 5 LGAs making a total of 25 communities. In the third stage, 2 villages were selected from the 25 communities to sum up 50 villages. The registered farmers were 1765, out of which 10 farmers were randomly selected from the 50 villages to sum up 500 farmers.

Primary information was collected using research instrument which captured the study objectives. Consequently, out of the sampled 500 farmers, only 428 respondents were found useful for the study based on the retrieved questionnaire. Data were analysed using percentage, and multivariate probit regression model. The multivariate probit regression model is expressed as follows;

$Ᵽ_i = \beta_i X_i + U_i$ ---------- eqn. 1

Where

$Ᵽ_i$ = Dependent Variables (Adaptation Strategies)
$Ᵽ_1$ = Planting of drought-tolerant crops (Yes = 1, No = 0)
$Ᵽ_2$ = Soil-water conservation (Yes = 1, No = 0)
$Ᵽ_3$ = Modifying planting dates (Yes = 1, No = 0)
$Ᵽ_4$ = Implementing crop rotation (Yes = 1, No = 0)
$Ᵽ_5$ = Off farm Diversification (Yes = 1, No = 0)
$Ᵽ_6$ = Improved irrigation (Yes = 1, No = 0)
$Ᵽ_7$ = Reforestation (Yes = 1, No = 0)
$Ᵽ_8$ = Early access to weather information (Yes = 1, No = 0)
X_i = Independent variables (Source of agricultural extension service)
X_1 = Farmer-to-farmer extension (Yes = 1, No = 0)
X_2 = Mobile phones (Yes = 1, No = 0)
X_3 = Radio (Yes = 1, No = 0)
X_4 = Organized workshops/seminars (Yes = 1, No = 0)
X_5 = Cooperative societies (Yes = 1, No = 0)
X_6 = Agric field officers (Yes = 1, No = 0)
X_7 = Internet services (Yes = 1, No = 0)
X_8 = Newspapers (Yes = 1, No = 0)
X_i = Independent variables (Source of climate information service)
X_1 = Farmer-to-farmer networks (Yes = 1, No = 0)
X_2 = Radio (Yes = 1, No = 0)
X_3 = Community meetings (Yes = 1, No = 0)
X_4 = Mobile phones (Yes = 1, No = 0)
X_5 = Festivals (Yes = 1, No = 0)
X_6 = Local weather stations (Yes = 1, No = 0)
X_7 = Extension agents (Yes = 1, No = 0)
X_8 = Television (Yes = 1, No = 0)

Results and Discussion

Source of Agricultural Extension Service of Smallholder Farmers

The result in Table 1 shows that farmer-to-farmer extension services were indicated by 99.6% of the smallholder farmers. This implies that farmers in the region received extension information through their fellow farmers (Clement et al., 2024). This further implies that farmers learn faster from fellow farmers as it relates to agricultural operations. The use of mobile phones was indicated by 96.4% of the smallholder farmers. This implies that the smallholder farmers received extension service information via their mobile phones. The use of mobile phone in accessing extension information has become the newest technological advancement in recent times. This allows farmers to receive information at the comfort of their homes without much stress (Clement et al., 2024). A large number of the smallholder farmers, 90.7% used radio in accessing extension information services in the region. This connotes the importance of radio in the dissemination and communication of extension services among smallholder farmers. Radio has been an old technological tool used by local farmers because of its wider coverage and faster dissemination of extension information to a large audience, even in remote regions and localities. Its advantages cannot be over-emphasized (Antwi et al., 2022). Organized workshops/seminars were indicated by 88.4% of the smallholder farmers. This implies that the smallholder farmers received extension services via attending organized workshops/seminars.

Attendance of organized workshops/seminars exposes the farmers to extension service information while enlightening their understanding in the application of the information received from such exposures (Ikoyo-Eweto et al., 2023). Cooperative societies were indicated by 74.7% of the smallholder farmers. This implies that these group of farmers received extension service information from the various cooperative societies they belong. Cooperative society's do not only provide members with farming inputs and incentives but also represent source of extension service information (Akinola et al., 2023). Agricultural field officers were indicated by 70.2% of the smallholder farmers. This implies that the agricultural field officers provide extension information to smallholder farmers. These are trained extension agents that visits farmers in their local environments and communicate new farm innovations and methods to improve better farm yields and outputs.

Table 1: Source of agricultural extension service of smallholder farmers

Sources	**% (n=428)**
Farmer-to-farmer extension	99.6
Mobile phones	96.4
Radio	90.7
Organized workshops/seminars	88.4
Cooperative societies	74.7
Agric field officers	70.2
Internet services	68.9
Newspapers	61.3

Source: Field survey data, 2024. *Multiple responses

Source of Climate Information Service of Smallholder Farmers

Table 2 presents the source of climate information of smallholder farmers. Farmer-to-farmer networks were indicated by 94.4% of the smallholder farmers. This implies that the smallholder farmers received climate information via fellow farmers. This medium of communication and information dissemination has become prevalent in the local communities and among the rural famers (Sarku et al., 2025). Nowadays, farmers source climate information and weather conditions from fellow farmers. Radio was indicated by 90.6% of the smallholder farmers. This implies that majority of the smallholder farmers employed radio as a means of receiving climate information. Nowadays, most information relating to climate change and atmospheric weather conditions are communicated and disseminated via the radio stations. Also, its worthy of note that the smallholder farmers have radio and hence accessed climate information at wills (Antwi et al., 2022). Community meetings were indicated by 85.4% of the smallholder farmers. This implies that the smallholder farmers accessed climate information via attending community meetings and local gatherings. In local areas, community meetings are scheduled from time to time to discuss community issues and concerns and also serve as a veritable medium in dissemination of climate change information too.

The use of mobile phones was indicated by 81.6% of the smallholder farmers. This implies that mobile phones were of essence in the dissemination and communication of climate change information in the local communities (Ikoyo-Eweto et al., 2023). Mobile phones reach remote areas provided there are network services thereby covering a wider dissemination of climate information among the smallholder farmers. Its use is now accepted in the local areas as everyone now posses' mobile phones (Bizo et al., 2024). Festival occasions was indicated by 77.1% of the smallholder farmers. This implies that the smallholder farmers received climate change information through festival occasions. This means that festivals periods are very significance in the dissemination and communication of information relating to extreme weather conditions and events as it occurs in the local environments. In addition, festival occasions command a large turn-out of community members and opinion leaders who uses such gathering opportunity to communicate climate information (Bizo et al., 2024). Local weather stations were indicated by 65.8% of the smallholder farmers. This implies that these group of household farmers sourced climate information via their local weather stations. This station provides weather information and data relating to climate change and its associated consequences and proffers mitigation and adaptation strategies to cushion adverse effects (FAO, 2023). Some of these stations are associated with neighbouring universities, research institutes, etc.

Table 2: Source of climate information service of smallholder farmers

Sources	**% (n=428)**
Farmer-to-farmer networks	94.4
Radio	90.6
Community meetings	85.4
Mobile phones	81.6
Festivals	77.1
Local weather stations	65.8
Extension agents	63.5
Television	56.6

Source: Field survey data, 2024. *Multiple responses

Adaptive Capacity Knowledge of Smallholder Farmers through Agricultural Extension Sources

Table 3 presents adaptive capacity knowledge of smallholder farmers through agricultural extension sources. Planting of drought-tolerant crops was significant and positively related with farmer-to-farmer extension, radio and agriculture field officers. This implies that these agricultural extension sources facilitate the use of drought-tolerant crops thereby enhancing adaptive capacity of smallholder farmers (Adeleke et al., 2024). Farmers learn more and faster by following other farmers and via extension officers who exposes them to new innovations and practices. Soil-water conservation was significant and positively related with farmer-to-farmer extension, mobile phone, and Internet service. This connotes that the practice of soil-water conservation measures was aided by these agricultural extension sources. Information on improving soil fertility and water management can be sourced from the internet and via farmers' helplines. Modifying planting dates was significant and positively related with mobile phones and organized workshops/seminars (Osuji et al., 2023). This means that smallholder farmers varied their planting dates via access to weather information received via farmers' helplines and attendance to agriculture workshops/seminars.

Regular attendance of workshops/seminars increases adaptive capacity of smallholder farmers (Nocezo et al., 2024). Implementing crop rotation was significant and positively related with farmer-to-farmer extension, cooperative society and newspapers. This implies that adaptive capacity of smallholder farmers in practicing rotational cropping was aided by these agricultural extension sources. Farmers do acquire practical experiences following other farmers. Off farm diversification was significant and positively related with workshop / seminars and cooperative society. This implies that these agricultural extension sources expose smallholder farmers to off-farm occupations and activities that generate income and improve living standards (FAO, 2023). This is diversionary adaptive strategy to overcome climate change issues. Improved irrigation was significant and positively related with mobile phone, and organized workshops /seminars. This implies that the smallholder farmers engaged in irrigation services via information accessed from farmers' agriculture helplines, SMS, and regular agricultural workshops /seminars attendance. Rainwater harvesting has become a source of improved irrigation practices among smallholder farmers (FAO, 2023). Reforestation was significant and positively –related with organized workshops /seminars and internet services. This implies the replanting of trees, shrubs, and other forest resources to withstand adverse climatic and weather effects was facilitated by these agricultural extension sources (Ojo et al., 2024). Early access to weather information was significant and positively related with mobile phones, and radio. This connotes that these agricultural extension sources enhances adaptive capacity of smallholder farmers. Seeking early information regarding weather events assist farmers in making informed decisions concerning their agricultural enterprise (Osuji et al., 2023).

Table 3: Adaptive capacity knowledge of smallholder farmers through agricultural extension sources

Variables	Farmer-to-farmer extension	Mobile phone	Radio	Organized workshops /seminars	Cooperative society	Agric field officers	Internet service	Newspaper
Planting of drought-tolerant crops	0.056 (2.894)**	-0.672 (0.890)	2.883 (3.562)***	-0.965 (1.043)	0.677 (0.893)	0.999 (3.032)***	0.671 (0.566)	-0.771 (1.052)
Soil-water conservation	0.853 (2.672)**	0.990 (4.891)***	3.743 (0.572)	0.577 (0.099)	1.677 (1.057)	0.678 (1.822)	0.892 (2.033)**	2.677 (0.034)
Modifying planting dates	-4.678 (0.233)	3.623 (3.866)***	1.899 (0.566)	0.799 (2.657)**	-0.892 (0.772)	0.902 (0.300)	0.852 (0.789)	2.577 (0.443)
Implementing crop rotation	0.899 (3.234)***	0.578 (0.969)	-9.661 (1.901)	3.688 (1.099)	2.657 (2.781)**	0.798 (0.576)	0.541 (0.681)	2.799 (2.671)**
Off farm diversification	1.677 (0.890)	2.768 (0.672)	0.687 (0.211)	0.780 (3.789)***	0.899 (2.562)**	-1.677 (0.441)	0.772 (0.999)	0.421 (0.611)
Improved irrigation	1.900 (0.551)	0.888 (2.321)**	1.088 (0.761)	2.788 (2.041)**	0.889 (1.001)	0.666 (0.451)	0.432 (0.667)	1.424 (0.420)
Reforestation	0.621 (0.511)	0.521 (0.001)	-0.609 (0.911)	0.889 (2.781)**	1.670 (0.521)	0.711 (0.489)	2.761 (4.955)***	0.777 (0.501)
Early access to weather information	-1.063 (0.112)	2.701 (2.661)**	0.611 (3.802)***	0.561 (0.812)	2.052 (0.501)	-0.991 (0.882)	0.211 (0.701)	0.191 (1.001)

Source: Field survey data, 2024. Significant at ***1%, and **5%

Adaptive Capacity Knowledge of Smallholder Farmers through Climate Information Sources

Table 4 presents adaptive capacity knowledge of smallholder farmers through climate information sources. Planting of drought-tolerant crops was significant and positively related with farmer-to-farmer networks, community meetings, and extension agents. This implies that these climate information sources enhance adaptive capacity of smallholder farmers. No doubt the farmers' access to climate information via farmer-to-farmer networks, community meetings, and extension agents helps them to overcome extreme weather conditions and adapt favourably to climate change (Ojo et al., 2024). Soil-water conservation was significant and positively related with farmer-to-farmer networks, and mobile phones. This implies that the smallholder farmers' adpoted soil-water conservation measures such as soil fertility improvements, soil-organic manuring, mulching, rainwater harvesting via farmers collaborations and agricultural helplines. Modifying planting dates was significant and positively related with radio, and local weather stations. This connotes that the smallholder farmers modified their planting operations in lieu of extreme weather events through communications from radio and local weather stations (Hussein et al., 2024). No doubt, radio communications transverse to remote areas and has wider audience coverage. Implementing crop rotation was significant and positively related with community meetings, festivals and extension agents. This implies that these climate information sources helped the smallholder farmers in rotational cropping. Crop rotation is anti-climate change measures deployed by farmers in mitigating adverse effects of atmospheric weather conditions (Kolapo et al., 2023). Off farm diversification was significant and positively related with radio and community meeting

and television. This means that climate information sources expose smallholder farmers to other non-farm related enterprises such as food processing, handicrafts, and other artisans' activities. This diversionary measure provides adaptive income security for smallholder farmers (FAO, 2023). Improved irrigation was significant and positively related with mobile phones and festivals. This implies that access to improved irrigation systems of smallholder farmers was sourced via farmers' helplines and festivals. Improved irrigation systems such as rainwater harvesting, construction of water-pipelines to farms, etc improve farm yields and mitigate adverse weather events such as drought seasons and delayed rains (FAO, 2023). Reforestation was significant and positively related with community meeting and negatively related with television. This means that the adaptation strategy such as tree planting, forest regenerations, etc was aided via community meeting engagements of smallholder farmers (Ojo et al., 2024). Such gathering communicates climate information that assists smallholder farmers in handling adverse climate events. This also means that smallholder farmers without access to televisions are at the risk of climate information. Early access to weather information was significant and positively related with radio, mobile phones and local weather stations. This connotes that these climate information sources aids climate adaptive capacity of smallholder farmers. Early access to climate change information spurs farmers' preparedness in lieu of climate change excesses and fosters adaptation practices (Hussein et al., 2024).

Table 4: Adaptive capacity knowledge of smallholder farmers through climate information sources

Variables	Farmer-to-farmer networks	Radio	Community meeting	Mobile phones	Festivals	Local weather stations	Extension agents	Television
Planting of drought-tolerant crops	5.662 (2.691)**	-0.822 (0.511)	0.682 (2.721)**	0.791 (1.902)	-0.911 (0.831)	0.590 (0.911)	2.771 (3.091)***	0.888 (1.032)
Soil-water conservation	0.603 (2.802)**	0.689 (0.902)	-0.990 (0.732)	0.521 (3.901)***	0.722 (0.421)	0.590 (0.601)	0.690 (0.311)	0.421 (0.621)
Modifying planting dates	0.881 (0.661)	0.700 (2.661)**	0.898 (1.045)	-0.671 (0.511)	0.551 (0.022)	2.780 (3.534)***	-0.301 (0.211)	1.072 (0.003)
Implementing crop rotation	0.661 (0.421)	0.742 (0.601)	0.992 (2.772)**	2.556 (0.611)	0.211 (2.342)**	0.562 (1.001)	3.661 (3.701)***	0.890 (0.211)
Off farm diversification	-0.601 (0.891)	2.571 (2.901)**	0.771 (3.901)***	-0.590 (0.890)	0.662 (0.901)	0.341 (0.011)	0.501 (0.421)	0.590 (2.341)**
Improved irrigation	0.800 (0.441)	-0.931 (0.521)	0.771 (0.567)	0.899 (3.567)***	0.551 (2.901)**	-0.322 (0.661)	0.991 (0.511)	0.441 (0.222)
Reforestation	0.033 (0.661)	0.701 (0.401)	2.567 (2.801)**	-0.662 (0.221)	0.001 (1.052)	0.002 (0.031)	2.782 (0.511)	-1.032 (2.891)**
Early access to weather information	-0.227 (0.010)	3.002 (2.771)**	0.511 (0.221)	1.662 (2.899)**	0.602 (0.321)	2.679 (3.711)***	-0.662 (0.511)	0.322 (1.004)

Source: Field survey data, 2024. Significant at ***1%, and **5%

Conclusion and Recommendation

The study reveals that the smallholder farmers accessed agricultural extension information via farmer-to-farmer extension, mobile phones, radio, organized workshops/seminars, cooperative societies and agric field officers. Source of climate information includes; farmer-to-farmer networks, radio, community meetings, mobile phones, festivals and local weather conditions. Adaptive strategies of smallholder farmers include; planting of drought-tolerant crops, soil-water conservation, modifying

planting dates, implementing crop rotation, off farm diversification, improved irrigation practices and reforestation. Farmers were advised to engage proven adaptation measures to mitigate adverse effects of weather and extreme climate conditions.

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