Effects of Climate Change Adaptation Strategies on Food Crop Production in North East Nigeria

Hajjatu Tammi[1] Philemon Headboy[1] & Rogers Roland Wazakari [2]

[1]Department of Geography,
Adamawa State University,
Mubi, Adamawa State-Nigeria

[2]Department of Political Science,
Bayero University, Kano, Kano state-Nigeria
Corresponding author: rogersrolandwazakari@gmail.com

Abstract

The study examines the impact of climate change adaptation strategies on the efficiency of food crop production in northeastern Nigeria. Adaptation strategies, including changes in agricultural practices and systems, are acknowledged as crucial for farmers to cope with climate variability. These strategies aim to boost productivity, efficiency, and economic returns from farming. The research utilized a multi-stage sampling method to select 120 respondents, with data gathered via a structured questionnaire and analysed through both descriptive and inferential statistics. The sampling techniques included purposive sampling across the six states of Northeast Nigeria Adamawa, Borno, Yobe, Taraba, Bauchi, and Gombe. Descriptive statistics, such as percentages and frequencies, were employed, and a Multinomial Logit model was used to estimate the likelihood of achieving the study's objectives. Regression analysis indicated that factors such as marital status, age, education level, farming experience, farm size, access to extension services, and extension visits had positive and statistically significant effects ($P<0.01$) on adaptation. Major barriers to adopting climate change adaptation strategies among food crop farmers included high input costs, insufficient financial resources, labour costs, and inadequate climate information. The study concludes that farmers' socio-economic characteristics significantly influence their perceptions and adaptation to climate change. The study recommends the government and policymakers should broaden service coverage and improve service quality to address climate change-related risks, with special attention to disadvantaged groups such as poor farmers in remote areas, and extension agents should intensify efforts to raise awareness and educate farmers about climate change.

Keywords: Adaptation Strategies, Food Crop Production, Climate Change and North East Nigeria

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Introduction

Agriculture is a cornerstone of Nigeria's economy, employing approximately 70% of the population (Onyeweaku and Nwara, 2005). The sector is undergoing a transformation driven by commercialization across small, medium, and large-scale enterprises. However, agriculture in Nigeria faces various challenges, including soil and climatic factors, population pressures, technological limitations, and government policies. Specific obstacles include low productivity, environmental degradation, limited access to assets, inadequate market infrastructure, post-harvest losses, and insufficient financial and support services. A particularly pressing issue is climate change, which poses significant risks to Nigeria's development goals, such as those outlined in Vision 20:2020 (World Bank, 2008). Climate change not only hampers efforts to reduce poverty but also threatens ecosystem health and the availability of water and food, potentially escalating human conflicts.

The frequency of weather-related disasters has surged over the past forty years, intensifying the stress on Nigeria's agricultural systems, particularly crop production (Ayinde, Muchie, and Olatunji, 2011). The country's natural and agricultural ecosystems, including freshwater and coastal resources, are highly vulnerable to climate change. This situation underscores the urgent need for a comprehensive and systematic response to climate change, one that integrates broader development goals while addressing the gender-specific needs and roles within society. Climate change directly impacts agriculture, notably food production (Kuta, 2011), and adds complexity to the challenge of increasing agricultural output to meet the demands of a growing population while maintaining high environmental standards. According to the Commission of the European Communities (CEC, 2009), the negative impact on agricultural yields will likely worsen due to more frequent extreme weather events.

Farmers' adaptation to climate change and variability, particularly through the modification of agricultural practices and systems, is recognized as a key coping strategy. These strategies are expected to enhance farmers' productivity and efficiency in food crop production and improve their economic returns from farming. Adaptation involves adjustments to human, ecological, or physical systems in response to climate vulnerabilities (Adger et al., 2003; Quan & Dyer, 2008; Idoma et al., 2017). Improving or modifying agricultural practices to adapt to climate change will be crucial for meeting the food demands of modern societies (Rosegrant, 2008). Adaptation helps farmers secure their food, income, and livelihood in the face of shifting climatic and socioeconomic conditions, including fluctuations in local and global markets (Kandlinkar and Risbey, 2000). This is particularly important in developing countries like Nigeria, where high vulnerability to climate change is compounded by limited adaptive capacity.

Several initiatives have been launched to strengthen the agricultural sector, such as the Youth Initiative for Sustainable Agriculture (YISA) and the Value Chain Development Programme (VCDP). The VCDP adopts a holistic, demand-driven approach to addressing challenges along the cassava and food crop value chains. It emphasizes capacity building for actors and enablers within the value chain and is rooted in a long-term vision of adapting to climate change to foster economic growth, reduce poverty, and increase agricultural productivity. The Government of Nigeria and IFAD have adopted the value chain approach within the VCDP to enhance productivity, promote Agro-processing, and improve market access, thereby fostering greater private sector engagement. This study examines the impact of climate change adaptation strategies on food crop production efficiency in North-East Nigeria.

The findings of this study are expected to guide policymakers in crafting appropriate public policies to boost agricultural productivity and mitigate the effects of climate change on food crop production in Nigeria, particularly in the North-East. The results will also serve as a valuable resource for international and local donor agencies, researchers, and farmers focused on climate change mitigation and adaptation, aiding them in their efforts to secure funding and grants for environmental and resource management studies. The study was aimed to examine the socio-economic characteristics of food crop farmers in the study area; investigate farmers' awareness of changes in the climatic condition, identify the various adaptation strategies to climate change, determine the factors that affect the adoption of the various adaptation strategies, and to find out the constraints to the implementation of existing climate change adaptation strategies used by food crop farmers.

Methodology

Description of the Study Area

The North East (often hyphenated to the North-East) is the one of the six geopolitical zones of Nigeria representing both a geographic and political region of the country's northeast. It comprises six states – Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe. Geographically, the North East is the largest geopolitical zone in the nation, covering nearly one-third of Nigeria's total area. In terms of the environment, the zone is primarily divided between the semi-desert Sahelian savanna and the tropical West Sudanian savanna ecoregions. The region has a population of about 26 million people, around 12% of the total population of the country. Maiduguri and Bauchi are the most populous cities in the North East as well as the fifteenth and seventeenth most populous cities in Nigeria. Other large northeastern cities include (in order by population) Bauchi, Yola, Mubi, Gombe, Jimeta, Potiskum, Jalingo, Gashua, and Bama (Kabiru eta al, 2022).

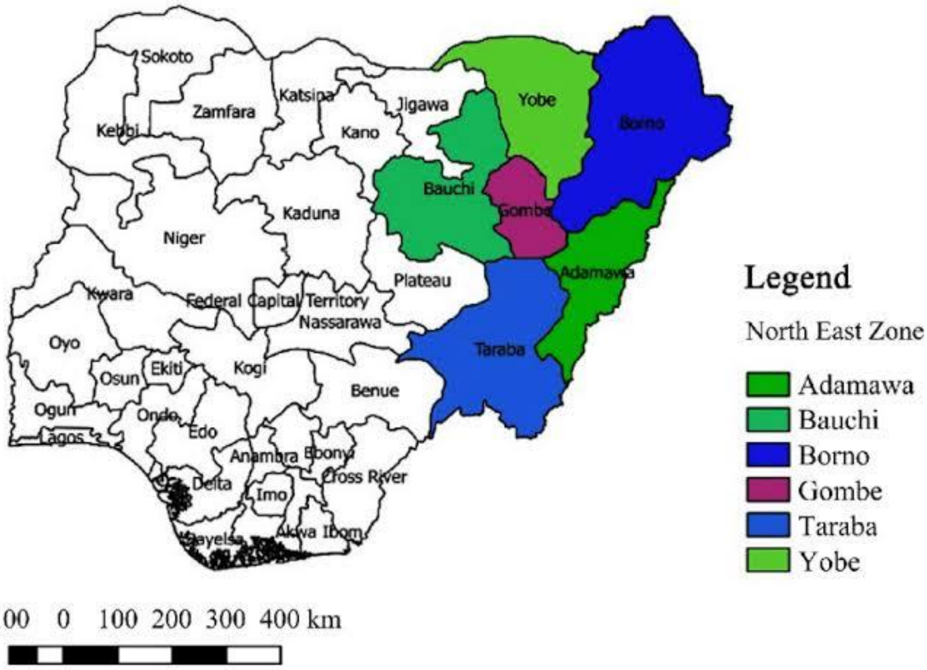

Figure 1: Map of Nigeria showing the six states in the North-East (Source: Google Maps, 2024)

Sample Size and Sampling Techniques

The sampling techniques that were used for this research is purposive sampling techniques, North East consists of six (6) States which are Adamawa, Borno, Yobe, Taraba, Bauchi and Gombe. Some Local Governments Area were purposively in North Eastern States.

Method of Data Collection

This process involves gathering information when conducting research. Data collection is typically categorized into two types: primary and secondary data. Primary data are those gathered for the first time directly through the research process, utilizing methods such as face-to-face interviews, questionnaire administration, direct measurement, or observation techniques. In contrast, secondary data refer to information that has already been collected by others, possibly in prior research. These data are sourced from existing literature, including paper and electronic research reports, government documents, institutional publications, and statistical reports (Eboh, 2009). In this project, a questionnaire was used as the primary data collection tool, with 120 respondents randomly selected from the study area. Additionally, verbal interviews were conducted to supplement the data collection process.

Analytical Techniques

The data for this study was analysed using both descriptive and inferential statistics. Descriptive statistics, namely percentages and frequencies were used. A Multinomial Logit model was also used to estimate the maximum likelihood to achieved objectives. The linear function assumes a linear relationship between the dependent and the independent variables. It takes the form:

$Y= b_0 + b_1x_1 + b_2x_2 +\ldots b_nx_{n} + Ei$

where;

Y = Food crop decision to adopt (dependent variable)

Y_1 = Rainfall, Y_2 = Temperature

b_0 = constant;

b_1 -b_6 = Coefficient

X_1= Age (years)

X_2= household (number of individual)

X_3= farm size hectare)

X_4= farming experience years)

X_5= food crop output

X_6= income

X_7 = climate change noticed

X_8 = information on climate

Ei= error terms

The estimated functions were assessed based on the significance of the R^2 value, as indicated by the F-statistics, the significance of the coefficients as determined by the t-statistic, the signs of the coefficients, and the magnitude of the standard error, all of which aligned with the study's a priori assumptions.

Results And Discussion

Table 1 reveals that 45.8% of respondents were between 36-45 years old, with an average age of 28. Idrisa et al. (2012) found that younger farmers tend to be more open to new ideas compared to older ones, as they often have broader external contacts and alternative employment opportunities, making them more willing to take risks in adopting new practices. However, this finding contrasts with Adebayo et al. (2011), who argued that the most active and productive age range for farmers is between 41-50 years, as individuals within this age group are better equipped to handle the physical demands of farming, which can significantly impact productivity and innovation diffusion.

The majority of the farmers (78.3%) were male, while females made up about 21.7% of the respondents. This suggests that men predominantly engage in food crop cultivation in the study area, and that male-headed households are more likely to be involved in farming than female-headed households. This aligns with Idrisa et al. (2010), who noted that men are more frequently engaged in farming activities due to the labour-intensive nature of the work. Additionally, men are often more accessible to extension agents and are more likely to learn about improved technologies, as their mobility is less restricted compared to women. This finding is consistent with Adesina (2000), who found that 78.2% of farmers adopting improved food crop varieties were male, with only 21.7% being female. Jan et al. (2007) identified gender as a significant factor influencing the adoption of irrigated food crop production, highlighting the considerable gender disparity in food crop farming in the study area. Kiker et al. (2002) suggested that female-headed households may be less responsive to adopting new technologies due to wealth disparities and cultural factors. In traditional settings, men are more likely to attend extension meetings, giving them greater access to agricultural information.

The study also found that 78.3% of the respondents were married, 15.8% were single, 3.3% were widowed, and 2.5% were divorced. The high percentage of married respondents suggests that marriage may increase the availability of family labour, which can enhance productivity on food crop farms. This finding supports Ayoade (2003), who indicated that married individuals constitute the majority of the food crop farming population. Married farmers are assumed to have more stability and greater access to family labour, which is essential for meeting the needs of their households (Obioha, 2009). Regarding household size, 34.2% of the farmers had 8-10 members in their households, while 27.5% had 5-7 members, with an average household size of 8 persons. In many rural settings, household size is a critical source of labour for farming, particularly during peak periods such as weeding and harvesting (Njuguna et al., 2015). This finding aligns with Okoye et al. (2004), who observed that farmers with larger households often utilize family labour to reduce production costs. However, larger household sizes may also imply greater financial constraints, as the need to meet daily family requirements increase, potentially leaving less cash available for purchasing inputs and adopting new technologies (Audu and Aye, 2014).

The study also showed that 43.3% of respondents had a primary education, 31.7% had a secondary education, 18.3% had a tertiary education, and 4.2% had no formal education, with 2.5% falling into other categories. The findings suggest that a significant number of farmers have formal education, which can enhance their agricultural practices. Education plays a crucial role in farming, particularly when farmers receive training on specific aspects and apply that knowledge. Educated farmers are more likely to seek and disseminate information to others. The relatively high literacy rate among respondents may facilitate better adoption of improved food crop varieties and the ability to apply new knowledge and skills effectively. Adewumi et al. (2007) similarly posited that literacy helps eradicate ignorance and promotes the adoption of new technologies. Education is also considered a form of human capital that increases farmers' self-awareness and managerial skills at the farm level. Therefore, household heads with higher education levels are expected to be more open to adopting new ideas and innovations, including improved food crop varieties.

The results further indicated that 50.8% of respondents had farm sizes of less than one hectare, while those with farm sizes of 1-2 hectares and 2.1-3.1 hectares accounted for 35.8% and 10.8%, respectively. This suggests that the majority of farmers (50.8%) are subsistence farmers with an average farm size of 1.5 hectares, meaning they operate on a small-scale basis. Small-scale farmers typically lack the capital to invest in large-scale agricultural production and rely mainly on family labour. They often depend on other farmers for agricultural information. Land fragmentation among family members is a common practice, intended to ensure that each family member owns a piece of land. However, this practice discourages commercial agriculture and can lead to conflicts within families. Nevertheless, if land is not shared among family members, some may be unable to acquire land if they lack the financial means to purchase it. This finding is consistent with Ati (2009), who reported that most farmers in Nigeria operate on a small scale, which limits agricultural production.

Table 1 also shows that 45.0% of farmers had between 16-21 years of farming experience, 34% had 6-10 years, 18.3% had 11-15 years, and 2.5% had 1-5 years, with an average farming experience of 13 years. The extensive farming experience suggests that farmers are likely to make sound decisions regarding resource allocation and farm management. This aligns with Johannes et al. (2010) and Kudi et al. (2011), who argued that as farmers gain more experience, they become better at evaluating the benefits of new technologies, leading to higher adoption rates. Regarding the use of improved food crop seeds, experienced farmers may use their knowledge to make informed decisions about their utilization. This is supported by Eboh (2009), who noted that farmers tend to engage more in practices with which they are familiar.

Table 1: Distribution of farmers based on their Socio-economic Characteristics

Variable	Frequency	Percentage
Age of Farmers (Years)		
15-25	3	2.5
26-35	26	30.0
36-45	55	45.8
46-55	14	11.7
56-65	12	10.0
Gender		
Male	94	78.3
Female	26	21.7
Marital status		
Single	19	15.8
Married	94	78.3
Divorced	3	2.5
Widow	4	3.3
Household size		
2-4	18	15.0
5-7	33	27.5
8-10	41	34.2
11-13	6	5.0
14-16	13	10.8
17-19	9	7.5
Educational Level		
None	5	4.2

Primary	52	43.3
Secondary	38	31.7
Tertiary	22	18.3
Others	3	2.5
Farm Size		
< 1	61	50.8
1-2	43	35.8
2.1-3.1	13	10.8
< 4	3	2.5
Farming experience		
1-5	3	2.5
6-10	41	34.2
11-15	22	18.3
16-21	54	45.0
Total	120	100

Source: Field survey, 2024

Level of Awareness of Climatic Changes Among Food Crop Farmers

Table 2 presents the perceptions of food crop farmers regarding climate change indicators based on their educational qualifications. Among farmers with a primary education, the major indicators identified include changes in rainfall patterns (18.3%), general dryness and humidity (34.2%), increases in temperature (25.0%), and stormy, windy rains (20.8%). Conversely, farmers with a secondary education predominantly perceived an increase in flooding (28.3%) as the most severe manifestation of climate change in the study area. This suggests that the respondents are aware of various climate change events in the region. The climate change indicators identified by the farmers, such as changes in rainfall patterns and general dryness, can negatively impact crop yields and increase production costs. Moreover, increased flooding and stormy, windy rains may result from intensified rainfall, high humidity, and warmer environmental conditions. Farmers' awareness of these climate change indicators is crucial, as it enables them to adopt appropriate adaptation measures.

Table 2: Distribution of respondent based on the climate change indicators on level of education of food crop

Variables	Non-Formal	Primary	**Secondary**	**Tertiary**
Changes in rainfall pattern	46(38.3%)	22(18.3%)	30(25.0%)	22(18.3%)
Humidity general dryness	31(25.8%)	41(34.2%)	19(15.8%)	29(24.2%)
Increase flood	26(21.7%)	34(28.3%)	38(31.7%)	22(18.3%)
Increase in temperature	42(35.0%)	30(25.0%)	18(15.0%)	30(25.0%)
Storming windy rains	53(44.2%)	25(20.8%)	20(16.7%)	22(18.3%)

Source: Field survey, 2024

Distribution of Farmers Based on Their Adaptation Strategies

Table 3 outlines the various adaptation strategies employed by the respondents to cope with changing climatic conditions. These strategies include migration (9.2%), engaging in off-farm jobs (11.0%), irrigation practices (26.6%), crop diversification (46%), and a small proportion (6.4%) who did not adopt any adaptation measures. These practices are implemented to optimize yields and maintain food security. Crop diversification, which involves cultivating a variety of crops either within the same plot or across different plots, mitigates the risk of total crop failure, as different crops respond differently to climate events. Nhemachena and Hassan (2007) noted that farmers are increasingly adopting crop management practices such as irrigation, water and soil conservation techniques, and adjusting planting and harvesting dates to ensure that critical growth stages do not coincide with severe climatic conditions**.**

Table 3: Distribution of farmers based on their adaption strategies

Variable	**Yes = 109**	**No = 11**
Migration	10(9.2%)	5(45.5%)
Off-farm jobs	12(11.0%)	0(0%)
Irrigation	29(26.6%)	0(0%)
Crop diversification	51(46.8%)	0(0%)
No adoption	7(6.4%)	6(54.5%)

Source: Field Survey, 2024

Factors Influencing the Adoption of Strategies that Food crop Adopt

Effects of farmer's socioeconomic and institutional characteristics on their adaption strategies (no of adaptation measures used). Dependent Variable**:** using a Multinomial Logit model to estimate the maximum likelihood of adoption of the various adaptation strategies by food crop. Independent Variables: these are variables which are thought to have influence on level of adoption of improved food crop seed. These explanatory variables are: age(X_1), sex (X_2), level of education (X_3), household size (X_4), farm size (X_5), extension contact (X_6), and farming experience (X_7). The independent variables for the study were:

Age of the Farmers: **t**his refers to chronological age or how old is the farmer, that is, number of years lived by the farmer. Farmer's age and adoption of technology are associated. As a farmer's age increases, it is expected that the farmer becomes conservative. Therefore, it is priori expected that farmer's age and level of adoption relate negatively. Thus, as a farmer's age increases the level of technology adoption is expected to decrease (Dereje, 2006). Sex: refers to the biological form of human being a male or female, it is prior expected that farmers who are male engaged in farming activities than their female counterpart because of its labour-intensive nature. It also expected that men are easily contacted by disseminators because their movements are not restricted thereby having the chance of being aware of improved technologies faster than the women.

Level of Education was measured by number of formal school years completed by the farmer. Education (formal) is assumed to increase farmers' ability to obtain, process, and use information relevant to the adoption of improved food crop seed. It is expected that educated individuals can make better decision to adopt components of the improved food crop seed than non-educated ones. In this study, education was treated as a continuous variable that was measured in number of years spent in formal school system. Household Size: This was measured in term of number of wives, children and dependents living in a household. It often determines how much family labour was put into the farm activities (Adeniji *et al.*, 2007).

Farm Size: The variable was measured in number of hectares of land devoted to food crop production Farm size was expected to positively influence the adoption of improved food crop seed; the probable reason could be that large land size provides a household with an opportunity to adopt the improved food crop seed and their production. The regression result shows that several characteristics of the farmers influence either positively their adaptive capacity to climate change. Factors that were highly significant at 1% level include marital status, age, educational level, farming experiences, farm size, access to extension and extension visits number of extension contacts per year, amount of savings and farm association were not significant. The R square value of 0.594 implies that about 59.4% of the adaptive capacity of the respondents was determined by their socio-economic and institutional characteristics.

The study revealed that age was positively significant implying that older farmers had higher adaptive capacity than the younger once. Farming experience had positive significant implying that higher experience increases the probability of uptake of many adaptation measures. This implies that highly experienced farmers are likely to have more information and knowledge on changes in climatic conditions and crop and livestock management practices. Frequent contact with extension agents also increases the probability of taking up adaptation measures. This is because farmers who have significant extension contacts have better chances of to be aware of changing climatic conditions and management practices, they can use to adapt to climate change. Similarly, educational level showed significant effect implying that farmers with higher educational levels were most likely to adopt adaptation measures than those with lower educational level. The R square value of 0.594 implies that about 59.4% of the adaptive capacity of the farmers was determined by their socio-economic and institutional characteristics.

This finding agreed with that of Idrisa *et al*. (2012) that literacy level positively influenced the intensity of adoption of improved soya-bean seed by farmers in Borno state. The results further reveal that farm size had positive and significant relationship with adoption of improved varieties food crop at 10% level of significance. This signifies a positively influence of the farm size on the adoption of improved food crop. That is, a unit increase in farm size could result to a significant influence on the adoption of the improved food crop varieties by .120 in the study area. Farm size was identified as an important socio-economic factor by (Jackline, 2002) in an adoption study of agricultural technologies.

Table 4: Factors influencing the adoption of the various adaptation strategies by food crop farmers

Variable	B	S.E	Z-Value	P-Value	Exp.(β)
Marital Status	2.850	0.8143	3.5000	0.000***	17.2878
Age	3.150	0.3706	8.5000	0.000***	23.3361
Educational level	1.380	0.4059	3.4000	0.000***	3.9749
Farming Experience	2.100	0.6176	3.4000	0.000***	8.1662
Farm Size per Hectare	2.250	0.7759	2.9000	0.002***	9.4877
Amount of Savings	1.360	0.9067	1.5000	0.068	3.8962
Farm Association	1.560	1.9500	0.8000	0.212	4.7588
Access to Extension Services	1.890	0.6750	2.8000	0.003***	6.6194
Extension Visits	1.650	0.3235	5.1000	0.000***	5.2070
R^2=59.4%					
F=46.32					

Note: *=p<0.05, **=p<0.01, ***p<0.001.
Source: Field Survey, 2024

Constraints to the Adoption of Climate Change Adaptation Strategies by Food Crop Farmers

Adaptation to climate change in the State is limited by several factors. The distribution of respondents' views on these constraints is outlined in Table 5. According to the table, approximately 18.2% of the farmers identified the high cost of inputs as the primary barrier to adopting climate change adaptation strategies. About 16.1% cited insufficient financial resources as a significant constraint. Additionally, 15.2% of respondents pointed to the high cost of labor as a hindrance, while only 10.4% mentioned inadequate knowledge of adaptation strategies as a limiting factor. The study indicates that the high cost of inputs is the most significant obstacle to the adoption of climate change adaptation measures.

Table 5: Constraints to the adoption of climate change adaptation strategies by food crop

Constraints	Frequency	Percentage
Insufficiency of Financial Resources	65	20.8
Off-Farm Employment	13	4.2
Shortage of Land	23	7.4
High Cost of Labour	45	14.5
Transportation Problems	21	6.8
Insecure Property Rights	15	4.8
Inadequate Knowledge on Strategies	30	9.6
High Cost of Inputs	63	20.3
No Access to Water	17	5.5
Inadequacy of Climate Information	19	6.1
Total	311	100

*Multiple responses
Source: Field Survey, 2024

Conclusion and Recommendations

The study concludes that the socio-economic and institutional characteristics of farmers play a crucial role in influencing their perceptions and adaptations to climate change among rice farmers in the study area. Factors such as marital status, age, educational level, farming experience, farm size, access to extension services, and the frequency of extension visits were identified as significant in determining how rice farmers perceive and respond to climate change. Based on these findings, the following recommendations are proposed:

i. The government and policymakers should broaden service coverage and improve service quality to address climate change-related risks, with special attention to disadvantaged groups such as poor farmers in remote areas, the elderly, and children.
ii. The government should formulate policies aimed at enhancing farmers' adaptive capacities. Given the unpredictability of climate change effects, policy interventions should focus on addressing the root causes of vulnerability among rural populations in dryland areas, thereby strengthening the farmers' ability to adapt.
iii. Agricultural Development Programmes (ADPs) should improve media outreach to support the development of policies that enhance farmers' adaptive capacities.
iv. Extension agents should intensify efforts to raise awareness and educate farmers about climate change.

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