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Determinants of climate change adaptation strategies used by rice farmers in Southwestern, Nigeria

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Abstract

Poor adaptation to climate change is a major threat to sustainable rice production in Nigeria. Determinants of appropriate climate-change adaptation strategies used by rice farmers in Southwestern Nigeria have not been fully investigated. In this study, the determinants of climate change adaptation strategies used by rice farmers in Southwestern Nigeria were investigated. Data were obtained through Focus Group Discussions (FGDs) and field survey conducted in the study areas. Data obtained were analyzed using descriptive and inferential statistical tools such as percentage and regression analysis. The major climate change adaptation strategies used by the respondents included; planting improved rice variety such as Federal Agricultural Research Oryza (FARO) (80.5 %), seeking early warning information (80.9 %), shifting planting date until the weather condition was favourable (99.1 %), and using chemical fertilizer on their farms in order to maintain soil fertility (20.5 %). The determinants of climate change adaptation strategies used by the farmers, included access to early warning information (β=43.04), access to fertilizer (β=5.78), farm plot size (β=–12.04) and access to regular water supply (β=–24.79). Climate change adaptation required provision of incentives to farmers, training on drought and flood control, and the use of improved technology to obtain higher yield.

Keywords: improved seed, adaptation strategies, information, climate change, rice-farmers

1 Introduction

Climate change threatens biodiversity and human well-being, with thousands of publications demonstrating impacts across ecosystems, economic, and social structure (Williams *et al.*, 2008). For instance, sustainable rice production and consumption are central factors in meeting food security of poor people in developing countries. However, the magnitude of the changes that are likely to take place due to incidences of climate change in developing countries is not well investigated.

Climate change directly alters precipitation and temperature patterns, which are the key natural inputs in agricultural production. One of the effects of climate change is the rise in temperature that leads to water deficit (Chinvamo, 2010; Mitin, 2009). Climate-change may cause drought in the middle of wet season which can damage seedlings on fields. Excess rainfall may as well cause floods which in turn result in less aeration of soil (Mitin, 2009). Besides, causes uncertainties in the onset of the farming season and as well as agricultural losses due to changes in temperature and rainfall patterns (Kawasaki & Herath, 2011; Wassmann & Dobermann, 2007). Agarwal (2008a) projected 18 % decline in Thai rice by 2020s will be caused because of alterations in temperature, rainfall cycle, soil quality, pests' invasions and disease infestations attributable to negative impacts of climate change. Kawasaki & Herath (2011) also confirmed that Thailand suffered more than US$ 1.75 billion losses as a result of floods, storms, and droughts. They observed that many rice growers in river basin areas faced the risk of losing paddy fields in floods

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and droughts prone areas. These vulnerable people in Africa are facing huge difficulties resulting from the increase of temperature and continuous droughts (BNRCC, 2011). It was estimated that African countries are likely to have agricultural losses of up to 4 % of GDP due to climate change by 2010 (Mendelsohn *et al.*, 2000). Parts of the countries in Africa that experienced soil erosion and operate rain-fed agriculture could have decline in agricultural yield of up to 50 % between 2000 and 2020 due to increasing impact of climate change (Apata *et al.*, 2009; IPCC, 2007). Climate changes also influences domestic water availability and health of farm families besides its negative impact on the main economic sectors (agricultural production systems) (IPCC, 2007; Brooks *et al.*, 2009). The impacts of climate change on human well-being particularly the poor in developing countries are profound, widespread and deadly (Brooks *et al.*, 2009). The 2007/8 Human Development Report warns that, in the next 50–80 years, 600 million people are likely to be affected by malnutrition; an additional 1.8 billion people are likely to be living in a water-stressed environment (UNDP, 2007). Climate change affects every aspect and sector of African socioeconomic development and is cross-sectoral in nature. This in turn deepens poverty and decreases the standards of living of the community.

Based on the occurrence of climate change in Africa farmers should adopt appropriate adaptation strategies to climate change in order to continue production of rice (BNRCC, 2011). Individual farmers may adapt to climate change in different ways based on their capability. An individual adaptation scheme would differ from governmental policy that considered a much larger scale (Kawasaki & Herath, 2011). Efforts to adapt to climate change can be directed at preventing its occurrence or at minimizing damage. Eisenack & Stecker (2010) define adaptation as "decision-making processes and actions that enhance adaptive capacity". Adaptive capacity encompasses the enabling conditions for adaptation. Climate-change adaptation refers to spontaneous or organized processes through which human beings and societies adjust to changes in climate, thereby making changes in the operation of land and natural resource use systems and other forms of social and economic organisations (Quan & Dyer, 2008). Adaptation is place and context specific, with no single approach for reducing risks among vulnerable groups or across all settings. Effective risk reduction and adaptation strategies consider the dynamics of vulnerability and exposure and their linkages with socioeconomic processes, sustainable development, and extent of climate change (IPCC, 2014). Adaptation depends on biophysical and socio-economic vulnerability or sensitivity. Biophysical sensitivity has to do with physiological effect of climate change on crops, land, soil, water bodies and atmosphere (Mitin, 2009). On the other hand, the socio-economic sensitivity means extent of decline in yields and production, increase in number of people at risk of hunger and food insecurity, migration, and social unrest (IPCC, 2001, 2007; Chikaire *et al.*, 2011).

Two main types of adaptations are autonomous and planned adaptation. Autonomous adaptation is the reaction of a farmer to changing precipitation patterns, in that he/she changes crops or uses different harvest and planting/stocking dates. Planned adaptation measures are conscious policy options or response strategies, often multi-sectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptation (Chikaire *et al.*, 2011). The strategies adopted may depend on their access to information, knowledge, resource availability, including fund and the power of the society. Other factors influencing climate change adaptation are personal experience of the farmers and access to improved climate forecast. Also, climate forecasts can improve household well-being while poor forecast information can actually be harmful to poor farmers (Agarwal, 2008b; Agarwal & Perrin, 2008). The ability to respond to climate forecasts and the benefits obtained from their use are determined by policy and institutional environment as well as the socio-economic position of the farmers' household (Ziervogel *et al.*, 2005; Vogel & O'Brien, 2006).

In Nigeria, farmers are facing problem of extreme weather events such as floods, droughts and low soil fertility which are responsible for low rate of rice production. These challenges called for adaptation to climate change or variability in order to maintain optimum level of production (Arimi & Jenyo-Oni, 2014). However, there is limited information on types of adaptation strategies used by farmers in Nigeria. Furthermore, the determinants of appropriate climate-change adaptation strategies used by rice farmers in Nigeria have not been fully investigated. Past studies on determinants of climate change adaptation used by farmers in Nigeria focused on cassava, cocoa, and fisheries production with limited emphasis on rice production (Oyekale *et al.*, 2009; Oyekale & Oladele, 2012; Obatolu *et al.*, 2003; Arimi, 2014). This study, therefore, identifies determinants of appropriate climate-change adaptation strategies used by rice farmers in Southwestern, Nigeria, with hope of alleviating the negative impacts of climate change on rice production.

2 Methodology

2.1 Study area

This study was carried out in Southwestern Nigeria. The South-west zone lies between latitudes 5°N and 9°N with an area of 114,271 square kilometres, representing 12 % of the country's total land mass. The climate of the study area experiences a double rainfall maxima characterized by bimodal high rainfall peaks, with a short dry season and a longer dry season falling between and after each peaks. Average zonal annual rainfall is 1250 mm. The mean annual temperature is 27°C. Agriculture is the major occupation of the people in the study area. Rice production serves a very crucial role in the nation's food security as it is currently produced in all five agro-ecological zones of the country namely; southeastern, northcentral, northeastern and northwestern Nigeria. In terms of environmental challenges, the southwestern zone faces soil erosion, land degradation, flood, and drought that are currently worsened by climate change (BNRCC, 2011).

A multi-stage sampling procedure was used to select respondents for the study. The first stage of selection involved purposive selection of Ogun and Ekiti states among the six states in the South-western agro-ecological zone. This was because of high intensity or rate of rice production in the two states. The second stage involved purposive selection of Agricultural Development Programme (ADP) zones where rice was grown in the two states. ADP is responsible for coordinating agricultural activities of farmers in Nigeria. The administrative structure of ADP consists; zones, blocks and cells. Zone and block comprise of at least 4 to 5 local government while cell comprises of several villages that are located in the block. Yewa and Ikole zones were purposively selected in Ogun and Ekiti states, respectively. Three blocks were randomly selected from each zone to have a total of six block from the two states. Two cells were randomly selected from each selected block to give a total of six cells from each state. The total number of registered farmers in the twelve selected cells from Ogun and Ekiti states were 1,084 and 1,066 rice farmers, respectively.

Ten percent of the farmers in each state were randomly selected to have 108 and 107 respondents (215 in total as sampled size) from selected cells in Ogun and Ekiti states respectively as shown in Table 1.

Both quantitative and qualitative methods of data collection were used in obtaining information from the selected respondents. Focus group discussions (FGDs) were conducted among the selected rice farmers in Ogun and Ekiti states. The FGDs consisted of groups of female and male in each state. These groups were made up of 8–10 discussants. Qualitative data were obtained to complement the information obtained through interview schedule (quantitative method) in order to have better understanding of adaptation strategies used by these farmers.

Data on determinants of farmers adaptation strategies were obtained from the respondents through interview schedule using questionnaire. Instrument for data collection was subjected to face and content validity. Reliability of the instrument was determined through split-half technique, a reliability coefficient of 0.86 was used. Information was obtained on personal characteristics of the respondents, types of climate change adaptation strategies used as well as their knowledge on various adaptation strategies. Data collected were analyzed using descriptive and inferential statistical tools. A multiple regression was used to ascertain variables influencing farmers' adaptation strategies (Eqn. 1).

$$Y = b_0 + b_1x_1 + b_2x_2 + \ldots + b_{16}x_{16} + b_u \qquad (1)$$

Components of the regression equation:

b_0: regression constant

b_1–b_{17}: coefficient of x, which is the contribution of each independent variable to dependent variable

Y: determinants of adaptation strategies used: Use =1, Not use = 0

x_1: sex: male=1, female=0

x_2: age (years) (exact number)

x_3: marital status: married =1, not married =0

x_4: access to early warning information: yes = 1, no = 0

x_5: knowledge: high = 1, low = 0

x_6: education: formal education =1, no formal education =0

x_7: years of experience (years)

x_8: size of farm (hectare)

x_9: membership of farmers association: member of association =1, not a member =0

x_{10}: access to capital: yes = 1, no = 0

x_{11}: access to other land: yes = 1, no = 0

x_{12}: access to improved seeds: yes = 1, no = 0

x_{13}: contact with extension agents: contact with extension agent =1, no contact =0

x_{14}: poor access to water or functional irrigation system =1, otherwise =0

x_{15}: poor access to fertilizer: yes = 1, no = 0

x_{16}: participation in workshops and conferences: yes = 1, no = 0

b_u: error term

Table 1: *Sampling procedure and sample size*

States purposively selected	*No. of zones*	*No. of zones purposively selected*	*No. of blocks selected*	*No. of cells selected (2 per block)*	*No. of reg. farmers in selected cells*	*10 % farmers sampled*
Ogun	4	1	3	6	1084	108
Ekiti	2	1	3	6	1066	107
Total	6	2	6	12	2150	215

Source: data from the study

3 Results and discussion

Majority (64.7 %) of the respondents was middle-aged (31 to 50 years), and this indicates a potential for active labour participation in rice production (Table 2). This finding is similar to the results obtained by Adejare & Arimi (2013) who reported that the majority of agricultural labour force in Nigeria falls between 35 to 50 years. Most (61.9 %) of the respondents were male while the rest were female. The low participation of women could be attributed to core cultural values which place more household responsibilities on women than the men. Example of such responsibilities includes housekeeping and child rearing. There was indication that women were somewhat involved in agricultural production in order to support their family needs. The educational level of farmers may be helpful in sourcing information from various sources on climate change adaptation strategies as 74.0 % of the respondents had formal education ranging from primary to tertiary level. However, the proportion of farmers with primary education (27.0 %) was higher than that of tertiary education (11.0 %). Allison *et al.* (2009) posited that vulnerability and adaptation of a nation to climate change impact depends on level of education of its citizens.

A larger proportion of the respondents (73.0 %) were married while 13.0 % were single. Decision-making on climate change adaptation strategies to be adopted may be jointly taken by their household members because social relations are a strong bonding factors among the locals in the study areas. Oladele & Adu (2003) have observed that resource poor farmers considered their family welfare and situation before spending money on adoption of improved production technology such as pumping machine for irrigation, chemical fertilizer for improving productivity and improved seed. This means that farmers' income is a determinant of the types of climate change adaptation strategies used.

Most rural farmers in southwestern Nigeria are small scale holders (Adejare & Arimi, 2013). This was observed in the study with 54.0 % of farmers cultivating less than an hectare of farmland. Distribution of respondents on sources of farm credit revealed that 82.3 % of them did not have access to bank credit. Poor access of farmers to credit facilities may discourage adoption of appropriate climate change adaptation technology as most farmers will not be able to procure necessary inputs such as the Federal Agricultural Oryza (FARO) technology which includes drought tolerant rice seed and herbicide. Bryan *et al.* (2009) posited that farmers access to credit facilities as well as membership of local institution (association) enhanced adaptation to climate change.

Eighty-one percent of the respondents belong to one form of farmers' association or the other. These farmers' organisations are effective channels of communicating information to farmers. Therefore, information that will increase farmers' knowledge and skill on climate change can be passed on to them through their associations.

It was observed that all farmers interviewed were aware of climate change impacts on rice production. For instance, a comment made by some of the respondents during the FGDs stated that

– "We are not only aware of climate change; it is affecting our rice farms.' 'Last year (2011), flood ravaged our rice farms and there was nothing we could do".

– "Even, sometimes after planting and we are expecting rain to fall it may not fall".

– "It causes dry spell during the raining season".

– "In the past, we usually planted our rice between April and May', but now we cannot decide when to plant, we have to wait until rainfall is fully established".

Table 2: *Socioeconomic characteristics of respondents in Ekiti and Ogun states, Nigeria (n= 215)*

Socio-economic variables	*Frequency*	*Percentage*
Age		
21–30	28	13.0
31–40	52	24.2
41–50	87	40.5
51–60	36	16.7
61 and above	12	5.6
Sex		
Male	133	61.9
Female	82	38.1
Educational level		
No formal education	56	26.0
Primary	58	27.0
Secondary	76	35.3
Tertiary	25	11.6
Marital status		
Single	28	13.0
Married	157	73.0
Divorced	19	8.8
Widowed	11	5.1
Income from rice		
≤ ₦30,000	43	20.0
₦31,000–₦60,000	127	59.1
₦61,000–₦90,000	34	15.8
₦91,000 and above	11	5.1
Farm size (ha)		
≤ 1.0	116	54.0
1.1–2.0	61	28.4
> 2.0	38	17.6
Sources of credit		
Friends and relation	44	21.5
Bank	38	17.7
Cooperative societies	109	50.7
Personal saving	192	89.3
Membership of social organizations		
Cooperative societies	120	55.8
Age groups	78	36.3
Village council of elders	54	25.1
Farmers' associations	174	80.9
Ordinary social clubs	36	16.7
Contact with extension agents		
Less than 6 times per year	21	9.8
Six times in a year	58	27.0
Once in a year	72	33.5
Fortnightly	64	29.8
Awareness		
Yes	215	100.0
No	–	–

Frequency of contact with extension agents by the respondents was varied with only 29.8 % of the respondents having contact with extension agents fortnightly. This could be due to drastic reduction in the number of extension workers in the study areas coupled with inadequate transportation facilities faced by extension workers in Nigeria (Oladele & Adu, 2003). Poor extension services may hinder farmers' access to necessary information on climate change adaptation strategies.

A large number of farmers had adequate knowledge of climate change and its coping strategies. As evident in majority of the farmers provide a correct response to the knowledge check statements on climate change and its adaptation strategies (Table 3). The local people had knowledge of climate change adaptation and they are expected to adopt them on their farms in order to mitigate climate change effects. However, 45.6 % of the respondents did not know that climate change can cause loss of soil fertility. They, therefore, need enlightenment on this to help them maintain soil fertility. Similarly, 60.0 % of the respondents did not know that climate change caused invasion of pests and diseases on farms. This could be attributed to the fact that they have not experienced pests' invasion on their farms. Large proportion of the respondents did not insure their farms. Therefore, risk transfer mechanisms should be included in adaptation strategy of the farm family. Majority of the respondents reported that extreme change in weather affect health conditions of farm families.

Table 4 reveals that the majority (80.5 %) of the respondents planted improved variety as a means of coping with climate change as well as increasing production. Kawasaki and Herath (2011) observed that improved rice variety such as Jasmine rice variety and RD 12 have high capacities for coping with climate change, as such varieties can survive in submerged water for 20 days. Early warning information is utilized by a larger percentage (80.9 %) of the respondents. Early warning systems that inform the communities of the planting date in the study areas about upcoming extreme weather events assisted in adjustments to climate change variability (Eisenack & Stecker, 2010). Most respondents (99.1 %) have shifted the planting date until the weather was favourable. Only few of the respondents avoided flood prone areas as compared to other land uses. This could be due to differences in their socio-economic status. Resource poor farmers could not just move to another location without being helped financially. This is because the issue of finance also affects people's decision on the use of other farm input such as fertilizer among others.

Table 3: *Respondents knowledge about climate change adaptation strategies in Ekiti and Ogun states, Nigeria (n=215)*

Knowledge questions	*Correct*		*Incorrect*	
	Frequency	%	Frequency	%
Climate change can negatively affect rice production, true or false	215	100.0	–	–
Participation in workshops and conferences cannot really improve one's adaptation skill and knowledge	119	55.3	96	44.7
Seeking for early warning information on climate change is a waste of time because it is not necessary	215	100.0	–	–
Climate change can reduce soil fertility	117	54.4	98	45.6
Shifting planting date is one way of coping with climate change	215	100.0	–	–
Avoidance of flood prone areas can reduce rice losses, true or false	97	45.0	116	55.0
Use of supplementary irrigation is a means of coping with water scarcity, true or false	203	94.4	12	5.6
Climate change increases invasion of pests and diseases, true or false	86	40.0	129	60.0
Planting of improved varieties can reduce negative impact of climate change on rice production	117	54.4	98	45.6
Insuring farm against risk is a way of mitigating losses or coping with climate change	63	29.3	152	70.7
Sudden break in rainfall cannot affect rice production	204	94.9	11	5.1
Climate change may cause extreme change in weather condition which can cause sickness among farm families	204	94.9	11	5.1

Table 4: *Climate change adaptation strategies used by respondents in Ekiti and Ogun states, Nigeria (n=215)*

Adaptation strategies used	*Often used*		*Occasionally used*		*Never used*	
	Frequency	%	Frequency	%	Frequency	%
Planting of improved rice varieties	173	80.5	42	19.5	–	–
Seeking early warning information on climate change	174	80.9	41	19.1	–	–
Shifting planting dates	213	99.1	2	0.9	–	–
Diversified into other business	73	34.0	127	59.1	15	7.0
Avoidance of flood prone areas	44	20.5	78	36.3	122	56.7
Intensified pest control	–	–	48	22.3	167	77.7
Increased use of fertiliser to maintain soil fertility	44	20.5	52	24.2	119	55.3
Use of shallow ground water for irrigation	32	14.9	41	19.1	73	44.0
Use of supplementary reservoir for water storage	32	14.9	58	27.0	90	41.9
By insuring farm against risk	–	–	31	14.4	184	85.6
Consulting spiritual leader for prayer	181	84.2	34	15.8	–	–
Shifting of harvesting period	213	99.1	2	0.9	–	–
Mulching	44	20.5	61	28.4	110	51.2

Poor use of chemical fertiliser and insurance scheme by many of the respondents against climatic risk of event of flash flooding, temperature change and severe rainfall was noticeable. Only few (20.5 %) of the respondents often used chemical fertilizer on their farms in order to maintain soil fertility. This could be due to high cost of the input that hinder farmers from using it on their farm. Some of the respondents also indicated that they consulted with their spiritual leaders for prayers, to avert disaster, such as flood ravaging their farm land and low productivity.

During the FGDs respondents asserted the following reasons for not using some of the adaptation strategies. They said that

– "We could not adopt some of the adaptation technologies introduced by extension agents because of financial difficulties. For instance, we could not afford the pumping machine. Last year, when flood ravaged our rice plantation, government promised to give us some financial assistance, until today we have not received anything".

– "We were willing to obtain loan from bank to have money to procure farm inputs, but we could not access the loan due to lack of collateral, even after forming ourselves into groups as suggested by bank officials".

– "Some of us did not have access to information as regards early warning, so how will we use what we don't have access to?"

– "We don't know how we can sustain the use of water from shallow ground to irrigate large farm".

– "We do not have enough patronage to the improved rice seeds that were introduced, which extension agents claimed to be drought tolerant after planting it. Local variety (Ofada,) was preferred to improved varieties called Federal Agricultural Research Oryza sativa (FARO) introduced by extension agents".

During the FGDs women groups said that

– Controlling flood requires the use of tractor to make standard drainages, but we do not have access to tractor hiring services. We would be grateful if government can help us, because we are really suffering. Likewise, Rice production requires a lot of labour to carry out farm work especially organic manure application and harvesting. This is limiting our farming operation.

– The farmers have stated that they need financial assistance to acquire different technologies.

The regression model of determinants of climate change adaptation strategies used by rice farmers revealed a positive relationship between independent variables and the dependent variable ($R = 0.53$, $R^2 = 0.46$, $F = 3.81$) (Table 5). The model has a good fit and significant at 1 % ($p = 0.00$). From the variables that were included in the model, only four were significant, which were access to early warning information ($\beta = 43.04$), access to fertilizer ($\beta = 5.78$), farm size ($\beta = -12.04$) and poor access to regular water supply ($\beta = -24.79$), with access to information indicating very strong contribution. Farmers' access to early warning information and their access to fertilizer were the major predictors of adaptation strategies used by the farmers. This finding is corroborated by Eisenack & Stecker (2010) who posited that public access to early warning information is an important factor affecting adaptation to climate change. In a similar finding, Kawasaki & Herath (2011) noted that rice farmers' increased use of chemical fertilizer in order to improve soil fertility so as to attain increased rice yield.

Table 5: *Multiple regression showing determinants of climate change adaptation strategies used by rice farmers in Ogun and Ekiti states, Nigeria*

Variables	*β*	*t-values*
Constant	–19.23	–0.53
Gender	12.38	1.72
Age	0.44	0.67
Marital status	–2.42	–0.18
Access to early warning information	43.04	3.51*
Knowledge of farmers on climate change adaptation	8.86	3.79
Educational level	4.32	0.61
Access to capital	24.02	2.68
Farm size	–12.04	–1.38*
Years of experience	2.03	0.67
Farmers association	–23.68	–2.28
Access to other land	1.50	0.16
Access to improved rice seeds	1.02	0.82
Access to fertilizer	5.78	0.46*
Contact with extension agents	3.02	1.65
Poor access to water	–24.79	–1.57*
Participation in workshop and conferences	26.08	3.01

However, insignificant positive relationship existed among gender, age, knowledge of farmers on climate change adaptation, access to capital, years of farming experience, access to improved seed, contact with extension agents, farmers participation in workshops and adaptation strategies used by rice farmers. The implication of this finding is that farmers' participation in workshops and seminars exposed them to the acquisition of skills and knowledge that enhance their adaptation to climate change. Also, the provision of information by electronic media enables the farmers to have access to information concerning risk mitigation and adoption of innovation.

4 Conclusion

Generally, climate change adversely affects food production including rice production in Nigeria. As rice production remains a source of income for rural communities in selected study areas, adaptation of rice production by farmers to climate change is imperative. This is to improve their livelihoods and ensure food security. A better understanding of ongoing adaptation measures and the determinants of adaptation strategies used by the stakeholders is important to create policies aimed at promoting successful adaptation strategies for the sector.

Common adaptation strategies outlined the use of improved rice production technology. These included the planting of drought-resistant rice seeds (FARO variety), changing planting dates, use of early-warning information, use of shallow ground water, avoidance of flood-prone areas and farm insurance by a few. There is huge dependence of the farmers on the media reports through radio and television. The main determinants of climate change adaptation strategies used by the farmers, include access to early warning information from the media sources; access to fertilizer based on credit availability; farm size based on available farming space, and access to regular water supply from shallow ground water. Following present farming conditions in the study areas, there is need for greater government support to make farmers better at adaptation methods. The government should invest in programmes that will improve water utilisation such as construction of dams and irrigation systems. It is important also to strengthen the agricultural extension systems with particular attention to small-scale farmers who have limited resources to confront climate change. In addition to this, economic conditions in developing countries like Nigeria warrant the use of incentives to assist farmers in the areas of training on coping strategies for drought and flood control.

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