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Determinants of rice farmers adaptive capacity to flooding for sustainable production in Benue State, Nigeria

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ABSTRACT

The study examined determinants of rice farmers adaptive capacity to flooding for sustainable production in Benue State, Nigeria. Multistage sampling procedure was used in the selection of eighty (80) rice farmers. Data was collected using structured interview schedule. Data was analyzed using frequency, percentage, mean and standard deviation. Results show that the indicators that best described the determinant (economic resources D_1) of farmers adaptive capacity were income diversification increases adaptive capacity (91.3%) and remittances received by farmers (77.5%), while More access to family/household labor (81.3%) best described the determinant, social capital (D_2). Results show that the indicators useful in assessing the determinant, economic resources were; income diversification increases adaptive capacity ($\bar{x}$=3.25; SD= 0.854) and remittance received by farmers enhances adaptive capacity ($\bar{x}$=3.11; SD= 0.816). Data show that economic resources with 74.45 score was identified as the most relevant determinant of rice farmers adaptive capacity to flooding, followed by technology (70.60). Result show that the farmers' adaption measures to flooding include: diversification of sources of income ($\bar{x}$=3.85) and construction of adequate flood water storage capacity ($\bar{x}$=.2.62). Government and non-governmental organizations should prioritize interventions that would enhance rice farmers adaptive capacity to flooding by strengthening economic resources which will in turn aid their diversification of income and access to remittances, in addition to provision of facilities for floodwater storage.

Key words: Rice Farmers; Determinants of Adaptive Capacity to Flooding

1. INTRODUCTION

Rice production in Nigeria has continued to be a very important segment in the agricultural sector due to the preference of the grain among households, to whom it serves as a major staple food that is essential for their livelihood sustainability (Mutiga et al., 2021). Despite the importance of rice to the Nigeria populace, its production has continued to face reoccurring challenges, specifically as a result of natural disaster. Natural disasters such as flooding upsets the production cycle of rice, thereby leading to crop losses which has continuously jeopardized food security

in the region (United Nations Development Programme (UNDP), 2023). Unpredictable changes in weather and climate conditions have consistently triggered flooding, especially in major rice producing areas in Nigeria (Benue State inclusive), thereby undermining attempts and efforts by both large scale and medium scale farmers towards sustainable agricultural production and the stability of the economy (National Agricultural Extension and Research Liaison Services (NAERLS, 2023).

Benue State, known to be located in the fruitful Benue Valley, is among the key major rice-producing regions in Nigeria. Regrettably, it is also highly exposed to regular flood events, often as a result of heavy rainfall, runover of the Benue River, weak drainage systems, and human activities such as blockage of waterways (Ishaya et al., 2023). These floods meaningfully submerge farmlands, thus leading to delay of early planting of seeds and consequently leading to reduction in the productivity of the rice farmers (Muhammad & Kersha, 2018). According to Bagena et al. (2025), the overflow (flooding) of rivers in Benue State usually causes severe damages to the production of rice in the state. These damages occur in the form of reduction in yield or outright washing away of crops, thus leading to unanticipated hardships for farmers who depend to a great extent on agricultural production for their livelihood.

Rice producers in Benue State are often threatened with the impacts of flooding and some of the challenges they encounter include; post-harvest losses, damaging of crops, and loss of farmland (Shima, 2024). These challenges jeopardize efforts by stakeholders towards the sustainability of rice production and the quest to exacerbate food insecurity and poverty reduction among different categories of farmers and farming neighbourhood (Wangum et al., 2024). These challenges occurring as a result of persistent flooding, necessitates the need for farmers in the region to build adaptive responses in other to mitigate and cope with the impacts of recurrent flood events all through their production cycle. The ability of the rice farmers to cope with climate related risks such as flooding would reduce crop losses and enhance their resilience to keep up with production during extreme climatic conditions. It is pertinent to note that the rice farmers access to these adaptive responses is a function of their adaptive capacity (AC).

Adaptive capacity is the skill needed for an individual or community to attune to potential damage, and take advantage of opportunities, or respond to consequences associated with environmental hazards like flooding. Adaptive capacity is checkmated by essential determinants such as existing economic resources, information (knowledge), facilities (infrastructure), and social networks that are requisite in coping or adjusting to situations. Similarly, Abdul-Razak & Kruse (2017) revealed that access to improved economic development, formal education, tools (technology), wisdom (knowledge), basic facility (infrastructure), organizations (institutions), and social networks (social capital) are used to determine the adaptive capacity of an individual. On the other hand, rice farmers adaptive capacity to flooding entails the ability of the rice farmers to expect, embrace, handle, and survive the impacts of flood events during production cycle through the practice of various strategies such as alteration of planting dates and time, planting of rice varieties that tolerate flood, diversification of sources of income and collaboration with extension professionals for timely access to basic support and production (Yadav & Ibrar, 2023).

The need for rice producers in Benue Sate to possess basic adaptive capacity in order to aid them to stay strong and active during rice production cycles cannot be overemphasized. It boosts their resilience capacity and makes them less vulnerable to crop losses, thereby stabilizing their profit and income, in addition to enhancing sustainable rice production despite climatic conditions which continues to change. Sincere work to enhance rice farmers adaptive capacity is crucial in order to sustain rice production, especially in flood-prone regions such as Benue State. This will greatly aid the farmers ability to manage the overflow of rivers and on the long run, contribute to food security. Therefore, examining the determinants of rice farmers' adaptive capacity to flood events in Benue State is critical since it will unravel best ways to aid farmers adaptive responses to flooding. Based on this background, the study examined the determinants of rice farmers adaptive capacity to flooding for sustainable production in Benue State, Nigeria. Specifically, the study sought to: identity indicators that best described the determinants of the rice farmers AC to flooding; ascertain usefulness of the indicators in describing the determinants of AC; ascertain the relevance of the determinants of the farmers AC to flooding; and ascertain rice farmers adaptation measure to flooding.

2. MATERIALS AND METHODS

The study was carried out in Benue State, Nigeria. The State is located within latitudes 6° 25' N and 8° 30' N, 8'N and longitudes 7° 45' 'E and 9° 30' E (NPC, 2006). Benue State stretches across the transition belt between the forest and savannah vegetation. The area consists of undulating hills and grassy open space in the North and dry savannah in the South. The State is a major producer of food and cash crops including: yam, cassava, maize, groundnut and rice.

All the rice farmers in Benue State constituted the population of the study. Multistage sampling procedure was used in the selection of the respondents for the study. In the first stage, two local government areas (Markudi and Kastina-Ala) out of 23 local government

areas in the state were purposively selected. The purposive selection of the two local government areas was because of the preponderance of rice farmers in the LGAs. In the second stage, two communities each were randomly selected from each of the two LGAs. This gave a total of 4 communities for the study. In the third stage, two villages were randomly selected from each of the communities, giving a total of eight villages. In the fourth stage, snowball sampling technique was used to select ten (10) rice farmers from each of the selected villages, giving a total of eighty (80) rice famers for the study.

Data was collected using structured interview schedule, in line with the specific objectives of the study. The indicators that best describe the six (6) determinants (Economic resources, social capital, Awareness and training, technology, Infrastructure, and Institutions) of adaptive capacity was identified by asking the respondents to tick yes or no where applicable from a list of indicators for each of the determinants. Some of the indicators include: diversity of source of income, access to family/household labor, level of literacy, land holding size etc.

Usefulness of the indicators in describing the determinants of adaptive capacity of the farmers to fooding was ascertained using a five-point Likert-type scale of highly useful=4, very useful=3, useful=2, not useful=1. The values were added to get 10 and were further divided by 4 to get a mean cut-off point of 2.5. Any indicator with a mean value of 2.5 and above were regarded as highly useful, while indicators with mean score less than 2.5 were regarded as less useful.

Furthermore, the respondents were asked to rank the determinants of adaptive capacity using the ranking technique of Fabbris (2013) involves putting the determinants in an order of relevance, from the most relevant to the least relevant determinant. Each of the determinants of adaptive capacity of the farmers was ranked and proportioned relative to an assumed total adaptive capacity score of 100. The Ranking(R) score for each determinant was therefore ascertained by getting the average of the ranking scores assigned to it by all the respondents.

Farmers' adaptation measures to flooding were identified using a five-point Likert-type scale of 'regularly (4)' 'often (3)' 'sometimes (2)', 'rarely (1)' and 'never (0)'. The values were added to get 10, which was further divided by 5 to get a mean cut-off point of 2. Any variable with a mean value of 2 and above was regarded as major adaptive measure, while variables with mean values of less than 2.0 was regarded as minor adaptive measure. Some of the variables for adaptive measures include: planting of flood resistant varieties, change of planting date, etc. Data was analyzed using frequency, percentage, mean and standard deviation. The Statistical Product Service Solution (SPSS) software package version 22 was used for data analysis.

3. RESULTS & DISCUSSION

Indicators that described the determinants of the rice farmers' adaptive capacity to flooding

Table 1 shows the indicators that described the determinants of farmers adaptive capacity to flooding. The indicators of economic resources(D1) as indicated by the respondents show that income diversification increases adaptive capacity (91.3%), remittances received by farmers (77.5%), and access to agricultural extension services (66.3%) described the determinant. This implies that economic resources, especially income diversification, external financial support, and access to extension services, are critical factors in enabling farmers to adapt effectively to flooding impacts. This finding is in line with Enwa & Achoja (2023) who revealed that farmers ability to diversify income sources help to reduce dependency on flood-affected crops.

On the other hand, 81.3% of the farmers indicated that access to family/household labor well described the determinant of adaptive capacity, social capital (D_2), while 77.0% each of the respondents indicated that the indicators, participation in farmer-based organizations and participation in social organization gives good description of the determinant (D_2). This suggests that family labour and collective action (social networking) are critical resources for coping and adapting to challenges such as flooding. This implies that rice farmers perceive social relationships, labour support, and group participation as vital components of their capacity to adapt effectively to environmental stresses. Social capital thus plays a central role in their resilience strategies.

Moreso, 58.0% of the farmers indicated that the indicator, accepting the fact that flooding in farms may occur anytime and the need to adapt is an essential step to adapting to flooding provides a good description of the determinant (awareness and training D_3) of adaptive capacity; 45.0% of the farmers indicated the indicator, level of literacy provides a good description of the determinant, awareness and training (D_3), 67.5% indicated that the indicator, access to flooding information gives a good description of D_3, 67.5% indicated that the number of years of experience in farming gives a good description of D_3, while 66.3% indicated that access to agricultural extension services provides a good description of D_3. This corroborates with Pathak et al. (2020) that access to and application of knowledge may also be seen as strong determinants of adaptive capacity.

Table 1 shows that 47.5% of the farmers revealed that the indicator, knowledge of cultivation of improved rice varieties, provides a good description of the determinant (technology D4) of adaptive capacity, while 45.6.0% revealed that the indicator, use of wire gauze round the farm provides a good description. This suggests moderate level of awareness and appreciation among the rice farmers regarding knowledge of use of improved varieties of rice and use of wire gauze for fencing of the farm as adaptive tools to flooding. It also implies that a significant number of the farmers may not yet fully recognize or utilize the aforementioned technologies as effective adaptive tools.

Similarly, 92.5% of the farmers revealed that farmers with large landholdings stand a better chance of diversifying their farming practice to adapt to flooding than those with small landholdings as indicator of the determinant (infrastructure D5) of adaptive capacity, while 78.8% indicated that the indicator, access to good road network enhances farmers' capacity to access landholdings for diversification, gives a good description of infrastructure (D_5) as a determinant of AC. This suggests that land availability and access to a good road network by farmers are critical factors enabling adaptive strategies like crop diversification, thereby strengthening their adaptive capacity against flooding.

Also, 46.3% the farmers indicated that the access to disaster relief assistance enhance adaptive capacity in times of flooding shocks and disturbances as an indicator of the determinant, institutions (D6) is critical for its description, while 45.0% indicated the indicator, access to government subsidies for agriculture input gives a better description of institution (D_6) as a determinant of the farmers adaptive capacity to flooding. These findings highlight that adequate institutional support, through direct assistance and subsidies, is essential in describing the determinant, while also building the adaptive capacity of the farmers and reducing vulnerability among farming communities.

Table 1: Indicators that best described the determinants of the rice farmers adaptive capacity to flooding

Determinants of adaptive capacity	Indicators	Frequency	Percentage (%)
Economic resources (D1)	Income diversification increases adaptive capacity	73	91.3
	Remittances received by farmers	62	77.5
	Access to credit	51	63.7
Social capital (D2)	Access to family/household labor	65	81.3
	Participation in farmer-based organizations	56	70.0
	Participation in social organizations	56	70.0
Awareness and training (D3)	Accepting the fact that flood intrusion in farms may occur anytime and the need to adapt is an important step to adapting to flooding	47	58.8
	Level of literacy	36	45.0
	Access to flood information	54	67.5
	The number of years of experience in farming	51	63.7
	Access to agricultural extension services	53	66.3
Technology (D4)	Knowledge of cultivation of improved cassava varieties	38	47.5
	Use of wire gauze round the farm	36	45.0
Infrastructure (D5)	Farmers with large landholdings stand a better chance of diversifying their farming practice	74	92.5
	Access to a good road network	63	78.8
Institutions (D6)	Access to government subsidies for agricultural inputs	36	45.0
	Access to insurgency relief assistance	37	46.3

Usefulness of the indicators in describing the determinants of adaptive capacity

Table 2 shows that the indicators highly useful in describing the determinant of adaptive capacity (economic resources (D1)) of the rice farmers include: income diversification increases adaptive capacity ($\bar{x}$=3.25), remittance received by farmers enhances adaptive capacity

($\bar{x}$=3.11), and access to credit ($\bar{x}$=3.00). This implies that farmers with more diversification of income have a higher adaptive capacity than farmers with less diverse sources of income. Also, remittances farmers receive play an essential role in enhancing their capacity to adapt to changes; farmers with access to credit are more economically able to adapt to change than those with less access to credit. This is in agreement with Kates (2018) who opined that whether economic resources are expressed as the economic assets, capital resources, financial means or wealth, the economic conditions of nations and groups clearly is a determinant of adaptive capacity.

Similarly, the indicator highly useful in describing the determinants of adaptive capacity (social capital D2) of rice farmers include: access to family/household labour ($\bar{x}$=2.85), participation in farmer-based organizations ($\bar{x}$=2.78) participation in social organizations ($\bar{x}$=2.79). This implies that strong social networks, family support, and active community engagement are key drivers in describing social capital as a determinant of rice farmers' adaptive capacity to flooding.

Similarly, the indicator highly useful in describing the determinants of adaptive capacity (awareness and training D3) of the rice farmers' include: accepting the fact that flood in farms may occur anytime and the need to adapt is an important step to adapting to flooding ($\bar{x}$=2.58), the number of years of experience in farming ($\bar{x}$=2.53), and access to agricultural extension services ($\bar{x}$=2.60). This suggests that awareness, experience and training are vital elements in describing the determinant (D_6) of farmers adaptive capacity to flooding.

On the contrary, all the indicators of the determinant, technology (D4) as indicated by the rice farmers are less useful in describing the determinant. The indicators include: Knowledge of cultivation of improved rice varieties gives farmers chances of adapting to flood ($\bar{x}$=2.33), Use of wire gauze around the farm ($\bar{x}$=2.14). These findings suggest that technological factors such as knowledge of improved variety and physical protective measures (use of wire gauze around the farm) are not strongly viewed by rice farmers as effective means of enhancing their flood adaptive capacity. This could imply existing challenges in technology access, suitability, or adoption that tend to reduce their practical influence on resilience.

Furthermore, the indicators useful in describing the determinants of adaptive capacity (infrastructure D5) of rice farmers include: Farmers with large landholdings stand a better chance of diversifying their farming practice to adapt to flooding than those with small landholdings ($\bar{x}$=3.30), Access to good road network enhances farmers' capacity to access landholdings for diversification ($\bar{x}$=2.92). This implies that farmers with large landholdings stand a better chance of diversifying their farming practice in order to adapt to flooding than those with small landholdings. This consistent with Nwangwu et al. (2024) who stated that farmers owning larger land parcels have better opportunities for diversifying cropping patterns and employing flood mitigation techniques, thereby enhancing resilience to flooding.

Table 2 shows the indicators of the determinant, institution (D_6) are less useful describing the determinants of adaptive capacity of rice farmers include: Farmers with access to government subsidies for agriculture input are more resilient to flooding than those with no access to government subsidy ($\bar{x}$=2.25), access to insurgence relief assistance enhances adaptive capacity in time of flooding ($\bar{x}$=1.96). This suggests that farmers with access to government subsidies for agriculture input are somewhat more resilient to flooding than those without such access. This implies that subsidies contribute positively but not strongly to the farmers' adaptive capacity to flooding. This corroborates with Baishakhy, Islam, Kamruzzaman (2023) who stated that while access to inputs including subsidies can enhance resilience, the effect is not always strong due to other limiting factors such as market access and knowledge gaps.

Table 2: Usefulness of the indicators of determinants of adaptive capacity

Determinants of adaptive capacity	Indicators	$\bar{x}$	SD
D1	Income diversification increases adaptive capacity	**3.25**	0.854
	Remittances received by farmers	**3.11**	0.816
	Access to credit	**3.00**	1.050
D2	Access to family/household labor	**2.85**	0.975
	Participation in farmer-based organizations	**2.78**	1.009
	Participation in social organizations	**2.79**	1.144
D3	Accepting the fact that flood intrusion in farms may occur anytime and the need to adapt is an essential step to adapting to flooding	**2.58**	1.161
	Level of literacy	2.27	1.278

	Access to flood information	2.30	1.343
	The number of years of experience in farming	**2.53**	1.192
	Access to agricultural extension services	**2.60**	1.150
D4	Knowledge of cultivation of improved cassava varieties	2.33	1.308
	Use of wire gauze around the farm	2.14	1.163
D5	Farmers with large landholdings stand a better chance of diversifying their farming practice	**3.30**	0.939
	Access to good road network	**2.92**	1.141
D6	Access to government subsidies for agricultural input	2.25	1.296
	Access to insurgency relief assistance	1.96	1.250

Relevance of the determinants of the farmers' adaptive capacity to flooding

Result in Table 3 show the ranking scores of all the determinant of adaptive capacity. Economic resources (74.45) were identified as the most relevant determinant of rice farmers' adaptive capacity to flooding; technology and social capital, scored 70.60 and 68.57 each; awareness and training and infrastructure scored 54.53 and 51.41 each, while institutions (43.89) were identified as the least relevant determinants of farmers adaptive capacity to flooding. This suggest that financial capability is the most critical factor enabling farmers to adapt to and cope with flood impacts effectively. Overall, the results imply that while multiple factors contribute to adaptive capacity, economic resources are paramount, supported by technology and social networks. This finding agrees with that of Pathak (2024) that the most relevant determinant of adaptive capacity is economic resources.

Table 3: Ranking score of determinants farmers' adaptive capacity

Determinants	Ranking score
Economic resources (D1)	74.45
Social capital (D2)	68.57
Awareness and training (D3)	54.53
Technology (D4)	70.60
Infrastructure(D5)	51.41
Institutions (D6)	43.89

Farmers' adaptation measures to flooding

Table 4 shows that the farmers' major adaption measures to flooding include: diversification of sources of income ($\bar{x}$=3.85), construction of adequate flood water storage capacity ($\bar{x}$=.2.62), adequate access to early warning system ($\bar{x}$=.2.78), use of dikes ($\bar{x}$=.2.08), diversification of crop produced ($\bar{x}$=.2.51), use of flood resistant of varieties ($\bar{x}$=.2.50) and Change in time of farm operation ($\bar{x}$=2.50).

Other adaptation measures include: widening of natural flood plains ($\bar{x}$=1.95), planting of trees ($\bar{x}$=1.88), addition of large wood debris to river channel ($\bar{x}$=1.89), and building of leaky dams to delay the flow of water from upland stream ($\bar{x}$=1.91).

Overall, the results show a pragmatic and risk-focused adaptation profile of the rice farmers. The emphasis on income diversification, early warnings, crop and operational adjustments, reveal a priority for strategies that provide quick, and flexible responses to reduce vulnerability. Physical and ecological measures such as widening of natural flood plains is less practiced, possibly reflecting barriers in knowledge, capacity or coordination of the farmers. This agrees with the finding of Pathak et al. (2020) that adaptation measures employed by farmers include rechanneling of river, harvesting of crops before flooding, and use of dikes.

Table 1: Farmers' adaptation measures to flooding

Adaptation measures	$\bar{x}$	Std. Deviation
Diversification of sources of income	**3.85**	1.083
Construction of adequate flood water storage capacity	**2.62**	1.351
River corridor management	**2.35**	1.023
Use of different structural flood production measures	**2.46**	1.125
Adequate access to early warning system	**2.78**	1.221

Use of dikes	**2.08**	1.326
Widening of natural flood plains	1.95	1.080
Planting of trees	1.88	1.173
Addition of large wood debris to river channel	1.89	1.283
Building of leaky dams to delay the flow of water from upland stream	1.91	1.160
Diversification of crop produced	**2.51**	1.396
Harvesting of crops before flooding	**2.34**	1.376
Rechanneling of river	1.91	1.313
Use of flood-resistant varieties	**2.50**	1.312
Change in time of farm operation	**2.50**	1.378

4. CONCLUSION

The rice farmers adaptive capacity to flooding is determined by economic resources with indicators such as diversification of sources of income and access to remittances being integral in helping the farmers to cope with the overflow (flooding) of water. The rice farmers high-ranking adaptation measures used were; diversification of sources of income, construction of floodwater storage, and use of early warning systems. To promote sustainable rice production amidst flooding challenges, interventions should prioritize strengthening economic resources, improving access to social support networks, and enhancing flood management infrastructure.

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Author's Contribution

CEU: Conception/design, development of data collection instrument, interpretation of data (60%)
ODU: Conceptualization, writing introduction, editing, and analysis (40%)

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Conflict of interest

The authors declare that they have no conflicts of interests, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical approval

The study was done in conformity with ethical guidelines. Participation was entirely voluntary, and all respondents provided informed consent. The participants' anonymity and confidentiality were ensured, and the data obtained were utilized purely for the study. The ethical guidelines for Human Subjects are followed in the study.

Informed consent

Oral informed consent was obtained from individual participants included in the study.

Data availability

Data that support the findings of this study are embedded within the manuscript.

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