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Evaluation of the Effect of 2022 Flooding on Rice Production in the Flood Plain of Buruku Town, Buruku Local Government Area of Benue State, Nigeria.

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A B S T R A C T

This study evaluates the effects of the 2022 flooding on rice production in the floodplain of Buruku Town to provide insights into the multifaceted challenges faced by rice-cultivating communities in flood-prone areas. The study objectives include determining the extent of 2022 flooding in the study area, analyzing the extent of rice cultivation in the area in 2022, examining the effect of 2022 flooding on rice production in the area, examining the strategies adopted by farmers to cope with flooding in the area, and suggesting mitigation measures to control the effect of flooding on rice production in the area. The method of data collection used in this study involved a combination of structured questionnaires and use of geospatial data, including coordinates which were determined by Global Positioning System (GPS). A sample size of 252 farmers was determined using the Taro Yamane formula (1973) from a total population of 680 registered rice farmers. Descriptive statistics such as tables, frequencies, mean and median were used to summarize and describe the key variables, including rice output. Spatial analysis, utilizing GIS, allowed for the visualization and quantification of the flood extent and its effect on rice fields through techniques such as spatial interpolation and overlay analysis. The findings reveal that 80% of the floodplain area was inundated during the flood event, leading to reduction in rice output by 88.67%. The study recommended the cultivation of flood-resistant rice varieties that can withstand prolonged periods of submersion and educate farmers on the benefits and cultivation practices associated with these resilient varieties, enhancement of early warning systems that will allow farmers to implement necessary precautions, such as adjusting planting schedules, implementation of financial support mechanisms that would provide a safety net for farmers, enabling them to recover more quickly from the adverse effects of floods and continue with their agricultural activities, as well as strengthening agricultural extension services.

Keywords: Flooding, Rice Production, Agricultural Resilience, Coping Strategies, Mitigation Measures

1. Introduction

Flooding poses a significant threat to agricultural productivity, especially in regions like Nigeria's floodplains, where farming activities are concentrated around water sources (Adelekan and Asiyanbi, 2016). These floodplains are fertile and ideal for growing crops such as rice, which thrives in waterlogged conditions. However, excessive flooding can have devastating effects on crops, soil quality, and farming infrastructure. The 2022 flooding event in the Buruku floodplain, situated in Benue State, Nigeria, caused widespread damage to rice production. The flooding resulted in waterlogging, soil erosion, crop submersion, and pest infestations, leading to reduced yields and economic losses for local farmers. The annual floods in this region have become more severe in recent years due to climate change, further exacerbating the vulnerability of agricultural activities in the area. With rice being a staple crop and a major source of income for the farming communities in Buruku, the effects of such flooding events are significant not only for food security but also for the livelihood of the rural population (Yaduvanshi et al., 2019; Alam et al., 2021).

1.1 Brief Overview of the 2022 Flooding Event.

The 2022 flooding event in Nigeria was an unprecedented natural disaster that had far-reaching impacts across multiple states, including significant effects on agricultural production. This event was part of a broader pattern of increasingly frequent and severe flooding incidents observed in Nigeria in recent years (Nkeki and Akpu, 2023). The scale and intensity of the 2022 floods were particularly notable. According to government figures, between February and September 2022, approximately 600 people lost their lives, 1,546 were injured, and over 100,000 individuals were displaced due to flooding across Nigeria (Onyekwere et al., 2021). The floods affected 320 local government areas across 35 states, including the Federal Capital Territory, demonstrating the widespread nature of the disaster (Patrick, 2020). The agricultural sector, a cornerstone of Nigeria's economy, was severely impacted by the 2022 floods. Preliminary reports indicated widespread damage to agricultural land and infrastructure across multiple states (Olorunfemi et al., 2023). The flooding event coincided with the critical growing season for many crops, including rice, potentially leading to significant yield reductions and economic losses for farmers.

In the context of Buruku Town and its surrounding floodplain, the 2022 flooding event was particularly significant. The area, characterized by its extensive floodplains and importance for rice production, experienced severe inundation. The floodplains in Buruku are typically subject to annual flooding between August and November (Adashu, 2014), but the 2022 event was reported to be of exceptional magnitude and duration. The severity of the 2022 floods was attributed to a combination of factors, including intense rainfall, poor drainage systems, and the effects of climate change. Climate scientists have noted that such extreme weather events are likely to become more frequent and intense due to global warming (Ayanlade et al., 2022), highlighting the urgent need for improved flood management and climate adaptation strategies.

The 2022 flooding event in Nigeria, and particularly its impacts on agricultural areas like the Buruku floodplain, underscores the vulnerability of the country's food production systems to extreme weather events. It emphasizes the critical need for comprehensive studies to understand the specific impacts of such events on key crops like rice, to inform more effective disaster preparedness and response strategies, and to enhance the resilience of agricultural systems in flood-prone areas.

The Benue River Basin, where Buruku Town is located, experiences seasonal flooding due to heavy rains and overflow from the Benue River. Adebayo, Mashi, & Tukur (2022) found that floods in this region typically result in reduced rice yields due to submergence of crops, erosion of fertile soil, and increased pest infestations. Studies by Ibrahim & Olayinka (2022) indicate that the frequency and intensity of flooding events in the region have increased over the past two decades due to climate change, making it imperative to study their effects on agriculture more closely.

Farmers in flood-prone floodplain often adopt a combination of traditional and modern coping mechanisms to mitigate the effects of flooding on rice production. Traditional methods include constructing small earthen embankments or ridges around farmlands to prevent water from completely submerging crops, as well as adjusting planting schedules to avoid peak flood periods. In recent years, more innovative strategies have been introduced, such as the adoption of flood-tolerant rice varieties, which are specifically bred to withstand periods of submergence. Some farmers have also turned to the use of irrigation systems that help regulate water levels on their farms. However, the effectiveness of these strategies is often limited by infrastructure gaps, access to resources, and the financial capacity of the farmers.

Larger-scale mitigation efforts, such as the construction of drainage systems or levees by government agencies, remain inadequate or poorly maintained, leaving many farmers vulnerable to recurrent flooding. Studies, such as those by Adebayo., Mashi, & Tukur (2022) and Ouma et al. (2020), highlight the importance of community-based approaches where local knowledge is combined with modern flood mitigation techniques to enhance the resilience of agricultural communities. Despite these efforts, the unpredictable nature of flooding, exacerbated by climate change, continues to challenge farmers' ability to effectively protect their crops and livelihoods from water-related disasters.

2. Materials and methods

2.1 Study Area

The Buruku floodplain is situated within Buruku Town, located in the Mbaapen Council Ward of Buruku Local Government Area, Benue State, Nigeria. Geographically, it is positioned between latitude 7° 27′ 0″ N and 7° 28′ 30″ N, and longitude 9° 11′ 30″ E and 9° 12′ 45″ E. The floodplain is bounded by the River Katsina-Ala to the east and Buruku Town to the west, encompassing an area of approximately 87.28 hectares (See Figure 1).

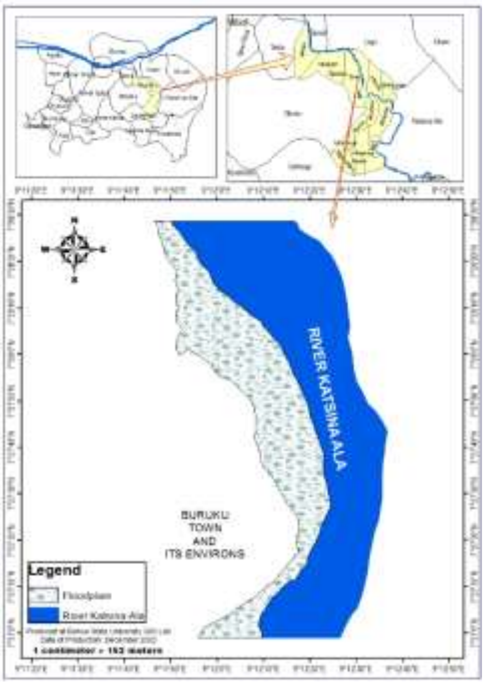

Figure 1 – Buruku Floodplain

The topography of the Buruku floodplain is characterized by its low-lying terrain, typical of riverine areas. The region features a network of water bodies, including the River Ambighir and River Amile, alongside numerous streams and ponds. The area also contains swampy sections and is marked by loose soil composition. The landscape is interspersed with patches of thick forest, reflecting the region's natural vegetation cover. Elevation within the Buruku area varies, with an average elevation of approximately 350 feet (106.7 meters) above sea level. Within a two-mile radius of Buruku, there is a maximum elevation change of 203 feet (61.9 meters). The topography becomes more varied over larger distances, with substantial elevation differences of up to 3,520 feet (1,073 meters) observed within a 50-kilometer radius (Nyagba, 1995).

Geologically, the Buruku floodplain is dominated by ferruginous soils. The soil texture in the River Katsina-Ala floodplain, which includes the Buruku floodplain, ranges from sandy to loam. Many locations are characterized by coarse, loose sand with lower aggregate stability. The soils are predominantly deep and sandy, with the dominance of sand particles reducing the influence of the clay fraction on physical and chemical parameters, thereby decreasing soil porosity (Nyagba, 1995). The floodplain's proximity to the River Katsina-Ala significantly influences its hydrological characteristics. The river's seasonal flooding patterns play a crucial role in shaping the floodplain's ecology and agricultural potential. The regular inundation contributes to the deposition of nutrient-rich sediments, enhancing soil fertility but also posing challenges for flood management and agricultural practices.

These geographical and topographical features of the Buruku floodplain contribute to its suitability for rice cultivation, as well as its vulnerability to flooding events. The low-lying terrain, proximity to major water bodies, and soil characteristics create conditions that are favourable for wetland rice cultivation but also increase the area's susceptibility to inundation during periods of heavy rainfall or upstream flooding.

The Buruku Floodplain, located in a tropical wet and dry climate (classified as Aw under the Köppen climate classification system), experiences two distinct seasons: a rainy season from late April to early October, and a dry season from November to March. The region receives an annual rainfall of 1000mm to 1300mm, with peak precipitation occurring in August and September, primarily in the form of violent convectional showers, which contribute to soil erosion (Tyubee, 2006; AOCAT Meteorological Station, 2016). The dry season is marked by significantly reduced rainfall and increased aridity. Temperatures remain consistently high throughout the year, with two annual peaks observed in late March and April, and relative humidity varies seasonally (AOCAT Meteorological Station, 2016).

The Buruku Floodplain is situated within the Guinea Savannah zone, but human activities such as urbanization and agriculture have altered the natural vegetation. The area is now dominated by artificially planted species, including mango, pawpaw, cashew, guava, and Gmelina trees, with remnants of the original savannah vegetation found in undeveloped areas. This shift reflects changing land-use patterns, particularly the transition from subsistence agriculture to more intensive farming practices. The floodplain's hydrological regime, characterized by seasonal rainfall and periodic flooding, supports wetland rice cultivation, which has become a significant agricultural activity in the region (Peel, Finlayson, & McMahon, 2007).

3. Methodology

This study adopted a mixed-methods research design, integrating both quantitative and qualitative approaches to gain a comprehensive understanding of the impact of the 2022 flooding on rice production in the Buruku floodplain. The mixed-methods design allows for the collection of numerical data, such as changes in rice outputs, and contextual insights, such as farmers' coping strategies and perceptions of flood impacts. The quantitative component involved the use of Geographic Information Systems (GIS) to map the extent of flooding and assess the spatial distribution of affected areas. Field surveys were conducted to collect structured data from a representative sample of 252 rice farmers, focusing on farm characteristics, production levels, and the extent of flood damage. The qualitative component involved semi-structured interviews with key stakeholders, including agricultural extension officers, community leaders, and farmers, to explore the socio-economic implications of flooding and the effectiveness of mitigation strategies. Focus group discussions (FGDs) were also conducted to capture collective community perspectives on flood management practices. The research design was carefully structured to ensure that the data collected addressed the key research questions, which included the extent of the flooding, its direct effects on rice production, and the coping mechanisms adopted by farmers. By combining quantitative measures with qualitative insights, this study offers a robust analysis that not only quantifies the flood's impact but also highlights the human and social dimensions of agricultural resilience in flood-prone areas. This approach is particularly important in understanding both the immediate effects of the flooding and the broader, long-term challenges faced by farming communities in the Buruku floodplain.

3.1 Data Collection

A structured questionnaire was developed to gather comprehensive data from rice farmers on the impacts of the 2022 flooding on their agricultural practices and livelihoods. The design of the questionnaire was carefully aligned with the study's objectives, ensuring that the questions were clear and directly relevant to the research focus. To facilitate accurate and consistent responses, a combination of structured questions was employed, allowing for standardized data collection while ensuring that farmers could provide detailed insights into their experiences. The questionnaire was specifically tailored for administration to rice farmers within the study area, with the goal of capturing both quantitative and qualitative information essential for the analysis. A total of 252 questionnaires were distributed through stratified random sampling to ensure representation across different farm sizes and proximities to the river, across the study area to ensure adequate representation and data reliability.

A Garmin GPS72 handheld Global Positioning System (GPS) device was employed to accurately capture the geographic coordinates of rice fields in the study area, ensuring precise spatial mapping of the areas affected by the 2022 flooding. This device enabled the researcher to systematically document the exact locations of submerged fields, facilitating detailed spatial analysis. In addition to GPS data, high-resolution satellite imagery was utilized to analyze the extent of flooding and its impacts on land use. Geographic Information Systems (GIS) and Remote Sensing tools were instrumental in this process, allowing for the visualization and analysis of spatial data layers. The integration of satellite imagery provided clear, high-resolution visual representations of the flood extent, which were crucial for assessing its impact on rice cultivation and surrounding land use. These tools allowed for the integration and overlay of multiple spatial data layers, greatly enhancing the study's ability to comprehensively evaluate the flooding's effects on rice production. By combining GPS data, satellite imagery, and advanced GIS analysis, this approach ensured a robust and thorough methodology, enabling a comprehensive assessment of the study's objectives.

3.2 Techniques for Data and Statistical Analysis

To accurately determine the extent of the 2022 flood, fieldwork was conducted using a handheld Global Positioning System (GPS) device to spatially sample and record the coordinates of locations identified by farmers as having been submerged during the flood. In each of the affected locations, both the geographic coordinates and the elevation above mean sea level were recorded. A total of 17 locations were sampled, as presented in Table 1. The average height above the mean sea level of the submerged areas was calculated to be 96.06 meters.

Table 1: Sample Elevations of Areas under water in Buruku Floodplain during the 2022 Flood

S/N	Latitude (Degrees)	Longitude (Degrees)	Height Above Sea Level (m)
1	7.45789	9.20414	93
2	7.45824	9.20411	97
3	7.45848	9.20397	96
4	7.45804	9.20458	97
5	7.45993	9.20388	96
6	7.46056	9.20410	95
7	7.46108	9.20369	95
8	7.46188	9.20320	94
9	7.46224	9.20311	94
10	7.46446	9.20279	95
11	7.46516	9.20253	95
12	7.45504	9.20527	95
13	7.45317	9.20373	96
14	7.45215	9.20188	99
15	7.45176	9.20132	99
16	7.45031	9.19959	100
17	7.44905	9.19852	97

To further analyze the flood extent, the collected GPS coordinates were first entered into Excel and subsequently exported into ArcGIS 10.7 software for spatial analysis. Using ArcGIS Geostatistical Analyst, the Empirical Bayesian Kriging model was applied to perform surface modeling, generating a flood extent surface for the 2022 flood event. This surface was then converted into a raster dataset for further analysis.

The statistical analysis employed in this study integrates various techniques to thoroughly assess the impact of the 2022 flooding on rice production in the flood plain of Buruku Town, Buruku Local Government Area, Benue State. Descriptive statistics, including the use of tables, frequencies, means, and medians, were applied to summarize and provide a clear depiction of key variables such as rice yield and other related factors. These techniques enabled the identification of trends and patterns in rice production before and after the flood event.

In addition, spatial analysis using Geographic Information Systems (GIS) was employed to visualize and quantify the extent of flooding and its effect on rice cultivation areas. This spatial analysis incorporated methods such as spatial interpolation to estimate flood coverage in areas where direct data was unavailable and overlay analysis to examine the relationship between flood extent and rice field locations. By integrating these spatial techniques, the study was able to provide a detailed, location-specific assessment of flood impacts on rice production, offering valuable insights into the geographic distribution of affected areas.

4. Discussion of Results

4.1 Demographic and Social Characteristics of Respondents

The demographic and social characteristics of the respondents, as shown in Table 2, reveal that the majority (44%) are between the ages of 30-39, followed by those aged 40-49 (28%), with smaller proportions in the younger (14%) and older (14%) age groups. The sample is predominantly male (70%) and largely married (60%), while widows make up 22% and singles 14%. Regarding educational qualifications, most respondents (60%) have a secondary education, with a smaller portion having tertiary education (18%), and a minority lacking formal education (6%). In terms of occupation, the vast majority (76%) are engaged in farming, while 24% are involved in trading. This data suggests a relatively young, male-dominated, farming population with moderate educational attainment.

Table 2: Demographic and Social Characteristics of Respondents

S/N	Items	Group	No of respondent	Percentage (%)
1	**Age Range**	18-29	35	14
		30-39	110	44
		40-49	70	28
		50 and above	35	14
		Total	**250**	**100**
2	**Sex**	Male	175	70
		Female	75	30
		Total	**250**	**100**
3	**Marital status**	Single	35	14
		Married	150	60
		Widow	55	22
		Divorce	10	4
		Total	**250**	**100**
4	**Educational Qualification**	No Formal Education	15	6
		Primary Education	40	16
		Secondary Education	150	60
		Tertiary Education	45	18
		Total	**250**	**100**
5	**Occupation**	Farming	190	76
		Trading	60	24

Total	**250**	**100**

4.2 Extent of 2022 Flooding in the Area

Table 3 provides an overview of the extent of the 2022 flood event on the Buruku floodplain. Of the total floodplain area of 87.28 hectares, 70.1 hectares, or 80%, were flooded, leaving only 17.18 hectares (20%) unaffected by the floodwaters. This demonstrates that the majority of the floodplain was severely impacted by the flood event, with significant implications for rice production and other agricultural activities in the region. The widespread flooding underscores the vulnerability of the Buruku floodplain to such events, highlighting the urgent need for flood mitigation strategies and better preparedness measures to protect agricultural land and minimize damage during future floods. The high percentage of flooded areas emphasizes the scale of the disaster and the extent of the challenge faced by local farmers in mitigating the impacts on their livelihoods.

Table 3: Extent of 2022 flood event on Buruku Floodplain

Responses	**Area in hectares**	**Area %**
Flooded Area	70.1	80
Unflooded Area	17.18	20
Total Floodplain	**87.28**	**100%**

4.3 The Effect of 2022 Flooding on Rice Production in Buruku Floodplain

Table 4 provides insights into the relationship between farm size and rice production before and in 2022 among farmers in the Buruku Floodplain. The data indicates that 55% of respondents cultivate farms ranging from 0.6 to 1 hectare, producing the highest total number of bags before 2022 (4,500 bags) and a significant decline to 1,500 bags in 2022, resulting in a mean of 12 bags per farmer. Conversely, those with less than 0.5 hectares produced 750 bags before 2022 but saw a drastic reduction to just 125 bags in 2022, with a mean production of only 2.5 bags. Farmers with larger plots (1.1-1.5 hectares) initially produced 2,400 bags, decreasing to 800 bags in 2022, while those with 1.6-2 hectares reported a sharp decrease from 16,500 bags to 313 bags, showing a mean production of 660 bags. Overall, the data highlights a notable decline in rice production across all farm sizes from before 2022 to 2022, underscoring the challenges faced by farmers in the Buruku Floodplain during this period.

Table 4: Farm Size and number of bags of rice produced before and in 2022 by Farmers in Buruku Floodplain

Size of Farm	**Frequency**	**Percentage (%)**	**Number of Bags Before 2022**	**Number of Bags in 2022**	**Mean Number of Bags Before 2022**	**Mean Number of Bags in 2022**
< 0.5 Hectares	50	20	750	125	15	2.5
0.6-1 Hectares	125	55	4500	1500	36	12
1.1-1.5 Hectares	50	29	2400	800	48	16
1.6-2 Hectares	25	11	16500	313	660	12.52
Total	250	100	24150	2738	-	-

4.4 Distance of Rice Farms from the River in Buruku Floodplain

Table 5 illustrates the distribution of rice farms in the Buruku Floodplain based on their distance from the river. The data reveals that 55% of the farms are situated between 51-100 meters from the river, representing the largest proportion of respondents. This is followed by farms located within the 0–50-meter range, comprising 20% of the total, while 29% of farms are between 101-150 meters away, and only 11% are located 151-200 meters from the river. The results indicate that a significant number of farmers position their fields relatively close to the river, likely for easier access to water resources, which is essential for rice cultivation. Overall, the proximity of the farms to the river may play a critical role in agricultural practices and production outcomes in the region.

Table 5: Distance of Rice Farms from the River in Buruku Floodplain

Distance	Frequency	Percentage %
0-50m	50	20
51-100m	125	55
101-150m	50	29
151-200m	25	11
Total	**250**	**100%**

4.5 Coping Strategies Adopted by Rice Farmers for the Future

Table 6 presents the coping strategies adopted by rice farmers for the future, highlighting their responses to challenges faced in rice cultivation. The most common strategy is early harvesting, employed by 30% of farmers, indicating a proactive approach to mitigate the risks associated with unfavorable weather or flooding. Relocation to higher ground follows closely at 25%, suggesting that many farmers are willing to move their operations to more secure areas to protect their crops. Temporary embankments or levees are utilized by 20% of farmers, demonstrating an effort to create physical barriers against flooding. Diversification of income sources is adopted by 15% of farmers, reflecting a strategy to reduce reliance on rice farming alone. Lastly, 10% of farmers rely on social networks and community support, emphasizing the importance of collaboration and mutual aid in overcoming agricultural challenges.

Table 6: Coping Strategies Adopted by Rice Farmers

Coping Strategy	Percentage of Farmers
Early Harvesting	30
Relocation to Higher Ground	25
Temporary Embankments/Levees	20
Diversification of Income	15
Social Networks/Community Support	10

Overall, these strategies indicate a varied and adaptive response among farmers as they seek to sustain their livelihoods in the face of environmental uncertainties.

5. Conclusion

The study on the effects of the 2022 flooding on rice production in Buruku Town's floodplain underscores the significant challenges that floods pose to agricultural livelihoods and community resilience. The research findings indicate substantial post-harvest losses caused by flood-related damage, highlighting the urgent need for proactive strategies to mitigate these impacts and enhance agricultural resilience. Farmers in the area employ a range of adaptive coping mechanisms, including early harvesting, the construction of temporary embankments, and income diversification, demonstrating their resourcefulness and community solidarity in responding to flood risks. The study stresses the importance of tailoring adaptation strategies to the specific socio-economic and environmental contexts of flood-prone agricultural communities. This approach is critical to effectively addressing the unique vulnerabilities and needs of such populations. The insights gained from this research offer valuable recommendations for policymakers, agricultural stakeholders, and local communities, aiming to bolster resilience and promote sustainable agricultural practices in regions susceptible to flooding.

A multi-faceted approach—incorporating technological innovation, community empowerment, and robust policy support—is crucial for building resilient agricultural systems and fostering thriving communities in flood-prone areas. Translating these findings into actionable steps and investments is essential to protect vulnerable populations and ensure long-term agricultural productivity and sustainability. Through coordinated efforts and strategic planning, the challenges posed by recurrent flooding can be mitigated, leading to a more resilient and prosperous future for the region.

6. Recommendation

Based on the findings of this study, the following recommendations are proposed to mitigate the impact of flooding on rice production in the flood plain of Buruku Town, Buruku Local Government Area, Benue State, Nigeria:

I. Farmers should be encouraged to adopt flood-resistant rice varieties capable of withstanding prolonged submersion. These resilient varieties will reduce crop loss during flooding events. Agricultural extension services should be enhanced to educate farmers on the benefits, cultivation practices, and long-term advantages of these varieties to improve adoption rates and resilience to future flooding.

II. There is an urgent need for government intervention to improve flood management infrastructure within the rice-producing areas. This includes the construction of levees, dikes, and drainage systems that can help mitigate the severity and frequency of flooding. Such infrastructure would significantly reduce the vulnerability of rice production to seasonal floods, contributing to increased crop yields and economic stability for local farmers.

III. Strengthening early warning systems is crucial for enabling farmers to take timely action in response to potential flooding. These systems should provide accurate, real-time information, allowing farmers to adjust planting schedules, evacuate crops where possible, and implement other flood-preventative measures. The use of mobile technology and local broadcasting channels can enhance the reach and effectiveness of these systems.

IV. Encouraging crop diversification is essential to mitigate the risk of total crop loss due to flooding. Farmers should be educated on the benefits of integrating other flood-tolerant or drought-resistant crops alongside rice. This approach will not only provide a buffer against flood-related losses but also improve food security and income stability within the region, reducing farmers' overall vulnerability to environmental hazards.

V. Establishing financial support mechanisms, such as crop insurance and emergency relief funds, is critical for helping farmers recover from the adverse effects of flooding. These mechanisms would provide a safety net, enabling farmers to resume agricultural activities more rapidly after a flood. Government and private sector collaboration can facilitate the development of these financial systems to ensure they are accessible and effective in addressing the needs of affected farmers.

VI. The role of agricultural extension services should be reinforced to provide continuous education and support to farmers, particularly in areas of improved farming techniques, flood-resistant crop varieties, and disaster preparedness. Extension agents should serve as a link between research institutions and farmers, ensuring the latest agricultural innovations are accessible to local farmers for more sustainable rice production in flood-prone areas.

VII. The establishment of community-based flood management initiatives would empower local communities to take collective action against the challenges posed by recurrent flooding. These initiatives could facilitate knowledge-sharing, resource mobilization, and coordinated efforts to protect farmlands from the impact of floods. Community engagement in flood management is vital for fostering resilience at the grassroots level, ensuring the long-term sustainability of rice production in the region.

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