

Exploring the Role of Indigenous Knowledge in Enhancing Crop Resilience to Climate Change in Southern Katsina

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ABSTRACT

The study aimed at exploring the role of indigenous knowledge in improving crop yield adaptation and productivity. The data were collected through a structured interview by systematically selecting 120 respondents from six out of eleven local government areas of Katsina South. The result shows that 80% of the respondent are males aged between 46 to 55 years with 21 and above years of farming experience. Also, 25% of the respondent noticed decrease in the total amount of rainfall received annually. This reduction has direct impact on agricultural activities in the region. The result shows that indigenous knowledge provides local farmers with forecasting/understanding of the amount of rainfall, the onset, and the types of crops to cultivate in the coming rainy season. The study also revealed that 83.3% of the respondents utilize indigenous knowledge to climate change impact and 75% of them find it effective. 86.7% of the respondent practice Modern farming. The study also revealed that local farmers used traditional weather forecasting, mixed farming, water management, seed saving, knowledge sharing, etc., to reduce the effect of climate change on crop yield. Also, the study reveals the indicators that improve high yield, such as the coming of 'Ganzari', a larval stage of an insect development that feeds on the leaves of the plant. This occurs when there is a short drought after planting, but after the short drought, the plant will regenerate. The study concluded that, local farmers possess a wealth of traditional knowledge that has been honed over generations, enabling them to adapt to environmental changes and sustain their crop yields.

Keywords: Indigenous knowledge, Climate Change, Adaptation, Crop Yield.

1. INTRODUCTION

As the global population continues to increase, ensuring food security becomes a critical challenge, especially in developing countries like Nigeria. Estimates suggest food production needs to be increased by 50% by 2030 and 70% by 2050 to meet basic human needs (Allen et. al. 2011, Mba 2013, Tester and Langridge 2010). Climate change poses significant challenges to crop yield, threatening global food security and livelihoods. According to Ray et al. (2019), climate change has resulted in varying impacts on global food production, with reductions in consumable food calories averaging

1% and affecting nearly half of food-insecure countries, with oil palm experiencing a 13.4% reduction and soybean 3.5%. These challenges manifest in various ways, impacting crop growth, productivity, and quality, and are exacerbated by factors such as rising temperatures, changing precipitation patterns, increased frequency of extreme weather events, and shifts in pest and disease dynamics.

Recent studies suggest that yields have already been impacted, crop yields decrease under future climate conditions (Ray et al. 2019). These issues collectively contribute to reduced agricultural yields, crop failures, and economic losses,

particularly in vulnerable regions with limited adaptive capacity and resources to cope with climate variability and change (Hatfield et al., 2011). Changing precipitation patterns and increasing variability in rainfall present a substantial obstacle to crop yield under climate change, disrupting planting schedules, water availability, and soil moisture levels, ultimately affecting crop growth and yield (Porter et al., 2014; Lobell et al., 2011; and Chakraborty and Newton, 2011).

Climate change also influences the dynamics of pests, diseases, and weeds, posing additional challenges to crop yield and agricultural productivity. Nyadzi and Ajayi (2021) view local farmers as victims of climate change impact rather than agents of adaptation. The primary means of increasing the resilience of crops is through increasing and stabilizing the main factors influencing the quality of farm produce (FAO 2015).

practices, IK holds the potential to complement and enrich conventional adaptation strategies, particularly in the context of the state's agrarian economy and vulnerable rural communities. There is under recognition and under documentation of indigenous knowledge role in crop resilience to climate change in Katsina state. Based on these problems stated, this research intended to provide an empirical study that measure improvement in crop resilience, as well as the lack of frameworks for integrating practices with modern climate-smart agriculture.

The aim of this study is to explore the role of IK in climate change adaptation and crop yield improvement in Katsina South. The study answered the question of what are the traditional farming practices and IK system used by local farmers to adapt to climate change and improve crop yields?

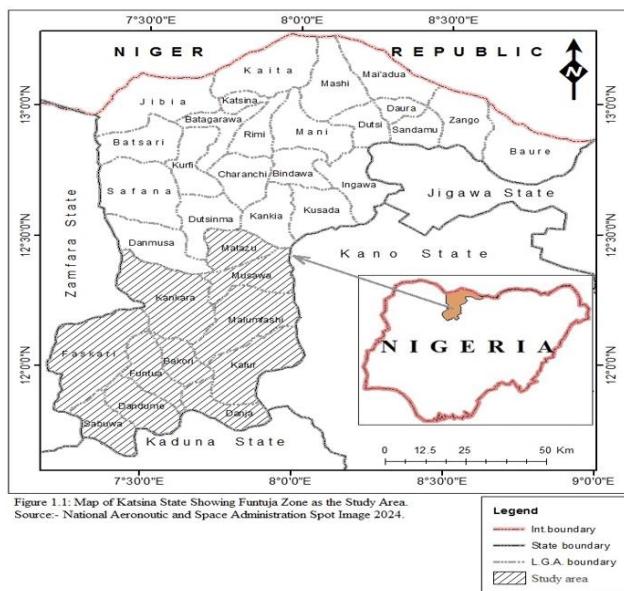


Figure 1.1: Map of Katsina State Showing Funtua Zone as the Study Area.
 Source: National Aeronautic and Space Administration Spot Image 2024.

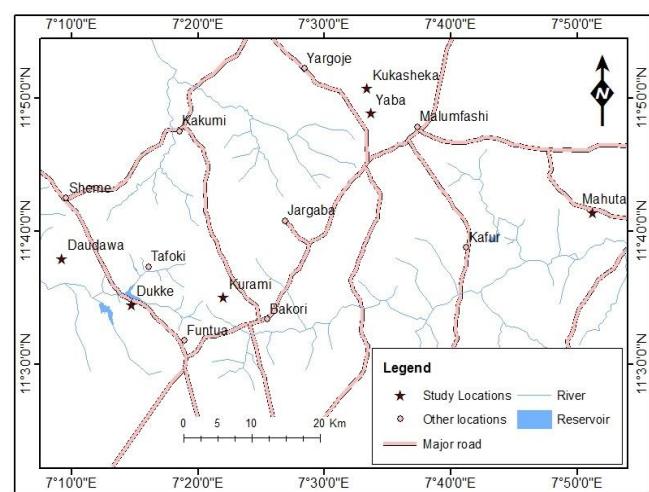


Figure 1.2: Map of Funtua Zone Showing Study Locations.
 Source: National Aeronautic and Space Administration Spot Image 2024.

Individual farmers adopt measures to adapt to the climatic influence on crop yield. Muller and Elliott (2015) found out that adaptive changes in crop management have the potential to increase yields by 7-15%. Warmer temperatures and altered precipitation patterns can favour the proliferation of pests and pathogens, leading to increased pest pressure, disease outbreaks, and crop damage. Indigenous Knowledge (IK) offers a potent tool for addressing the challenges of climate change. In this context, harnessing indigenous knowledge offers valuable insights for adapting agricultural practices to changing climatic conditions. Smith et al. (2022) posit that indigenous people have developed resilient agricultural techniques over generations, rooted in a deep understanding of the local ecosystem. Integrating this knowledge with modern agricultural practice can enhance crop yields and foster sustainable adaptation strategies (Garcia et al. 2023). With its deep roots in local traditions and

2. MATERIALS AND METHODS

Katsina South is situated in the southern part of Katsina state, known as Funtua senatorial Zone, in the North-western region, bordering Kano to the east, Kaduna to the South, and Zamfara to the West (see Figure 1). The Zone is located between latitudes $11^{\circ}30'N$ to $12^{\circ}30'N$ and longitudes $6^{\circ}45'E$ to $8^{\circ}15'E$. Katsina South is one of the three senatorial districts in the state, comprising 11 Local Government Areas, which include Funtua, Bakori, Danja, Dandume, Faskari, Malumfashi, Musawa, Matazo, Kafur, Kankara, and Sabuwa. The population of the region is approximately 2.5 million people (based on a 2023 estimate, mainly comprising Hausa and Fulani). The climate of the region was characterized by high temperatures up to $40^{\circ}C/104^{\circ}F$ during the dry season and low temperatures around $20^{\circ}C/68^{\circ}F$ during the rainy season and Harmatan. The annual rainfall of the

region is approximately 800 to 1000mm of rainfall (31-39 in) Sulaiman, Abdullahi, and Salisu 2020).

The data obtained from this study consists of both primary and secondary sources. The data on demographic characteristics of the farmers and farmers' Indigenous knowledge farming practice, general knowledge on climate change, effect of climate change on crop yield, climate change adaptive strategies, and integration of IK and Modern farming techniques were obtained through a structured questionnaire. However, secondary data, including a map of the study areas, population figures of farmers, and data regarding agro-climate relationships, were obtained from the Katsina State Ministry of Agriculture and Rural Development.

Table 1. Sample size

Local Govt. Area	Locality	Farmers population	Sample size
Funtua	Dikke	850	24
Bakori	Kurami	750	20
Faskari	Daudawa	650	18
Kankara	Kukasheka	350	14
Malumfashi	Yaba	450	16
Kafur	Mahuta	1200	28
Total		4250	120

Source: Field survey 2024

Six out of eleven LGAs in the study location were randomly selected, three localities were systematically selected from the six LGAs selected, the number of respondents chosen in each locality was based on its population size. Research assistants were used during the data collection. Thus, it was assumed that farmers in the same region would face similar problems and would likely benefit from the same set of solutions. The number of questionnaires administered in each locality is shown in Table 1. Systematic random sampling was used for questionnaire administration. The first farmer was randomly selected from the list of farmers in each of the selected localities, after which, every tenth farmer was selected.

Semi-structured questionnaires with open-ended and closed-ended questions were used to get information on the contribution of farmers farming practice to climate change adaptation, traditional crop varieties, and the integration of IK and modern farming techniques. For example, what are the effect of climate change on crop yield?

An in-depth interview was held in each of the six villages using purposive sampling method. Twelve (12) different interviews were conducted in the localities visited. The interview is aimed at balancing the information derived from questionnaire administration with a view of getting a consensus and developing a generalization on the use of IK in climate change adaptation in each village. Age, gender, farming experience, and farm size were used to consider the participants as these

factors are believed to affect variation in traditional knowledge in communities (Mogotisi et al., 2011)

3. RESULT AND DISCUSSION

3.1 Demographic characteristics

The table below shows demographic characteristics of the respondent (120) questionnaires were administered. (80%) of the respondents are males with (20%) women across age groups varied, with the 36-45 age groups constituting the highest proportion at (28.3%), followed closely by the 46-55 age groups at (30%), with (21.1%) of the respondents are above 55 years. This age group likely holds valuable IK about past climate patterns and traditional practices that could be useful for adapting to current and future climate changes. From the result, it indicated that the majority of the farmers who own farms are male, representing (80%) with only (20%) women. The representation of gender in the study is within various age groups. The farming experience of respondents was categorized into four groups based on the number of years (table 2). The distribution of respondents across these experience levels varied, with the highest proportion of respondents (25%) having 6-10 years of farming experience. This was followed by 1-5 years (21.6%). The distribution of farming experience can influence the utilization and transmission of indigenous knowledge. Respondents with longer farming experience may possess a deeper understanding of traditional farming practices and indigenous knowledge systems, which can be valuable for climate change adaptation. The proportion of respondents owning farms of 1-4 hectares (ranging from 26.7% to 28.3%). However, a smaller proportion (16.7%) of respondents owned farms of 5 hectares and above.

The main crops cultivated by respondents were examined to understand their potential impact on agricultural practices and adaptation strategies. Table 2 shows the main crops cultivated by respondents which are classified into three categories: food crops, cash crops, and tuber crops. The distribution of respondents cultivating each type of crop varied, with the majority of respondents (100%) cultivating food crops, followed by cash crops (86.7%) and tuber crops (41.7%). The main crop cultivated can influence the utilization and transmission of indigenous knowledge (Smith et al., 2020).

Traditional farming practices and IK systems vary depending on the type of crop cultivated, with different crops requiring specific knowledge and techniques for cultivation, pest management, and soil conservation. The choice of main crop cultivated can impact the selection and effectiveness of climate change adaptation strategies (Adger et al., 2005). Farmers cultivating diverse crops may have greater resilience to climate variability and extreme weather events. Lobell et al., (2011) posit that Food crops may be prioritized for subsistence and

nutritional security, whereas cash crops may contribute to household income and livelihood diversification. Tuber crops can also provide important dietary staples and income sources for farmers.

Table 2 Demographic Characteristics

Demography	Respondents	Percentages
Age Distribution	Age group	
	18-25	10
	26-35	10
	36-45	28.3
	46-55	30
Gender	56 and above	21.1
	Male	80
	Female	20
Farming Experience	Years	
	1-5	21.6
	6-10	25
	11-15	05
	16-20	11.7
Farm Size	21 and above	36.7
	Hectare	
	< 1	26.7
	1-2	28.3
	3-4	28.3
Main Crop Cultivated	5 and above	16.7
	Crops	
	Food crops	100
	Cash crops	86.7
	Tuber crops	41.7

Field survey 2024

Table 3 shows the responses obtained on change in rainfall patterns, a significant majority (91.7%) of respondents reported being aware of changes in rainfall patterns. This finding underscores the widespread recognition of climate change impacts, particularly alterations in precipitation regimes, within the agricultural community in Katsina (Ibrahim and Musa, 2024). Such awareness is essential for fostering proactive responses and adaptation strategies to mitigate the adverse effects of climate variability and extremes on agricultural production and livelihoods (Abdullahi, et al. 2023). Increased awareness of changes in rainfall patterns can inform the selection and implementation of climate change adaptation strategies. The survey shows that (25%) of the respondents said there is decreased in total annual rainfall received in the area, about (20%) and (16.7%) of them said there is a shift of rainfall distribution, erratic rainfall pattern and delay onset or early cessation of rainfall in the last few years.

25% of the respondents reported a noticeable decrease in the total amount of rainfall received annually. This reduction in overall precipitation

levels may result in prolonged dry periods and water scarcity, impacting agricultural activities and water availability for crops and livestock (Benestad, 2018, Norris, Allen, Evan, Zelinka, O'Dell, et al. 2016). Also, shift in the distribution of rainfall throughout the year. Pendergrass, and Hartmann, (2014) said this could involve changes in the timing, intensity, and duration of rainfall events, leading to irregular patterns of precipitation. Such shifts may disrupt traditional cropping calendars and necessitate adjustments in farming practices, Kurniadi, Weller, Salmond, and Aldrian, (2023). Increase in the frequency and severity of extreme weather events, such as heavy rainfall, storms, and floods. These events can cause soil erosion, crop damage, infrastructure destruction, and loss of life and property, posing significant challenges to agricultural resilience and disaster management, Smith, Khoday, and Kala, (2020).

Table 3 Climate Change Pattern

	Responses	Percentage
Awareness in Changes of rainfall pattern	Yes	91.7
	No	8.3
Changes in the Rainfall pattern	Decreased total annual rainfall	25
	Shift of rainfall distribution	20
	Erratic rainfall pattern	16.7
	Delayed onset or early cessation of rainfall	16.7
	Changes in Seasonal Rainfall Variability	8.3
Effect of changes on crop yield	Increased Frequency of Extreme Weather Events	13.3
	Total Damage	3.3
	Low Yield	50
	Moderately High yield	26.7

Field survey 2024

Erratic rainfall may lead to challenges in crop planning, irrigation scheduling, and water resource management, making it difficult for farmers to predict and adapt to changing environmental conditions (Abaje, Ogoh, Amos, and Abashiya, 2015). Also, a few respondents mentioned delays in the onset of rainfall at the beginning of the rainy season or premature cessation of rainfall towards the end of the season. Kane, Tahir, and Rabe (2023) said there is a shift in rainfall timing. This can disrupt planting and harvesting schedules, affecting crop growth stages and yield potential. Respondents observed alterations in the variability of seasonal rainfall patterns, with some seasons experiencing more pronounced dry spells or wet periods than in the past. These changes may influence cropping decisions, crop selection, and risk management

strategies in agricultural production systems (Abdullahi, et al. (2023)).

3.2 Effects of Changes in Rainfall Patterns on Crop Yield

Changes in rainfall patterns can have significant implications for crop yield, affecting agricultural productivity and livelihoods. The respondents were asked about the effect of changes in rainfall patterns on crop yield, providing valuable insights into the impacts of climate change on agricultural production. 50% of respondents reported that they experience low yields as a result of changes in rainfall patterns. Akinbile, Akinlade, and Abolude (2015) reported that low rainfall affects the yield of rice produced in Nigeria. While only 20% of respondents reported that climate change does not affect yields, they cultivated every year. This is because they normally utilize their farming experience. Lv, et al. (2013) said climate change has impacts on wheat yields in China.

Table 4: Indigenous Knowledge Practice

	Responses	Percentage
Utilization of IK to adapt CC	Yes	83.3
	No	16.7
Period of using IK practice		
1-5	26.7	
6-10	23.3	
11-15	20	
16 and above	30	
Effectiveness of IK practice		
Very effective	75	
Somewhat Effective	20	
Not Effective	05	
Farming practice		
Mixed Farming	60	
Water Management Techniques	35	
Soil Conservation	20	
Traditional Weather Forecasting	20	
Seed saving and Exchange	20	
Community Based Adaptation	10	
Knowledge Sharing and Learning	15	

Field survey 2024.

3.3 indigenous Knowledge

(83.3%) of respondents acknowledge that they utilize Indigenous Knowledge for climate change adaptation. Indigenous communities have developed a sophisticated appreciation of local ecosystems and climatic patterns (Green, Billy and Tapim, 2010).

This knowledge is often transmitted orally from generation to generation, reflecting a holistic worldview that integrates environmental, social, and spiritual dimensions. Also, the survey on traditional farming practices shows that farmers use traditional farming methods to adapt to a changing climate, 60% of respondents reported using mixed farming practices, 35% of respondents employ traditional soil conservation practices like contour ploughing or mulching. (20%) of respondents utilize traditional water management techniques, predict weather patterns, Seed saving and Exchange. Others include Community Based Adaptation, Knowledge Sharing and Learning.

Farmers who have been practicing local knowledge in their farming activities for 11-16 years and above are (20% and 30%) respectively, these individuals and communities have accumulated extensive experience and wisdom, resulting in sustainable agricultural systems characterized by high productivity, biodiversity conservation, and resilience to climate change impacts (Turner et al., 2008). While short-term impacts on crop yield may vary, initial benefits may include improved soil fertility, enhanced pest management techniques, and diversification of crops. However, the full potential of IK may not yet be realized within this timeframe (Porter et al, 2014).

Table 6: Integration with Modern Techniques

	Responses	Percentage
Awareness of modern techniques	Yes	86.7
	No	13.3
Use of the practice		
Yes	76.7	
No	23.3	

Field survey 2024

From the table 6 (86.7%) of the respondent are aware of modern farming techniques and (76.7%) are practicing modern farming techniques. Some example of modern farming techniques they practiced include modern seedling like soya beans, herbicide and pesticide, using modern implement like tractors etc. (Doss et, al 2018). The result shows how farmers combine IK and Modern farming techniques for climate change adaptation through crop diversification, Soil conservation and integrating trees into agricultural landscapes to provide shade, improve soil health, and create habitat for beneficial organisms (Lipper et, al. 2014, Nelson et, al. 2018).

The interview result shows that 35% of the farmers do not believe in climate change but rather attribute these changes to variations from time to time because there are differences between western and traditional counting of days in a year. Local farmers posit that they rely on the movement of moon and

Table. 5 Indigenous Knowledge Practice

S/N	Domain	Indigenous Knowledge	Description
1	Rainfall Prediction	Moon/Stars Movement, behaviour of animals (frogs, birds, ants etc) and sporadic from some specific trees.	Wind and stars movement, change in the behaviour of some animals and blooming of trees are used to predict rainfall onset and end of rainy season.
2	Crop prediction High yield	Appearance of morning stars for 7-8-month, insect (Ganzari), high fruiting and heavy harmattan dust.	Local farmers believe that appearance of morning stars for 7-8 month indicate high amount of rainfall, coming out of unusual insect (ganzari) and high fruiting from trees indicate high yield.
		Too much Appearance of rainbow, morning stars appears 2-3 months only and low fruit from trees.	Farmers believe that Constant Appearance of rainbow and stars for 2-3 month only indicate low rainfall that leads to low yield.
3	Crop Management	Indigenous crop rotation techniques, mix-farming and intercropping techniques.	Local Farmers has their own system of crop management through crop rotation, mix species based on ancestral knowledge to maintain soil fertility.

Source; Adapted from (Abdulrashid, 2020; Abdullahi 2023; Rankoana, 2022)

stars to differentiate between the seasons despite the fact that NIMET and other metrological agencies predict rainfall onset and session. This is because there is some limitation in the accessibility and communication gaps, faith, distrust in government etc. Therefore, farmers in northern Nigeria continue to rely on traditional rainfall prediction because they found them more accessible, culturally trusted and locally relevant than official forecast from agencies. They said Each season has seven (7) stars and each star spends 13 days before it disappears, only (*Harsan*) has 14 days among the stars during the dry season. Therefore, there are four seasons in a year rainy season (*Damina*) for example rainy season has the following stars (*Sarfu, Ewa, Shimako, Guhuru, Zabanana, Ikilili and Kalba*) others from the remaining seasons are (*Haka'a, Hana'a, Zira'a, Darfa, Nasara, jabaha, harsan*). They use these stars in forecasting when the rainy season will start, plus the other indicators, and as soon as these stars (*Sarfu*) appeared, we started preparation for this year's rainy season and planted immediately when the rain falls. The farmers have reported how they forecast the forthcoming rainy season using indicators, for example, *Adasonia digitata* (*Kuka*) is one of the important plants used as indigenous early warning indicators for rainfall occurrences in all the places visited (Abdulrashid 2020).

Table 7: indicators for high crop yield and Drought

Indicators	Prediction
Harmattan dust	High crop yield
High fruiting trees	High crop yield
Low fruiting trees	Low yield
Frequent appearance of a rainbow	Low yield
High temperature and heavy/dark cloud	Heavy rainfall destroys crops
Morning star (surayya) for 7-8 months	High crop yield
Morning star (surayya) for 2-3 months	Low yield
Insect (Ganzari)	High yield

Source: Adapted from Abdulrashid (2020)

The trees shed their leaves at the end of the long rainfall season and remain leafless during the long dry season. The communities also use the fruiting pattern of trees like mango (Abdulrashid 2020 and Mogotisi et al 2011).

Knowing the time when the rainy season will probably begin will help you to plant seeds that are within the time frame, we normally expect rainy season when the movement of wind changes from East to West, trees spore, toad noise, and movement of birds, etc. Rainfall mostly lasts for ninety to one hundred days in this area, usually from the last quarter of June to early October every year, so we plant our seed from June to July. Also, during the rainy season at the beginning, we experience a short drought which lasts for two to three weeks. During this period, the crop faces a lot of challenges, for example, there is a coming of a larval stage of insect development called (*Ganzari*) that eat almost all the leaves of the plant, but when the rain comes back, the plant normalizes and the farmers expect high yield. In addition, Harmattan dust has a direct impact on the fertility of the soil, Breuning-madsen therefore, the farmers believe that the higher the amount of dust received during Harmattan the higher the yield. Science believes that the harmattan dust from *sahara* desert contain phosphorus good for plant growth. Frequent experience of rainbow show that there will be a low yield, also, appearance of morning start called *surayya* for 7 to 8 months can lead to high crop yield, while disappearance of it (morning star) for 2 to 3-month result in drought. Lastly high temperature and heavy cloud result in heavy rainfall which destroy crops and lead to low yield. These correspond with account given by the communities as reported by Abdurrashid, (2020), and Ajibade and Eche (2017) in Nigeria, Iticha and Husen (2015) in Ethiopia, Okoya et al., (2017) in Uganda.

4. CONCLUSION

Indigenous knowledge plays a crucial role in climate change adaptation strategies, particularly in agricultural practices within Katsina South. The local farming communities possess a wealth of traditional knowledge that has been honed over generations, enabling them to adapt to environmental changes and sustain their crop yields. These indigenous practices include the use of drought resistant crop varieties, traditional irrigation techniques, soil fertility management, and the timing of agricultural activities with seasonal patterns. By

integrating this valuable knowledge with modern scientific approaches, there is significant potential to enhance the resilience of agricultural systems to the adverse effects of climate change. Thus, leveraging indigenous knowledge not only preserves cultural heritage but also offers practical solutions for sustainable agriculture in the face of climate variability.

Recommendations

1. Efforts should be made to integrate indigenous knowledge with contemporary modern techniques through Collaborative programs that can help develop hybrid practices that maximize crop yield and resilience to climate change.
2. Community Collaboration could foster greater involvement in the development and implementation of climate adaptation strategies.
3. Indigenous knowledge practices should be combined with climate smart agriculture to promote approaches that foster crop resilience and increase soil fertility rather than replacing indigenous knowledge.
4. Community workshops should be organized to strengthen knowledge transfer between older and younger farmers

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