



Quantitative ethnobotany of Afenmai people of Southern Nigeria: an assessment of their crop utilization, and preservation methods

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Abstract The study assessed crop utilization, preservation, and conservation methods in six local government areas (LGAs) that make up Afenmai land in Southern Nigeria. The Afenmai people use a total of 36 economic crops belonging to 20 higher plant families. Among these crops, only eight are used in all the LGAs that make up Afenmai including *Amaranthus hybridus*, *Dioscorea rotundata*, *Ipomoea batatas*, *Musa paradisiaca*, *M. sapientum*, *Talinum triangulare*, *Telfairia occidentalis*, and *Vernonia amygdalina*. The similarity in crop utilization patterns within

Afenmai land using Jaccard's index ranged from 38.24 to 100. The plants are mostly used fresh immature, fresh mature, processed immature, and processed mature. The highest use report of 481 was recorded from *V. amygdalina* whereas *Saccharum officinarum* had the lowest number of use report of 41. In addition, the results from the cultural value index analysis suggest *V. amygdalina* has the highest cultural value (0.38) whereas *A. hybridus*, *Mangifera indica*, *Ocimum gratissimum*, *S. officinarum*, *Theobroma cacao*, and *Zea mays* had the lowest value (0.01). The use category rank was in the order food > medicine > ornamental > others > building > religious and cultural. Individual crop ranking revealed *Cocos nucifera* > *Elaeis guineensis* > *T. occidentalis* and *T. cacao* as the 36th-ranked crop. Crops are stored using diverse traditional systems for periods ranging from less than a month to less than two years depending on the crop. Respondents believe traditional preservation methods either improve taste, make the taste worse, or are not sure of the benefits. In conclusion, there is a need for advocacy and public enlightenment campaigns to promote value-addition and sustainable post-harvest crop management in Afenmai land.

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Introduction

Crops are vital to agricultural ecosystems, fulfilling diverse human and animal needs and serving distinct roles in various categories, including food, fiber, feed, medicine, industrial, ornamental, and oil crops (Osawaru et al. 2014; Crop Science Society of America, 2022; Ogwu 2023). For the Afenmai people of Southern Nigeria, these crops support essential aspects of daily life and cultural heritage. Plant use categories is a central concept in ethnobotany that is used to classify plants based on their specific applications within human societies, such as food, medicine, fiber, and cultural use, reflecting the diverse ways communities interact with and depend on their natural environments (Cunningham 2001; Martin 2004). Food crops, such as grains and vegetables, are fundamental to human nutrition, while fiber crops like hemp and cotton are indispensable to textile production due to their durable, versatile fibers (Barbosa de Lima et al. 2020; Charles-Rodríguez et al. 2007; Osawaru and Ogwu 2020). Feed crops, essential for livestock, may be grown intentionally or occur naturally in pastures, offering varied feeding strategies such as green chop, hay, and silage (Roselló-Soto et al. 2018; Christiansen et al. 2020). Industrial crops like rubber play a significant role in sectors like healthcare by providing latex (Gharibi et al. 2020; Wurlitzer et al. 2019), while oil crops such as corn, canola, and soybean serve both dietary and industrial functions. Furthermore, ornamental crops hold cultural and economic value, especially in developing regions where they support national identity and local economies (Mobolade et al. 2019; Ng'ang'a et al. 2016). In the Afenmai land, roots, leaves, stems, and other plant parts are not only valuable for their utility but also hold economic and medicinal importance. Plants like *Vernonia amydalina* (bitter leaf), *Amaranthis* sp. (greens) and *Ocimum* sp. (scent leaf) are integral to traditional medicine, providing affordable healthcare solutions (Osawaru et al. 2016; Ogwu et al. 2017, 2018, 2023a, b). Additionally, some of the plants like *Musa* sp. are cultivated as sources of income. These practices highlight the diverse roles of crops in supporting both human health and livelihood within communities in Afenmai land, underscoring their cultural and economic significance. This study evaluates how the Afenmai community utilizes these crop categories, explores traditional methods of preservation and

conservation, and assesses strategies to maintain crop biodiversity, aligning with sustainable agricultural practices within their unique cultural framework.

The decline in global crop biodiversity poses a significant threat to global food security and agricultural sustainability (Meijaard et al. 2024). As agricultural practices have intensified over the years, particularly with the rise of monoculture farming, the diversity of cultivated plant species has diminished. This loss of biodiversity not only reduces the genetic pool available for breeding resilient cultivars but also compromises the ecosystem services that diverse agricultural systems provide. For instance, diverse cropping systems can enhance soil health, improve pest control, and increase resilience to climate change (Sufiyan 2022; Montoya et al. 2021). The erosion of crop biodiversity limits the ability of agricultural systems to adapt to changing environmental conditions, making them more vulnerable to pests, diseases, and climate variability (Aizen et al. 2009; Tamburini et al. 2020). Furthermore, the reliance on a narrow range of crop species for food production increases the risk of food insecurity, as any disruption to these key crops can have widespread consequences for nutrition and livelihoods (Tamburini et al. 2020; Obahiagbon and Ogwu 2023, 2024).

The conservation of plant genetic resources (PGR) for food and agriculture is critical for sustaining global food security and biodiversity. Initiatives like the Svalbard Global Seed Vault, which houses over a million seed samples, underscore the importance of preserving plant diversity to ensure future food security (Mutungi et al. 2015). Effective conservation and utilization of PGR are pivotal in maintaining the adaptability of global agriculture, which must address the dual challenges of sustainable practices and increasing productivity to support a growing global population (Saravanan 2010; Jeeva et al. 2006). Preservation techniques, which aim to prevent spoilage and extend the shelf life of food, are essential for maintaining the nutritional quality of crops. Different methods, such as drying, chemical preservation, and refrigeration, are applied based on the specific requirements of each crop type (Dhaliwal & Singh 2010; Adejumo & Raji 2007). These methods mitigate the loss of vital nutrients, especially in vitamin-rich crops like fruits and leafy vegetables (Gupta 2013; Ogwu et al. 2018). Techniques like solar and artificial drying help reduce moisture content to levels

that inhibit microbial and enzymatic activity, while chemical preservatives create environments hostile to spoilage organisms (Sarangi et al. 2009; Chua & Chou 2003). Refrigeration and freezing are also effective in prolonging shelf life by slowing or halting microbial activity (Kiruba et al. 2008).

This study investigates the traditional methods of crop utilization, preservation, and conservation among the Afenmai people in Southern Nigeria. The focus is on understanding how these practices can help address food insecurity in the region, a critical issue given the high rates of malnutrition across Africa, including Nigeria (FAO, 2021a, b). Despite agriculture being a major contributor to Nigeria's GDP, food security and chronic hunger remains a critical issue due to economic and environmental factors (FAO, 2021a, b; Global Hunger Index 2022). The recent acknowledgment of a food crisis by the governor of Edo state, coupled with significant post-harvest losses, highlights the urgency of identifying effective strategies to mitigate these challenges (Obaseki 2022; Asiru 2018). Sustainable solutions to this issue may include implementing solar-powered cold storage facilities, adopting climate-smart agriculture, and promoting value-added processing for perishable crops are critical to reducing post-harvest losses, enhancing food security, and boosting income for smallholder farmers (FAO, 2021a, b; World Bank 2019). Expanding access to these technologies, providing training on effective storage practices, and encouraging crop diversification can help mitigate the impacts of climate change and variability on agricultural productivity (FAO, 2021a, b). In addition, the findings from this study aim to provide essential data to inform interventions targeting food security and reduce post-harvest losses in Afenmai and similar regions. This study will document and analyze the crop utilization, preservation, and conservation methods practiced by the Afenmai people of Southern Nigeria. Specifically, it aims to categorize the various crops based on their uses, including food, medicinal, and industrial purposes; assess the traditional preservation techniques employed by the community and evaluate their effectiveness; and identify the conservation practices in place to protect these crops from overexploitation and ensure their sustainability for future generations. This study not only enhances our understanding of local ethnobotanical knowledge but also aims to contribute to broader efforts in sustainable agriculture and

biodiversity conservation by offering insights that can support conservation policies and community-led initiatives.

Materials and methods

Study design and area

The survey design was adopted in this study. The survey design was used to assess and predict the views, reactions, or standings of many people on the methods of conservation and preservation of crops in Afenmai land. The target population for this study was all the local government areas (LGAs) in Afenmai land. This includes six LGAs—Akoko-Edo, Etsako Central, Etsako East, Etsako West, Owan East and Owan West. These LGAs occupy a land area of about 6,082 km² and as at 2022 is home to about 1.4 million people (NBS 2007; City Population 2023). In the past, there were agitations for the Federal government to declare Afenmai a state with headquarters at the centrally located town of Auchi (7°04'N 6°16'E). This area is bounded to the east by the river Niger, flanked by Ondo state on the west and Kogi state to the north.

Samples and sampling techniques

A random sampling technique was used to sample participants from the six LGAs. 39–44 participants were sampled from each LGA, Akoko-Edo (42), Etsako Central (39), Etsako East (42), Etsako West (41), Owan East (44) and Owan West (42). This yielded a total of 250 participants. The instrument used for this study is questionnaires. It is composed of a battery of questions to which each participant was required to respond. The questionnaire is divided into four sections. Section 1 captured the demographic data of the participants, Section 2 contained questions on crop-people interaction while Section 3 focused on the local preservation of crops. Section 4 contained questions on the conservation of crops.

Ethical considerations

Ethical approval for the study was obtained from the Institutional Review Board of the Research and Scientific Committee, Auchi Polytechnic, Nigeria with

the reference # AUCPOLY/010/2024/023. Informed consent was obtained from all participants before data collection. Participants were assured of the confidentiality and anonymity of their responses, and their participation was voluntary. They were required to append their names, signatures, and date on the questionnaire. The instrument was validated by experts in plant conservation and preservation in the Department of Plant Biology and Biotechnology. The experts evaluated the instrument for content and face validity. The questionnaires were administered in two batches of 125 each. The first batch was administered during the period of the late planting season which is around October to November 2021. The second batch of questionnaires was administered during the period of the early planting season which is around March to May 2022. The total number of questionnaires administered in both batches was 250.

Data analysis

The data obtained from the responses given by the participants to the questionnaires were utilized to generate matrices. The matrices were used to calculate several parameters including the following: Jaccard index, use value, informant consensus factor, relative importance index, frequency of citation, relative frequency of citation, number of use reports, cultural value index, fidelity index, direct matrix ranking, relative popularity level.

Jaccard index (JI)

The formula that was used to compute the JI index (González-Tejero et al. 2008) is:

$$JI = \frac{c \times 100}{a + b - c}$$

where, “a” is the reported number of crops of the study LGA “A,” “b” is the reported number of crops of LGA “B” and “c” is the number of crops common in both LGAs “A” and “B.”

The JI was used to show the degree of species similarity among the six LGAs. The JI was used to show the degree of species similarity in a study in India conducted by González-Tejero et al. (2008).

Use category (UC)

In ethnobotany, plant UC encompass classifications such as food, medicinal, fiber, fodder, ornamental, industrial, cultural, fuel, and construction uses, representing the varied roles plants play in traditional and indigenous practices for nutrition, health, and economic support within communities (Cunningham 2001; Martin 2004). The formula for calculating UC often involves determining the percentage of plants used within a specific category relative to the total number of plant species documented –

Use Category Percentage

$$= \left(\frac{\text{Number of species used in a specific category}}{\text{Total number of species documented}} \right) \times 100$$

In this study, UC and number of use reports (NUC) were used and not a percentage. This calculation allows ethnobotanists to understand the prevalence of specific plant uses within a community or region (Albuquerque & Hanazaki 2009; Osawaru and Ogwu 2014).

Use value (UV)

UV was computed using this formula:

$$UV = \frac{\sum U}{N}$$

where “U” is the number of uses reported by the participants for a given crop and “N” is the total number of participants.

Any crop that scores a high use value is indicative that the crop has many use reports, a low value is indicative of fewer use reports by the participants. Use value was employed by Singh et al. (2012) and Kadir et al. (2013) in their ethnopharmacological survey of medicinal plants.

Informant consensus factor (ICF)

The Informant Consensus Factor was computed by using the equation below: (Faruque et al., 2018)

$$ICF = \frac{Nu - Nt}{Nu - 1}$$

where “Nu” is the total number of use reports for each use category and “Nt” stands for the total number of crops used in that category. The resulting value ranges from 0 to 1, with higher values indicating a greater level of consensus among informants about the use of specific plants within a category, suggesting cultural significance or reliance on certain species for specific needs (Heinrich et al. 1998). ICF has been previously used to ascertain the level of homogeneity in the responses reported by the participants in the ethnobotany of medicinal plants used in Antakya a multicultural district in Hatay Province of Turkey (Güzel et al. 2015).

Frequency of citation

The FC was computed using the following formula:

$$FC = \frac{\text{Number of times an individual crop was cited}}{\text{The total number of times all crops were cited}} \times 100$$

Frequency of citation is a statistical tool used to determine the cultural significance of plants. Aston (2011) used it in his survey of ethnobotanical plants of the Western Cape in South Africa.

Relative Frequency of Citation (RFC) on the other was computed by using the following formula (Tardío and Pardo-De-Santayana 2008):

$$RFC = \frac{FC}{N}$$

where FC refers to the number of participants who cited the use of the crops and N refers to the total number of participants involved in the survey. The RFC index has a range between 0 and 1, it is “0” when no participant cited a crop and “1” when all participants cited a crop as useful. Islam et al. (2014) used the RFC index in a survey of ethnobotanical plants of medicinal importance in Bangladesh.

Use reports (UR)

The number of use reports is among the most popular statistical tools for determining the cultural importance of crops (Kufer et al. 2005). To understand the use report, consider this scenario: participant “i” reports the use of the crop “s” in the use category “u”. The outcome of the combination of these 3 variables is defined as a use report. In a specific survey

that utilized NS species (s1, s2, ..., sNS) whose total number of use categories is NC (u1, u2, ..., uNC) and N participants (i1, i2, ..., iN), UR_{sui} can yield the value of 1 when a combination exists or 0 when this combination is not reported. The ethnobotanical matrices can be grouped in various manners by fixing one or two of the variables. The formula used to estimate the number of use reports is (adapted from Kufer et al 2005):

$$UR = \left[\sum_{u=u1}^{u_{NC}} + \sum_{i=i1}^{i_N} UR_{ui} \right]$$

Kufer et al. (2005) utilized several use reports in a survey of historical and modern medicinal plant uses in Eastern Guatemala. In the study, the total number of use reports was estimated as the sum of all instances where informants mention a particular plant for a specific use category. This metric helps quantify the cultural significance of a plant within a community by showing how frequently it is utilized for various purposes. It is calculated by counting each time informants report using a plant for categories like food, medicine, construction, and other uses.

Cultural value index (CV).

This index allows researchers to assess both the frequency and the variety of uses for a plant, giving a more holistic measure of its cultural importance in a given community. A higher CV suggests a plant is culturally significant, as it is used widely across various aspects of daily life. The CV was calculated using the formula from Reyes-García et al. (2006):

$$CV = \left(\frac{NUs}{NC} \right) \times \left(\frac{FCs}{N} \right) \times \left(\sum_{u=1}^{NC} \sum_{i=1}^N \frac{UR_{ui}}{N} \right)$$

There are 3 brackets, the 1st bracket contains NUs/NC where NUs is the number of the different uses recorded for the crops and NC is the total number of categories evaluated in the survey.

The 2nd bracket contains FCs/N where FCs is the relative frequency of citation of the crops (earlier defined) and N is the total number of participants. The 3rd bracket contains a summation of the number of participants who reported (i.e., UR_{ui} – use report) each use of the crops divided by N (summation of participants). These 3 brackets are multiplied

together to compute the CV. The CV has been used in ethnobotanical surveys of plants in rural communities carried out in India by Nagendrappa et al. in (2013a). Also, this metric has been applied in various ethnobotanical investigations, such as those by Tardío and Pardo-de-Santayana (2008), who used it to analyze the cultural importance of wild food plants in the Iberian Peninsula. Additionally, Pieroni (2001) utilized the CV in evaluating the role of local plants in dietary practices among ethnic communities in Italy, further validating the use of this index in cultural plant research.

Fidelity index (FL)

The FL index was calculated using the following formula:

$$FL = \frac{lp}{lu} \times 100$$

where lp is the number of participants who cited the use of a crop for a specific use category and lu refers to the total number of participants that cited the same crop for any use category. It is opined that those crops that are utilized repeatedly for the same use category are most possibly of biological significance. The Fidelity index was used by Khan et al. (2014) to carry out an ethnobotanical survey in Pakistan.

Direct matrix ranking (DMR).

This is a valuable tool for assessing and comparing the diverse uses of crops by calculating use values based on participant responses. In DMR, participants score each plant species across various use categories, such as food, medicine, and construction. The scores are then summed and ranked, providing a clear comparison of the utility and cultural importance of different crops within a community. This method has been effectively used in botanical surveys to reveal preferences and priorities for resource use. Notably, DMR has been applied in research by Rahman et al. (2016) in Bangladesh, Ribeiro et al. (2017), and Sadat-Hosseini et al. (2017), thus demonstrating its reliability for capturing local knowledge and values regarding plant resources.

Relative importance (RI)

This index provides an assessment of the cultural significance and versatility of plant species by comparing the use categories and use types across species. This was computed with the formula by Bennett and Prance (2000)

$$RI = \left(\frac{NUC}{NUCVS} \right) + \left(\frac{NT}{NTVS} \right)$$

where:

- **NUC** is the number of use categories reported for a specific plant species.
- **NUCVS** is the total number of use categories associated with the most versatile species (the species with the maximum number of use categories).
- **NT** is the number of use types (individual uses) recorded for the given species.
- **NTVS** is the total number of use types associated with the most utilized species (the species with the maximum number of individual uses).

RI has been used by Suleiman (2015) in ethnobotanical surveys of medicinal plants used by local people in Asir region, Saudi Arabia. Also, Uddin et al. (2014) in botanical surveys of medicinal plants used by herbal medicine practitioners in four villages of Kurigram district, Bangladesh.

Results

Participant demographics

The demographic profile of the 250 participants is summarized in Supplementary Table 1. Among them, 33% were male, and 67% were female. The age distribution was as follows: 50% were under 31 years, 40% were between 31 and 50 years, and 10% were over 50 years. Regarding marital status, 48% were married, 40% single, 7% divorced, and 3% cohabitating. Family size varied, with 75% having fewer than eight members and 25% having more than eight. The income distribution indicated that 85% earned less than ₳100,000, 12% earned between ₳100,000 and ₳200,000, and 3% earned above ₳200,000 (at an exchange rate of \$1=₳1603). Employment status included 39% students, 21% unemployed, 16%

housewives 16% full-time employees, and 8% part-time employees. Educational attainment levels ranged from secondary education (31%), university degrees (26%), technical degrees (20%), primary education (19%), to other qualifications (4%).

Crop diversity and distribution across LGAs

Participants reported a total of 36 crop species cultivated across Afemai land, spanning 20 botanical families (Supplementary Table 2). Notable species included *Abelmoschus esculentus*, *Amaranthus hybridus*, *Anacardium occidentale*, *Arachis hypogaea*, and *Cajanus cajan*. The family Poaceae had the highest representation with four species, while Arecaceae, Fabaceae, Malvaceae, and Solanaceae each had three species. In contrast, 13 families were each represented by a single species. The crop diversity varied by LGA: Akoko-Edo reported 24 species, Etsako Central reported 22, Etsako East reported 24, Etsako West reported 23, Owan East reported 24, and Owan West reported 22 (Table 1). Only eight crop species were common across all LGAs, including *Amaranthus hybridus*, *Dioscorea rotundata*, *Ipomoea batatas*, *Musa paradisiaca*, *Musa sapientum*, *Talinum triangulare*, *Telfairia occidentalis*, and *Vernonia amygdalina* (Supplementary Table 3).

Economic importance and utilization of crops

The crops were categorized based on their growth forms (shrub or herb), economic uses, and parts utilized for food (Table 2). Shrubs such as *Anacardium occidentale* and *Carica papaya* were common, while herbs included *Ocimum gratissimum* and *Sorghum bicolor*. Economic uses varied widely, encompassing leafy vegetables (*Abelmoschus esculentus*), fruits (*Anacardium occidentale*), oil crops (*Arachis hypogaea*), and cereals (*Oryza sativa*). The parts used for food included leaves, stems, corms, tubers, seeds, and fruits.

Species similarity and jaccard index analysis

The degree of species similarity among the six LGAs was assessed using the Jaccard Index (JI) (Table 3). The JI ranges from 0 to 1 (or as represented as a percentage from 0 to 100), where a higher value indicates a greater similarity in species composition. JI values

ranged from 38.24 to 100, with the highest similarity between Etsako West and Owan West (JI=100). Akoko-Edo and Owan East also showed a high similarity (JI=77.7), while the lowest similarity was between Etsako Central and Owan East (JI=38.24). In this study, the variation in JI values among LGAs, with some pairs showing high similarity (e.g., Etsako West and Owan West) and others low similarity (e.g., Etsako Central and Owan East), suggests that both ecological and cultural factors may be at play in determining the distribution and diversity of crop species across the regions. Shared species between similar JI pairs likely reflect common agricultural practices, species preferences, or ecological conditions conducive to specific crop types, indicating cultural and environmental influences on crop selection and agricultural practices in these areas (Osawaru and Ogwu 2014; Schmidts et al. 2015; Cruz 2019).

Cultivation practices, preservation methods, and market dynamics

Cultivation materials and their storage methods are detailed in Table 4. Seeds were the primary propagation material for 26 crops, while stems, corms, suckers, and fruits were used for others. Storage duration varied significantly, with 28 crops being stored for more than six months. Preservation methods were diverse, including sun-drying, storage in bags, and spreading on rafters (Table 5). Crops like *Zea mays* and *Theobroma cacao* exhibited multiple preservation techniques, suggesting adaptation to various environmental and economic conditions. The study revealed diverse market practices, with crops sold in various quantities such as cups, baskets, bags, and bottles (Supplementary Table 4). Prices ranged from ₦50 per fruit for *Prunus* to ₦35,000 per bag for *Oryza sativa*. Some crops, like *Ocimum gratissimum*, are predominantly grown in home gardens and are rarely sold commercially. The impact of preservation on taste was mixed: 25% of participants reported improved taste, 24% reported a decline, and 50.5% were unsure (Supplementary Table 5). The response of participants on how long crops can be preserved is captured in Supplementary Table 6. Among crops that were reported that can be stored for not more than 6 months are *Amaranthus hybridus* (leaves), *Carica papaya* (fruits and leaves), and *Celosia argentea* (leaves).

Table 1 Socioeconomic plants reported from the different local government areas within Afenmai land, Southern Nigeria

Species	Akoko-Edo LGA	Etsako Central LGA	Etsako East LGA	Etsako West LGA	Owan East LGA	Owan West LGA
<i>Abelmoschus esculentus</i>	X				X	
<i>Amaranthus hybridus</i>	X	X	X	X	X	X
<i>Anacardium occidentale</i>		X	X	X		X
<i>Arachis hypogaea</i>	X		X	X	X	X
<i>Cajanus cajan</i>	X				X	
<i>Capsicum annum</i>	X	X	X	X		X
<i>Carica papaya</i>		X	X	X	X	X
<i>Celosia argentea</i>	X				X	
<i>Cocos nucifera</i>	X	X		X	X	X
<i>Colocasia esculenta</i>	X		X	X	X	X
<i>Corchorus olitorius</i>	X		X		X	
<i>Cucumis lanatus</i>	X	X	X	X		X
<i>Dacryodes edulis</i>		X		X		X
<i>Dioscorea rotundata</i>	X	X	X	X	X	X
<i>Elaeis guineensis</i>	X	X		X	X	X
<i>Ipomoea batatas</i>	X	X	X	X	X	X
<i>Irvingia gabonensis</i>		X		X		X
<i>Lycopersicon esculentum</i>	X	X	X	X		X
<i>Mangifera indica</i>			X			
<i>Manihot esculenta</i>	X		X	X	X	X
<i>Musa paradisiaca</i>	X	X	X	X	X	X
<i>Musa sapientum</i>	X	X	X	X	X	X
<i>Ocimum gratissimum</i>		X				
<i>Oryza sativa</i>			X	X		X
<i>Persea americana</i>		X		X	X	X
<i>Prunus albidum</i>		X	X			
<i>Saccharum officinarum</i>				X		
<i>Sesamum indicum</i>		X	X			
<i>Solanum melongena</i>	X		X		X	
<i>Sorghum bicolor</i>	X		X		X	
<i>Talinum triangulare</i>	X	X	X	X	X	X
<i>Telfairia occidentalis</i>	X	X	X	X	X	X
<i>Theobroma cacao</i>					X	
<i>Vernonia amygdalina</i>	X	X	X	X	X	X
<i>Vigna unguiculata</i>	X		X		X	
<i>Zea mays</i>	X	X	X		X	

X, Reported within the local government area

Some of the crops that were reported that can be preserved for 6–18 months are *Cucumis lanatus* (fruits and seeds), *Dioscorea rotundata* (tubers), and *Irvingia gabonensis* (fruits and seeds). Crops that could be preserved for over 18 months include *Theobroma cacao* (fruits and seeds), *Manihot esculenta* (tubers), and *Elaeis guineensis* (fruits). The

response of the participants to the parts of crops put to non-food use and their number is displayed in Supplementary Table 7. Among the three crops which were reported 3 parts put to non-food use are *Vernonia amygdalina* and the parts are leaves, root, and stem; 2 parts of *Irvingia gabonensis* are put to non-food use, these parts are seed and stem. Among

Table 2 List of socioeconomic crops within Afenmai land showing their habit, economic plant category, and parts used as food

Crop	Habit	Economic plant category	Parts used as food
<i>Abelmoschus esculentus</i>	Herb	Fruit vegetable	Fruit
<i>Amaranthus hybridus</i>	Herb	Leafy vegetable	leaves and stem
<i>Anacardium occidentale</i>	Shrub	Fruit	Fruit
<i>Arachis hypogaea</i>	Herb	Oil	Fruit
<i>Cajanus cajan</i>	Herb	Legume	Seeds
<i>Capsicum annum</i>	Herb	Spices	Fruit
<i>Carica papaya</i>	Shrub	Fruit	Fruit
<i>Celosia argentea</i>	Herb	Leafy vegetable	leaves and stem
<i>Cocos nucifera</i>	Herb	Oil	Seeds
<i>Colocasia esculenta</i>	Herb	Tuber	Corm
<i>Corchorus olitorius</i>	Herb	Leafy vegetable	leaves and stem
<i>Cucumis lanatus</i>	Herb	Oil	Seeds
<i>Dacryodes edulis</i>	Shrub	Fruit	Fruit
<i>Dioscorea rotundata</i>	Herb	Tuber	Tuber
<i>Elaeis guineensis</i>	Herb	Oil	fruit and seeds
<i>Ipomoea batatas</i>	Herb	Tuber	Tuber
<i>Irvingia gabonensis</i>	Shrub	Fruit	Fruit
<i>Lycopersicon esculentum</i>	Herb	Fruit vegetable	Fruit
<i>Mangifera indica</i>	Shrub	Fruit	Fruit
<i>Manihot esculenta</i>	Shrub	Tuber	Tuber
<i>Musa paradisiaca</i>	Herb	Fruit	Fruit
<i>Musa sapientum</i>	Herb	Fruit	Fruit
<i>Ocimum gratissimum</i>	Herb	Spices	leaves and stem
<i>Oryza sativa</i>	Herb	Cereal	Fruit
<i>Persea americana</i>	Shrub	Fruit	Fruit
<i>Prunus albidum</i>	Shrub	Fruit	Fruit
<i>Saccharum officinarum</i>	Herb	Beverage	Stem
<i>Sesamum indicum</i>	Herb	Oil	Fruit
<i>Solanum melongena</i>	Herb	Fruit vegetable	Fruit
<i>Sorghum bicolor</i>	Herb	Cereal	Seeds
<i>Talinum triangulare</i>	Herb	Leafy vegetable	leaves and stem
<i>Telfairia occidentalis</i>	Herb	Leafy vegetable	leaves and seeds
<i>Theobroma cacao</i>	Shrub	Beverage	Seeds
<i>Vernonia amygdalina</i>	Herb	Leafy vegetable	leaves and stem
<i>Vigna unguiculata</i>	Herb	Legume	fruit and seeds
<i>Zea mays</i>	Herb	Cereal	Fruit

crops that recorded no non-food use are *Ipomoea batatas* and *Persea Americana*. The respondents indicated that the crops are eaten in different forms (Supplementary Table 8). *Zea mays* has the highest number of forms in which it is eaten; it has 7 forms which are boiled, roasted, fried, soup, flour, pap, and pudding. Six forms were reported for *Musa paradisiacal*, they are boiled, fried, roasted, porridge, flour, and salad. *Celosia argentea*, *Corchorus*

olitorius, and *Amaranthus hybridus* respectively report only 1 form in which they are used and that is soup. Participants reported that various parts of the crops were used as food. *Corchorus olitorius* recorded 3 parts which is the highest, these parts are the leaves, stem, and flower. *Talinum triangulare* recorded 2 parts: leaves and stem while *Persea americana* and *Prunus albidum* both recorded 1 part only, the fruit.

Table 3 Comparison of the number of species encountered in the six local government areas to show the degree of similarity by using the Jaccard index

Local government areas	Number of species recorded	Jaccard index
Species recorded in Akoko Edo	24	
Species recorded in Etsako Central	23	
Species recorded in Etsako East	24	
Species recorded in Etsako West	23	
Species recorded in Owan East	24	
Species recorded in Owan West	23	
Species common to Akoko Edo and Etsako Central	15	46.88
Species common to Akoko Edo and Etsako East	18	60
Species common to Akoko Edo and Etsako West	16	51.61
Species common to Akoko Edo and Owan East	21	77.7
Species common to Akoko Edo and Owan West	16	51.61
Species common to Etsako Central and Etsako East	16	51.61
Species common to Etsako Central and Etsako West	15	48.39
Species common to Etsako Central and Owan East	13	38.24
Species common to Etsako Central and Owan West	18	64.29
Species common to Etsako East and Etsako West	17	56.6
Species common to Etsako West and Owan East	15	46.88
Species common to Etsako West and Owan West	23	100
Species common to Etsako East and Owan East	16	50
Species common to Etsako East and Owan West	17	56.6
Species common to Owan East and Owan West	15	46.88

Conservation status

In this study, conservation status refers to the degree of availability of the target crop species in the local ecosystem. We assessed it based on reported abundance levels (i.e., underutilized, overutilized, rarely found, or abundantly available), which were determined through interviews with participants about the prevalence and seasonal collection patterns of the crops. This assessment provides insight into the local status of crop diversity and sustainability. Conservation status assessments indicated that 20% of crops were underutilized, 13.2% were overutilized, 5.8% were scarce or rarely found, and 60.8% were abundantly available (Table 6). Collection practices varied with seasons: 23.6% of crops were collected in the rainy season, 4.5% in the dry season, and 71.8% year-round (Supplementary Table 9). Participants reported obtaining crops from multiple sources, including markets (51.3%), home gardens (12.5%), and distant farms (29.2%) (Supplementary Table 10).

Utilization patterns and cultural significance

Utilization patterns varied across the six LGAs, categorized into fresh immature, fresh mature, processed immature, and processed mature forms (Supplementary Table 11). Crops like *Amaranthus hybridus* were primarily utilized fresh mature, while *Arachis hypogaea* was mostly processed. The direct matrix ranking highlighted the cultural importance of certain crops, with *Cocos nucifera* and *Elaeis guineensis* ranked highest in use diversity (Supplementary Table 13). Matrices generated on the crops' number of use reports, use category, relative importance, and frequency of citation are recorded in Table 7. The table shows that *Vernonia amygdalina* has the highest use reports of 481 followed by *Cocos nucifera* which has a value of 401. *Theobroma cacao* had a low number of use reports value of 44 but *Saccharum officinarum* had the lowest value of 41. The highest use category of 5 was reported for 5 crops: *Cocos nucifera*, *Musa sapientum*, *Elaeis guineensis*, and *Carica papaya*. The lowest use category of 1 was reported

Table 4 Types and sources of plant germplasm used as cultivation materials and their storage methods and durations within Afen-mai land

Crops	Cultivation Materials	How long can be stored	How stored	Where Crops are Maintained	Sources of cultivation materials
<i>Abelmoschus esculentus</i>	Seed	> 6 months	Bowls, and bags	Home gardens and distant farms	Market, personal collections, and from neighbours
<i>Amaranthus hybridus</i>	Seed	> 6 months	Bags	Home gardens and distant farms	Personal collections, and from neighbours
<i>Anacardium occidentale</i>	Seed	> 6 months	Bags	Home gardens and distant farms	Market, personal collections, neighbours, and wild collection
<i>Arachis hypogaea</i>	Seed	> 6 months	Bowls, and bags	Distant farms	Market, personal collections, and from neighbours
<i>Cajanus cajan</i>	Seed	> 6 months	Bags, and plastic cans	Distant farms	Market, personal collections, and from neighbours
<i>Capsicum annum</i>	Seed	> 6 months	Bags, and bowls	Home gardens and distant farms	Personal collections, neighbours, and from the market
<i>Carica papaya</i>	Seed	> 6 months	Bags	Home gardens and distant farms	Neighbours, personal collections, market, and wild collections
<i>Celosia argentea</i>	Seed	> 6 months	Bags	Home gardens and distant farms	Personal collections, and from neighbours
<i>Cocos nucifera</i>	Fruit	1–6 months	Floor, and in bags	Home gardens and distant farms	Personal collections, and from neighbours, market, wild collections, institution
<i>Colocasia esculenta</i>	Corm	1–6 months	Basket, and on the floor	Distant farms	Personal collections, market, and from neighbours
<i>Corchorus olitorius</i>	Seed	> 6 months	Bags	Home gardens and distant farms	Personal collections, and from neighbours
<i>Cucumis lanatus</i>	Seed	> 6 months	Bowls	Home gardens and distant farms	Personal collections, neighbours, and from the market
<i>Dacryodes edulis</i>	Seed	> 6 months	Baskets	Home gardens and distant farms	Market, personal collections, and from neighbours
<i>Dioscorea rotundata</i>	Tuber	> 6 months	On the floor, and baskets	Distant farms	Market, and from personal collections
<i>Elaeis guineensis</i>	Seed	> 6 months	Bags	Home gardens and distant farms	Government and nongovernmental organizations, market, and from neighbours
<i>Ipomoea batatas</i>	Stem	< 1 month	Bags, and in bowls	Distant farms	Neighbours, and from personal collections

Table 4 (continued)

Crops	Cultivation Materials	How long can be stored	How stored	Where Crops are Maintained	Sources of cultivation materials
<i>Irvingia gabonensis</i>	Seed	> 6 months	Bags, and in baskets	Home gardens and distant farms	Neighbours, personal collections, market, and wild collections
<i>Lycopersicon esculentum</i>	Seed	> 6 months	Bowls, and in bags	Home gardens and distant farms	Market, personal collections, and from neighbours
<i>Mangifera indica</i>	Seed	> 6 months	Basket, and in bowls	Home gardens and distant farms	Wild collections, market, government and nongovernmental organizations, and from neighbours
<i>Manihot esculenta</i>	Stem	< 1 month	Bags, and on floors	Distant farms	Market, personal collections, government and nongovernmental organizations, and from neighbours
<i>Musa paradisiaca</i>	Sucker	< 1 month	On the floor or in bags	Home gardens and distant farms	Neighbours, wild collection, and from personal collections
<i>Musa sapientum</i>	Sucker	< 1 month	On the floor	Home gardens and distant farms	Neighbours, wild collection, and from personal collections
<i>Ocimum gratissimum</i>	Seed	> 6 months	Bags	Home gardens	Personal collections, and from neighbours
<i>Oryza sativa</i>	Fruit	> 6 months	Bags, and in bowl	Distant farms	Market, personal collections, and from neighbours
<i>Persea americana</i>	Seed	> 6 months	Bags, and in baskets	Home gardens and distant farms	Neighbours, personal collections, market, and wild collections
<i>Prunus albidum</i>	Seed	> 6 months	Bags	Distant farms	Wild collections, market, government and nongovernmental organization, and from neighbours
<i>Saccharum officinarum</i>	Stem	< 1 month	On the floor	Home gardens and distant farms	Neighbours, personal collections, and from the market
<i>Sesamum indicum</i>	Seed	> 6 months	Bags, and in bowls	Distant farms	Personal collections, and from neighbours
<i>Solanum melongena</i>	Seed	> 6 months	Bowl, and in bags	Distant farms	Personal collections, neighbours, and from the market
<i>Sorghum bicolor</i>	Seed	> 6 months	Bag, and in bowls	Distant farms	Personal collections, market, and from neighbours

Table 4 (continued)

Crops	Cultivation Materials	How long can be stored	How stored	Where Crops are Maintained	Sources of cultivation materials
<i>Talinum triangulare</i>	Seed	> 6 months	Bowls	Home gardens and distant farms	Personal collections, from neighbours, and wild collections
<i>Telfairia occidentalis</i>	Seed	1–6 months	Bowls	Home gardens	Market, from neighbours, and from personal collections
<i>Theobroma cacao</i>	Seed	> 6 months	Bags, and in bowls	Distant farms	Market, personal collections, and from neighbours
<i>Vernonia amygdalina</i>	Seed, stem	> 6 months	Bags	Home gardens and distant farms	Personal collections, from neighbours, and wild collections
<i>Vigna unguiculata</i>	Seed	> 6 months	Bags, and plastic cans	Distant farms	Market, and from personal collections
<i>Zea mays</i>	Fruit	> 6 months	Bag, bowl, and rafters	Home gardens and distant farms	Market, personal collections, and from neighbours

for *Saccharum officinarum* and *Theobroma cacao*. Data on the use value of the crops indicates that *Vernonia amygdalina* has the highest value of 0.64 followed by *Musa paradisiaca* which had 0.36, and the lowest use value of 0.07 was calculated for *Mangifera indica*.

Values derived for the relative importance of the crops show that *Cajanus cajan* has the highest value of 0.51, this was followed by the value of 0.45 calculated for *Cocos nucifera*, *Elaeis guineensis*, and *Musa sapientum* and the lowest value of 0.09 was calculated for *Saccharum officinarum* and *Theobroma cacao*. The frequency of citation values for *Vernonia amygdalina* (7.7) and *Cocos nucifera* (6.5) was the highest, *Arachis hypogaea* had a value of 4.4 while *Mangifera indica* had the lowest value of 0.009. Fidelity level (FL%) values were calculated for various use categories (Table 8). For the food category, *Saccharum officinarum* and *Theobroma cacao* scored the highest (FL=100), while *Vernonia amygdalina* had the lowest (FL=51.9). In the medicinal category, *Vernonia amygdalina* again ranked highest (FL=47.8), indicating its prominence in traditional medicinal practices. Relative importance (RI) values varied, with *Cajanus cajan* having the highest (RI=0.51), suggesting its diverse use and significance in local cultures. The cultural value index (Table 9) identified *Vernonia amygdalina* as having the highest cultural significance

(0.38), while others like *Amaranthus hybridus* and *Mangifera indica* had lower values (0.01).

Discussion

This study has examined the critical roles that various crop types play within Afenmai land in Southern Nigeria in attempt to contribute towards addressing broader issues of food security and sustainability. Given the ongoing challenges posed by post-harvest losses, declining crop biodiversity, and environmental pressures, it is essential to evaluate how current crop utilization, preservation and conservation practices influence the resilience and productivity of local agriculture. The results of the study have provided insights into local ecological and ethnobotanical practices and identified areas for improvement. The demographic analysis of the 250 participants (Supplementary Table 1) revealed a predominantly female respondent base (67%), with a significant proportion under 31 years of age (50%). This demographic profile indicates a youthful, potentially dynamic community engaged in agricultural practices, with a diversity of educational backgrounds ranging from primary to university level. Such diversity could influence varying agricultural practices and preferences observed in this study. The demographic analysis indicates a

Table 5 Crop preservation techniques in Afenmai land and their frequencies

Crops	How crops are preserved	Frequency of the preservation method
<i>Abelmoschus esculentus</i>	Under direct sunlight	1
<i>Amaranthus hybridus</i>	Refrigerated	1
<i>Anacardium occidentale</i>	Spread on the floor, and in bags	2
<i>Arachis hypogaea</i>	Spread on the floor, sun, bags	3
<i>Cajanus cajan</i>	Under direct sunlight, plastic cans, and in bags	3
<i>Capsicum annum</i>	Under direct sunlight, and in bags	2
<i>Carica papaya</i>	Refrigerated	1
<i>Celosia argentea</i>	Refrigerated	1
<i>Cocos nucifera</i>	Spread on the floor, bags	2
<i>Colocasia esculenta</i>	Spread on the floor, basket	2
<i>Corchorus olitorius</i>	Refrigerated	1
<i>Cucumis lanatus</i>	Bowls	1
<i>Dacryodes edulis</i>	Bags	1
<i>Dioscorea rotundata</i>	Barns, spread on the floor,	2
<i>Elaeis guineensis</i>	Oil stored in jerry cans and bottles	2
<i>Ipomoea batatas</i>	Spread on the floor	1
<i>Irvingia gabonensis</i>	Spread on the floor, under direct sunlight, and in bags	2
<i>Lycopersicon esculentum</i>	Basket, fridge, and in plastic cans	3
<i>Mangifera indica</i>	Bowls, and refrigerated	2
<i>Manihot esculenta</i>	Tubers under direct sunlight, or spread on the floor, while the flour are stored in bags	3
<i>Musa paradisiaca</i>	Fridge, and in drums	2
<i>Musa sapientum</i>	Fridge, and in drums	2
<i>Ocimum gratissimum</i>	Bowls	1
<i>Oryza sativa</i>	Sun, spread on the floor, bags	3
<i>Persea americana</i>	Fridge	1
<i>Prunus albidum</i>	Basket, and refreidgerated	2
<i>Saccharum officinarum</i>	None was reported	0
<i>Sesamum indicum</i>	Bowls	1
<i>Solanum melongena</i>	Baskets	1
<i>Sorghum bicolor</i>	Bags, and under direct sunlight	2
<i>Talinum triangulare</i>	Fridge	1
<i>Telfairia occidentalis</i>	Fridge	1
<i>Theobroma cacao</i>	Under direct sunlight, spread on the floor, and in bags	3
<i>Vernonia amygdalina</i>	Under direct sunlight, and in bowl	2
<i>Vigna unguiculata</i>	Under direct sunlight, spread on the floor, and in bags	3
<i>Zea mays</i>	Under direct sunlight, spread on the floor, bags, and in silos	4

predominantly young population, with 50% of residents aged below 31 years. This aligns with research highlighting a youthful demographic profile in many Sub-Saharan African regions, which presents both opportunities and challenges for agricultural productivity and rural development (Adesina 2017). The

high proportion of individuals with low-income levels (85% earning below ₦100,000) and a substantial number of students (39%) suggests limited financial capacity and a reliance on informal or subsistence farming practices. This demographic profile necessitates targeted interventions to improve agricultural

Table 6 Conservation status of crops in Afenmai land: based on either of these predefined states—underutilized, over-utilised, scarce/rarely found, abundantly found around, no longer found around

Conservation status					
Crops	Underutilised	Overutilised	Scarce/ Rarely found	Abundantly Found around	No longer found around
<i>Abelmoschus esculentus</i>	0	45	0	40	0
<i>Amaranthus hybridus</i>	0	40	0	82	0
<i>Anacardium occidentale</i>	30	0	0	0	0
<i>Arachis hypogaea</i>	0	30	0	30	0
<i>Cajanus cajan</i>	23	0	34	0	0
<i>Capsicum annum</i>	0	86	0	81	0
<i>Carica papaya</i>	32	0	0	43	0
<i>Celosia argentea</i>	54	0	34	0	0
<i>Cocos nucifera</i>	30	0	0	107	0
<i>Colocasia esculenta</i>	60	0	87	0	0
<i>Corchorus olitorius</i>	65	0	0	0	0
<i>Cucumis lanatus</i>	0	120	0	100	0
<i>Dacryodes edulis</i>	65	0	0	0	0
<i>Dioscorea rotundata</i>	0	150	0	142	0
<i>Elaeis guineensis</i>	76	0	0	180	0
<i>Ipomoea batatas</i>	50	0	0	0	0
<i>Irvingia gabonensis</i>	0	0	0	54	0
<i>Lycopersicon esculentum</i>	0	60	0	60	0
<i>Mangifera indica</i>	0	0	0	40	0
<i>Manihot esculenta</i>	140	0	0	150	0
<i>Musa paradisiaca</i>	0	0	0	190	0
<i>Musa sapientum</i>	0	0	0	187	0
<i>Ocimum gratissimum</i>	27	0	0	0	0
<i>Oryza sativa</i>	0	0	0	82	0
<i>Persea americana</i>	57	0	0	0	0
<i>Prunus albidum</i>	23	0	0	0	0
<i>Saccharum officinarum</i>	30	0	0	0	0
<i>Sesamum indicum</i>	0	0	54	0	0
<i>Solanum melongena</i>	0	0	0	62	0
<i>Sorghum bicolor</i>	0	0	0	39	0
<i>Talinum triangulare</i>	0	0	0	201	0
<i>Telfairia occidentalis</i>	0	0	0	230	0
<i>Theobroma cacao</i>	40	0	0	0	0
<i>Vernonia amygdalina</i>	0	0	0	220	0
<i>Vigna unguiculata</i>	0	0	0	78	0
<i>Zea mays</i>	0	0	0	40	0
Total	802	531	209	2438	0
Percentage	20	13.2	5.8	60.8	0

Table 7 Use category and value of crops in Afenmain land and their relative importance, and frequency of citation

Crops	NUC	UC	UV	RI	FoC
<i>Abelmoschus esculentus</i>	95	3	0.13	0.26	1.5
<i>Amaranthus hybridus</i>	202	3	0.27	0.27	3.2
<i>Anacardium occidentale</i>	140	2	0.28	0.18	2.2
<i>Arachis hypogaea</i>	274	4	0.27	0.36	4.4
<i>Cajanus cajan</i>	92	3	0.12	0.51	1.4
<i>Capsicum annum</i>	138	3	0.18	0.26	2.2
<i>Carica papaya</i>	278	5	0.22	0.44	4.5
<i>Celosia argentea</i>	91	2	0.18	0.35	1.5
<i>Cocos nucifera</i>	401	5	0.32	0.45	6.5
<i>Colocasia esculenta</i>	222	3	0.3	0.27	3.6
<i>Corchorus olitorius</i>	138	3	0.18	0.26	2.2
<i>Cucumis lanatus</i>	134	4	0.13	0.34	2.1
<i>Dacryodes edulis</i>	172	3	0.23	0.26	2.7
<i>Dioscorea rotundata</i>	177	4	0.18	0.35	2.9
<i>Elaeis guineensis</i>	361	5	0.29	0.45	5.9
<i>Ipomoea batatas</i>	131	4	0.13	0.34	2.1
<i>Irvingia gabonensis</i>	104	2	0.21	0.18	1.6
<i>Lycopersicon esculentum</i>	89	3	0.12	0.26	1.4
<i>Mangifera indica</i>	56	3	0.07	0.25	0.009
<i>Manihot esculenta</i>	181	4	0.18	0.35	2.9
<i>Musa paradisiaca</i>	358	4	0.36	0.36	5.8
<i>Musa sapientum</i>	350	5	0.28	0.45	5.6
<i>Ocimum gratissimum</i>	61	3	0.08	0.25	0.01
<i>Oryza sativa</i>	91	3	0.12	0.26	1.4
<i>Persea americana</i>	93	2	0.19	0.17	1.5
<i>Prunus albidum</i>	87	3	0.12	0.26	1.4
<i>Saccharum officinarum</i>	41	1	0.16	0.09	0.6
<i>Sesamum indicum</i>	87	3	0.12	0.26	1.4
<i>Solanum melongena</i>	94	3	0.13	0.26	1.5
<i>Sorghum bicolor</i>	92	3	0.12	0.26	1.4
<i>Talinum triangulare</i>	348	2	0.7	0.19	5.6
<i>Telfairia occidentalis</i>	330	4	0.33	0.36	5.3
<i>Theobroma cacao</i>	44	1	0.18	0.09	0.7
<i>Vernonia amygdalina</i>	481	3	0.64	0.29	7.7
<i>Vigna unguiculata</i>	90	4	0.09	0.34	1.4
<i>Zea mays</i>	46	2	0.09	0.17	0.7

No of UC, Number of use reports; UC, Use category; UV, Use Value; RI, Relative Importance; FoC, frequency of citation

education and provide financial support to young farmers to enhance productivity (Ojo et al. 2022).

Our results highlight a rich diversity of crops cultivated in the region, including staple foods such as maize (*Zea mays*), rice (*Oryza sativa*), and cassava (*Manihot esculenta*), as well as economically

Table 8 Fidelity level value of crops in Afenmai land and their use category

Crops	Use Category	lp	lu	FL Value%
<i>Saccharum officinarum</i>	Food	250	250	100
<i>Theobroma cacao</i>	Food	250	250	100
<i>Sesamum indicum</i>	Food	250	254	98.4
<i>Zea mays</i>	Food	250	254	98.4
<i>Celosia argentea</i>	Food	250	255	98
<i>Lycopersicon esculentum</i>	Food	250	255	98
<i>Vigna unguiculata</i>	Food	250	256	98
<i>Cajanus cajan</i>	Food	250	256	97.6
<i>Dacryodes edulis</i>	Food	250	256	97.6
<i>Prunus albidum</i>	Food	250	256	97.6
<i>Oryza sativa</i>	Food	250	257	97.2
<i>Persea americana</i>	Food	250	257	97.2
<i>Ipomoea batatas</i>	Food	250	258	96.8
<i>Sorghum bicolor</i>	Food	250	258	96.8
<i>Abelmoschus esculentus</i>	Food	250	259	96.5
<i>Corchorus olitoriu</i>	Food	250	260	96.1
<i>Solanum melongena</i>	Food	250	260	96.1
<i>Colocasia esculenta</i>	Food	250	261	95.7
<i>Cucumis lanatus</i>	Food	250	261	95.7
<i>Capsicum annum</i>	Food	250	262	95.4
<i>Dioscorea rotundata</i>	Food	250	263	95
<i>Mangifera indica</i>	Food	250	264	94.6
<i>Manihot esculenta</i>	Food	250	265	94.3
<i>Anacardium occidentale</i>	Food	250	267	93.6
<i>Ocimum gratissimum</i>	Food	250	272	91.9
<i>Irvingia gabonensis</i>	Food	250	274	91.2
<i>Amaranthus hybridus</i>	Food	250	288	86.8
<i>Carica papaya</i>	Food	250	320	78.1
<i>Telfairia occidentalis</i>	Food	250	330	75.7
<i>Talinum triangulare</i>	Food	250	346	72.2
<i>Arachis hypogaea</i>	Food	250	357	70
<i>Cocos nucifera</i>	Food	250	391	63.9
<i>Musa sapientum</i>	Food	250	391	63.9
<i>Musa paradisiaca</i>	Food	250	398	62.8
<i>Elaeis guineensis</i>	Food	250	403	62
<i>Vernonia amygdalina</i>	Food	250	481	51.9
<i>Vernonia amygdalina</i>	Medical	230	481	47.8
<i>Musa paradisiaca</i>	Others	137	398	34.4
<i>Cocos nucifera</i>	Building	120	391	30.6
<i>Musa sapientum</i>	Others	112	391	28.6
<i>Talinum triangulare</i>	Medical	96	346	27.7
<i>Arachis hypogaea</i>	Medical	97	357	27.1
<i>Telfairia occidentalis</i>	Medical	73	330	22.1

Table 8 (continued)

Crops	Use Category	lp	lu	FL Value%
<i>Elaeis guineensis</i>	Building	69	403	17.1
<i>Carica papaya</i>	Medical	53	320	16.6
<i>Amaranthus hybridus</i>	Medical	37	288	12.8
<i>Elaeis guineensis</i>	Others	41	403	10.1
<i>Irvingia gabonensis</i>	Medical	24	274	8.7
<i>Anacardium occidentale</i>	Others	17	267	6.3
<i>Elaeis guineensis</i>	Ornamental	25	403	6.2
<i>Musa sapientum</i>	Medical	24	391	6.1
<i>Ocimum gratissimum</i>	Medical	16	272	5.8
<i>Elaeis guineensis</i>	Medical	18	403	4.4
<i>Mangifera indica</i>	Medical	11	264	4.1
<i>Cocos nucifera</i>	Others	14	391	3.5
<i>Capsicum annum</i>	Medical	9	262	3.4
<i>Manihot esculenta</i>	Medical	9	265	3.3
<i>Carica papaya</i>	Building	9	320	2.8
<i>Abelmoschus esculentus</i>	Medical	7	259	2.7
<i>Persea americana</i>	Medical	7	257	2.7
<i>Colocasia esculenta</i>	Medical	7	261	2.6
<i>Corchorus olitorius</i>	Medical	7	260	2.6
<i>Musa paradisiaca</i>	Medical	10	398	2.5
<i>Solanum melongena</i>	Medical	6	260	2.3
<i>Dioscorea rotundata</i>	Medical	6	263	2.2
<i>Ocimum gratissimum</i>	Others	6	272	2.2
<i>Celosia argentea</i>	Medical	5	255	1.9
<i>Sorghum bicolor</i>	Others	5	258	1.9
<i>Carica papaya</i>	Religious	6	320	1.8
<i>Manihot esculenta</i>	Others	5	265	1.8
<i>Zea mays</i>	Medical	4	254	1.6
<i>Cajanus cajan</i>	Medical	4	256	1.5
<i>Colocasia esculenta</i>	Others	4	261	1.5
<i>Cucumis lanatus</i>	Building	4	261	1.5
<i>Cucumis lanatus</i>	Medical	4	261	1.5
<i>Dacryodes edulis</i>	Medical	4	256	1.5
<i>Dioscorea rotundata</i>	Religious	4	263	1.5
<i>Ipomoea batatas</i>	Medical	4	258	1.5
<i>Lycopersicon esculentum</i>	Medical	4	255	1.5
<i>Oryza sativa</i>	Medical	4	257	1.5
<i>Solanum melongena</i>	Religious	4	260	1.5
<i>Telfairia occidentalis</i>	Religious	5	330	1.5
<i>Vigna unguiculata</i>	Medical	4	256	1.5
<i>Arachis hypogaea</i>	Building	5	357	1.4
<i>Arachis hypogaea</i>	Others	5	357	1.4

Table 8 (continued)

Crops	Use Category	lp	lu	FL Value%
<i>Oryza sativa</i>	Others	3	257	1.2
<i>Prunus albidum</i>	Medical	3	256	1.2
<i>Prunus albidum</i>	Others	3	256	1.2
<i>Sesamum indicum</i>	Medical	3	254	1.2
<i>Capsicum annum</i>	Others	3	262	1.1
<i>Corchorus olitorius</i>	Others	3	260	1.1
<i>Cucumis lanatus</i>	Others	3	261	1.1
<i>Dioscorea rotundata</i>	Others	3	263	1.1
<i>Ipomoea batatas</i>	Others	3	258	1.1
<i>Mangifera indica</i>	Others	3	264	1.1
<i>Sorghum bicolor</i>	Medical	3	258	1.1
<i>Cocos nucifera</i>	Medical	4	391	1
<i>Abelmoschus esculentus</i>	Others	2	259	0.7
<i>Cajanus cajan</i>	Others	2	256	0.7
<i>Cocos nucifera</i>	Ornamental	3	391	0.7
<i>Dacryodes edulis</i>	Others	2	256	0.7
<i>Musa sapientum</i>	Building	3	391	0.7
<i>Carica papaya</i>	Others	2	320	0.6
<i>Telfairia occidentalis</i>	Others	2	330	0.6
<i>Musa sapientum</i>	Ornamental	2	391	0.5
<i>Amaranthus hybridus</i>	Religious	1	288	0.3
<i>Ipomoea batatas</i>	Religious	1	258	0.3
<i>Lycopersicon esculentum</i>	Others	1	255	0.3
<i>Manihot esculenta</i>	Ornamental	1	265	0.3
<i>Sesamum indicum</i>	Others	1	254	0.3
<i>Vigna unguiculata</i>	Building	1	256	0.3
<i>Vigna unguiculata</i>	Others	1	256	0.3
<i>Musa paradisiaca</i>	Ornamental	1	398	0.2
<i>Vernonia amygdalina</i>	Building	1	481	0.2

Lp, number of participants who reported the utilization of the crop for a specific use category; lu, the total number of participants who mentioned the same crop for any use category

valuable plants like cocoa (*Theobroma cacao*) and cashew (*Anacardium occidentale*). A total of 36 crop species were identified across the six LGAs in Afenmai land, encompassing 20 botanical families (Supplementary Table 2). The diversity of crops and their distribution varied across the LGAs, with Poaceae being the most represented family. This diversity is crucial for ensuring food security and providing multiple income sources for farmers (Emefiene et al. 2018). Research has shown that crop diversification can mitigate risks associated with climate variability

Table 9 Relative frequency of citation and their cultural value index of crops in Afenmai land

Crops	No of Use category	NPCS	RFC	CV
<i>Abelmoschus esculentus</i>	3	86	0.34	0.02
<i>Amaranthus hybridus</i>	3	164	0.65	0.1
<i>Anacardium occidentale</i>	2	123	0.49	0.05
<i>Arachis hypogaea</i>	4	167	0.66	0.14
<i>Cajanus cajan</i>	3	86	0.34	0.02
<i>Capsicum annum</i>	3	126	0.5	0.05
<i>Carica papaya</i>	5	208	0.83	0.18
<i>Celosia argentea</i>	2	86	0.34	0.02
<i>Cocos nucifera</i>	5	209	0.83	0.26
<i>Colocasia esculenta</i>	3	211	0.44	0.07
<i>Corchorus olitorius</i>	3	128	0.51	0.05
<i>Cucumis lanatus</i>	4	123	0.49	0.05
<i>Dacryodes edulis</i>	3	166	0.66	0.09
<i>Dioscorea rotundata</i>	4	164	0.65	0.09
<i>Elaeis guineensis</i>	5	208	0.83	0.24
<i>Ipomoea batatas</i>	4	123	0.49	0.05
<i>Irvingia gabonensis</i>	2	80	0.32	0.02
<i>Lycopersicon esculentum</i>	3	84	0.33	0.02
<i>Mangifera indica</i>	3	42	0.16	0.01
<i>Manihot esculenta</i>	4	167	0.66	0.09
<i>Musa paradisiaca</i>	4	209	0.83	0.24
<i>Musa sapientum</i>	5	209	0.83	0.23
<i>Ocimum gratissimum</i>	3	39	0.15	0.01
<i>Oryza sativa</i>	3	84	0.33	0.02
<i>Persea americana</i>	2	86	0.34	0.03
<i>Prunus albidum</i>	3	81	0.32	0.02
<i>Saccharum officinarum</i>	1	41	0.16	0.01
<i>Sesamum indicum</i>	3	83	0.33	0.02
<i>Solanum melongena</i>	3	84	0.33	0.03
<i>Sorghum bicolor</i>	3	84	0.33	0.02
<i>Talinum triangulare</i>	2	250	1	0.28
<i>Telfairia occidentalis</i>	4	250	1	0.26
<i>Theobroma cacao</i>	1	44	0.17	0.01
<i>Vernonia amygdalina</i>	3	250	1	0.38
<i>Vigna unguiculata</i>	4	84	0.33	0.02
<i>Zea mays</i>	2	42	0.16	0.01

RFC, Relative Frequency of citation; CV, Cultural Value Index; NPCS, number of participants that cited crop

and market fluctuations, thereby enhancing resilience in farming systems (Di Falco & Chavas 2009). Moreover, the cultivation of leafy vegetables like *Amaranthus hybridus* and *Celosia argentea* is vital for nutritional security, providing essential vitamins

and minerals that are often lacking in staple-based diets (Mavengahama et al. 2013). However, only eight species were common across all LGAs, indicating a degree of specialization or preference for certain crops within specific areas (Table 1). The economic and cultural importance of these crops is underscored by their varied uses and the parts utilized for food (Table 2). For example, the high representation of shrubs such as *Anacardium occidentale* and herbs like *Ocimum gratissimum* highlights the diverse agricultural landscape and potential for varied crop utilization strategies tailored to local needs and conditions. The study's findings also highlighted significant variability in species similarity among the LGAs, as indicated by the Jaccard Index (Table 3). The high similarity between Etsako West and Owan West (JI=100) suggests shared agricultural practices and cultural affinities, while the low similarity between Etsako Central and Owan East (JI=38.24) points to possible ecological or cultural differences influencing crop selection and cultivation. These findings align with other investigation that have noted similar patterns of crop diversity influenced by local ecological and cultural contexts (Mobolade et al., 2019; Ng'ang'a et al., 2016; Mutungi et al. 2015).

Preservation and market dynamics revealed additional insights into crop management practices. The diversity of preservation methods, from sun-drying to storage in bags and baskets, reflects adaptations to both environmental conditions and economic constraints (Table 5). Crops like *Zea mays* and *Theobroma cacao*, which employ multiple preservation techniques, indicate a versatile approach to ensuring food availability and reducing post-harvest losses. However, the mixed responses regarding the impact of preservation on taste (Supplementary Table 5) suggest a need for improved methods that maintain both nutritional quality and consumer preferences. The preservation methods employed for various crops, such as sun drying, refrigeration, and storage in bags or bowls, reflect traditional knowledge systems adapted to local conditions. However, the effectiveness of these methods varies, with some preservation techniques improving taste while others detract from it. For instance, preservation improved the taste of *Arachis hypogaea* (groundnut) for 14% of participants but worsened it for 6%. These findings are consistent with research showing that traditional preservation methods can both positively and negatively

impact the sensory qualities of food, depending on the crop and method used (Opara 2010). Improving preservation techniques could enhance food quality and reduce post-harvest losses, which remain a significant challenge in Sub-Saharan Africa (Affognon et al. 2015). The conservation status data reveal that certain crops are overutilized (e.g., *Dioscorea rotundata*), while others are scarce or no longer found in the region (e.g., *Saccharum officinarum*). Overexploitation of certain crops remains unsustainable, even when they are sufficiently produced by farmers, as it can deplete soil nutrients, increase reliance on chemical inputs, and reduce biodiversity, all of which threaten the long-term health of agricultural systems and ecosystems (Foley et al., 2011; Tilman et al., 2011; Altieri 2018). This aligns with findings from other research that highlight the threats to agricultural biodiversity due to overexploitation, land-use changes, and climate change (Jarvis et al. 2008). Sustainable agricultural practices, such as crop rotation and agroforestry, can help conserve these critical resources while enhancing soil fertility and biodiversity (Altieri 2018; Ogwu and Osawaru 2023; Ogwu et al. 2023b). Policies aimed at promoting the sustainable use of plant genetic resources and supporting community-led conservation initiatives are crucial to maintaining agricultural diversity and resilience.

Economic considerations also play a crucial role in crop management. The pricing and market dynamics (Supplementary Table 4) highlight the economic value of different crops, with some, like *Oryza sativa*, fetching high prices in the market. In contrast, others, such as *Ocimum gratissimum*, are less commercially traded, indicating a preference for home cultivation and consumption. This economic behavior could influence the types of crops preserved and the methods employed, underscoring the importance of aligning preservation strategies with market demands and cultural preferences. The study shows that most crops are available all year round (71.8%), while others are seasonal. The availability of crops like *Abelmoschus esculentus* primarily during the rainy season reflects the region's agro-climatic conditions and has implications for market dynamics and food prices. Seasonal variations in crop availability can lead to price volatility and affect food accessibility for low-income households (Swinnen et al., 2021). Developing infrastructure for better storage and transportation, along with introducing cultivars adapted to different

climatic conditions, could help stabilize food supply and prices throughout the year (Pingali 2012). The study also explored the cultural significance of crops, as reflected in their utilization patterns across different categories (Supplementary Table 11). Crops like *Amaranthus hybridus* and *Arachis hypogaea* were predominantly used in fresh and processed forms, respectively, highlighting the diversity in crop use based on cultural practices and preferences. This variation in crop utilization is further supported by the high use value and relative importance of crops like *Vernonia amygdalina* and *Cajanus cajan*, which were found to have the highest cultural value indices (Tables 7 and 9). These crops play a vital role not only in the local diet but also in cultural and medicinal practices, as evidenced by the high-fidelity levels in the food and medicinal categories (Table 8; Ogwu and Ikhajagbe 2024). The findings suggest that while some crops are integral to local culture and everyday life, others are more specialized and used in specific contexts or for specific purposes. This specialization is crucial for understanding how different crops are valued and managed within the community, providing insights into potential areas for intervention to enhance food security and sustainability. For instance, the high cultural value and diverse uses of crops like *Vernonia amygdalina* and *Cocos nucifera* indicate a strong basis for promoting their conservation and sustainable utilization, aligning with previous findings on the importance of cultural values in agricultural practices (Roselló-Soto et al. 2018; Christiansen et al. 2020; Prieto-Santiago et al. 2020).

Conclusions

The findings from this research underscore the need for targeted interventions to improve crop preservation and conservation methods in Afenmai land. Traditional preservation techniques, while valuable, may not suffice in reducing post-harvest losses or ensuring food security. Modern technologies could offer promising alternatives to traditional methods, enhancing crop shelf life and reducing losses. These technologies, including Evaporative Cooling Systems, solar-powered cold rooms, and hermetic storage solutions, provide sustainable options that align with local conditions and cultural practices. To effectively implement these innovations, it is vital to provide

training for local farmers and raise awareness about the benefits of improved preservation methods. Collaborative efforts among farmers, support for technology adoption, and public awareness campaigns are essential for promoting sustainable agricultural practices and enhancing food security in the region. Overall, improving post-harvest management practices, expanding access to effective storage facilities, and fostering community engagement in sustainable agricultural initiatives are critical for ensuring long-term food security and resilience against food scarcity in Afenmai.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval and consent to participate Ethical approval for the study was obtained from the Institutional Review Board of the Research and Scientific Committee, Auchi Polytechnic, Nigeria with the reference # AUCPOLY/010/2024/023. Informed consent was obtained from all participants before data collection. Participants were assured of the confidentiality and anonymity of their responses, and their participation was voluntary.

Consent for publication All the author expressly consents to the publication of the work.

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