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RESEARCH ARTICLE

Smallholder Farmers' Use of Indigenous Knowledge Practices in Agri-food Systems: Contribution of Food Security Attainment Drive

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Abstract: Most of the world's poor, including those in Nigeria, live in rural and agrarian settings and are engaged in agricultural practices for sustenance. Meanwhile, increasing agricultural productivity requires the adoption of modern technologies and improved farming systems, which entail considerable cost outlays for initial adoption and continued use. These costs may be out of reach for resource-poor smallholder farmers, hence the need to embrace indigenous knowledge practices (IKPs) in an agrarian economy such as Nigeria. This research examined the contribution of farmers' food security attainment efforts through the use of IKPs. Drawing on a documentary review of literature and empirical evidence, as well as data collected from 349 randomly selected smallholder farmers, the study applied descriptive statistics, a standardized food insecurity experience scale survey module, and a multivariate probit regression model to analyze the dataset. The findings revealed that almost 86% of the farmers have a strong and positive perception of the effectiveness of IKPs on agricultural production, while approximately 90% of the farmers are food insecure (those in the chronic and moderate food insecurity categories). The results also indicated that farmers' food security status, household size vis-à-vis dependency ratio, awareness of IKPs, age of the farmers, years of farming experience, access to extension services, and frequency of visits by extension personnel significantly influenced farmers' use of traditional farming practices, crop selection/rotation strategies, and water management techniques in the study area. Despite the farmers' use of IKPs, most of them are still largely food insecure, which raises serious concerns. Given this, the study recommends a multi-stakeholder partnership to foster synergies between the use of indigenous knowledge and modern scientific approaches by farmers, harnessing the complementary strengths of both knowledge systems to address the contemporary challenges faced by smallholder farmers in the agri-food systems.

Keywords: Smallholder farmers; Indigenous knowledge practices; Food insecurity experience scale module; Documentary review; Multivariate probit model

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1. Introduction

The food system represents an interdependent chain of activities involving production, processing and distribution, and consumption which aim to bring satisfaction to human needs [1,2]. Smallholder farming plays a pivotal role in the food systems and agrarian landscape in Nigeria [3], especially in south-west Nigeria. The region, consisting of states such as Osun, Oyo, Osun, Ekiti, Ondo and Lagos, is characterized by a predominantly agricultural economy with a significant portion of the population engaged in small-scale farming activities (smallholders) [4,5]. The term "smallholder" according to Nwaobiala, Alozie and Anusiem [6] refers to farmers who cultivate relatively small plots of farmland, and are often characterized by inadequate access to resources, including land, capital, and technology, with the primary focus on the cultivation of staple crops such as cassava, yams, maize, and rice, and such farmers often employ traditional farming techniques, passed down through generations, which are adapted to the local environmental conditions and resources available to them.

The farming system in Nigeria, particularly South-west Nigeria is diverse, reflecting the varied climatic and soil conditions across different areas within South-Western Nigeria, but are also faced with numerous challenges, including land degradation, unpredictable weather patterns, and limited access to markets. Importantly, the vulnerability of smallholder farmers to external shocks, such as droughts and market fluctuations seriously underscores the importance of using sustainable agricultural practices that enhance resilience and reduce dependence on external factors [7,8]. Generally, smallholder arable farmers encounter a myriad of challenges that significantly impact their agricultural productivity and overall livelihoods. One of the primary challenges is land degradation, a consequence of unsustainable farming practices, deforestation, and soil erosion [8]. As a result, farmers face a reduction in arable land, limiting their capacity to cultivate crops and affecting overall yields. Another critical challenge is the unpredictable and increasingly erratic weather patterns because changes in rainfall patterns and prolonged droughts can lead to crop failure, posing a threat to food security for both the farmers and the broader community [3]. This in addition to extreme weather events such as floods can cause significant damage to crops and infrastructure, exacerbating the vulnerability of smallholder arable farmers [8]. Access to markets is another persistent challenge for smallholder farmers in South-Western Nigeria [7], while limited infrastructure and inadequate transportation setups further create very difficult conditions for the farmers in their bid to transport their produce to markets promptly and with little cost [3]. All these not only affect their income but also contribute to post-harvest losses, as perishable goods may spoil before reaching the final consumers. In addition to limited access to credit and financial resources which hinders farmers' ability to invest in improved seeds, fertilizers, and mechanized equipment, which also keeps them in a cycle of low productivity and subsistence farming, smallholder farmers often face challenges related to the adoption of modern agricultural technologies and practices. Aside from the highlighted factors, the sustainability of farming systems is also increasingly threatened by factors such as population growth, urbanization, and the encroachment of modernization, which hitherto threatens the attainment of the zero hunger target of the country, in line with the United Nations' Sustainable Development Goal 2 (SDG2) [9,10]. Food security is a critical issue in today's society due to its direct link to the well-being of the population and the overall stability of the society. Given the peculiarity of the study area and Nigeria at large, with agriculture serving as the primary source of livelihood for a substantial proportion of the population, food security attainment is intricately tied to the success and sustainability of the agri-food sector vis-à-vis smallholder farming system [11,12]. Ensuring food security is not only essential for meeting the nutritional needs of the population but also for promoting social and economic stability.

Given various challenges encountered by farmers and the recent development in the agri-food sector, there is an increasing "rejuvenated recognition" of the application of indigenous knowledge practices (IKPs) which are environmentally friendly and cost-effective, to achieve sustained development in farming operations [13]. Farmers employ a range of IKPs that have evolved over generations and are deeply rooted in the local agricultural context. These IKPs encompass various aspects of farming, including traditional cultivation methods, crop selection/rotation strategies and water management techniques [13–16]. The practices play a crucial role in addressing the challenges faced by smallholder arable farmers in the agri-food systems.

In lieu of all the identified challenges facing the agri-food systems, and the potential pathway to ameliorate, recognizing and leveraging IKPs are essential steps toward developing sustainable solutions for the challenges faced by smallholder arable farmers, this research was guided by the following objectives. The first objective of this research is to identify the farmers' specific personal and socio-economic characteristics, as well as IKPs employed by them in the study area, which aim to provide a proper understanding of the rich tapestry of indigenous knowledge that underpins the agricultural practices of smallholder farmers in the region. The second objective assessed the farmers' perception about the effectiveness of the IKPs, while the third objective investigated the farmers' food security status. Equally, the fourth objective examined if farmers' food security drive and other dynamics influence the farmers' use of IKPs in the study area, while the study also hypothesized that there is no difference in the use of IKPs between male and female farmers in the study area.

This research holds significant importance in contributing to the existing body of knowledge on sustainable agriculture and food security attainment, particularly in the context of harnessing IKPs with modern scientific approaches by the smallholder farmers in Nigeria. First and foremost, most of the previous related studies in Nigeria, Africa and the world over have largely focused on the use of IKPs by farmers to drive food security status [17–27]. However, our study investigated the influence of people's food security drive on the use of IKPs by farmers. It is important to stress that people's concerns and needs are crucial areas to consider in order to incorporate indigenous knowledge practices to achieve the desired rural development outcome [28]. This is in line with Abraham Maslow's hierarchy of needs, governed by motivational theory, which also models human needs [29,30]. Deficiency needs arise due to deprivation (in this case, food insecurity) and are said to motivate people to take action (in this case, the use of IKPs) when they are not met. More so, the motivation to fulfill such needs will become stronger the longer the duration they are denied. For instance, the longer an individual stays without food, the hungrier they will become, and when such happens, steps needed will be taken to be food secure through- food availability, food accessibility and food utilization based on dietary requirements. Indeed, Maslow [30] also stated that individuals must satisfy lower level deficit needs (physiological or basic needs—food, water and shelter) before progressing on to meet higher level growth needs (safety needs, esteem needs, and self-actualization or self-fulfillment needs). This is particularly useful for understanding what motivates and fulfills human existence [29,30]. This theory places the urge and the need for food (in this case, food security) among others, as an integral part of human needs for self-fulfillment, and it is essentially the first step to a successful agrarian development plan in terms of farmers' drive towards food security attainment by using local knowledge in farming activities. This position cannot be more apt than in the context of using IKPs to boost food productivity, and in turn, the urge and drive to be food secure which influences the use of indigenous knowledge practices, which is also motivated by local needs.

The findings of this research can enhance the academic discourse on sustainable agriculture that have evolved over generations, by shedding more light on the empirical perspectives of the efficacy of indigenous practices. Traditional farming methods, rooted in local ecosystems, often demonstrate resilience and adaptability, offering important insights for broader sustainable agriculture practices globally. As such, this study contributes to the global discourse on sustainable agriculture by showcasing the relevance of food security attainment drive by farmers towards the use of IKPs, while at the same time promoting environmentally friendly and resilient farming practices.

2. Review of Literature on the Concept of Farmers' Indigenous Knowledge Practices in Agriculture

Many extant studies have been conducted on the application of farmers' indigenous knowledge in farming systems. According to Nnadi, Chikaire and Ezudike [17], as well as File and Nhamo [26], food security attainment can be driven through the application of various IKPs by farmers, and vis-à-vis. Food security is a multidimensional concept encapsulating the availability, accessibility, utilization, and stability of food resources to ensure a consistent, nutritionally adequate diet for all members of a population [31,32]. The framework governing the use of IKPs and achieving food security recognizes the interconnectedness of various factors, including agricultural production, distribution systems, socio-economic conditions, ecological and cultural standings of society as well as policy environments [26,27]. Given the various age-long farmers' practices embedded in IKPs, this study broadly grouped IKPs into traditional farming methods, crop selection/rotation strategies, and water management techniques.

2.1 Traditional Farming Methods

Traditional farming methods are agronomic practices, deeply embedded in the cultural fabric of farmers, and form a cornerstone of IKPs in agriculture. According to Melash et al. [27], these practices are often characterized by their adaptability to local environmental conditions and reliance on old practices, passed down through different generations. Intercropping, a common traditional farming method, involves planting different crops in proximity on the same piece of land. For example, yams might be planted alongside maize or cassava, creating a synergistic relationship among the crops. This practice not only maximizes land use efficiency, but also promotes biodiversity by providing a natural pest management strategy, as certain plant combinations deter and minimize the impact of pests and diseases more effectively than monocultures [33]. The success of intercropping is a testament to the indigenous knowledge that has guided farmers and the local communities in creating and harnessing the natural synergies between different crops for sustainable and resilient agricultural ecosystems [33]. Another traditional method involves the use of organic and natural fertilizers, such as animal manure and plant residues. These materials enhance soil fertility and structure, promoting sustainable and environmentally friendly farming practices [27,34]. The reliance on organic fertilizers aligns with the indigenous understanding of the interconnectedness of soil health, plant productivity, and overall agricultural sustainability.

Besides intercropping and the use of organic and natural fertilizers, traditional agronomic farming practices also encompass a spectrum of practices that showcase the resourcefulness of the smallholder farmers. Agroforestry is another notable practice where trees are integrated into agricultural landscapes. Trees provide shade, prevent soil erosion, and often contribute to the fertility of the soil through nutrient cycling [26]. Additionally, the practice of cover cropping, where specific crops are grown to cover and protect the soil during fallow periods, aids in maintaining soil structure and fertility [27]. These methods are rooted in indigenous knowledge, reflecting an understanding of the interconnectedness between different elements of the ecosystem. Furthermore, the utilization of natural pest control methods, such as planting certain crops to deter pests or introducing beneficial insects, is another dimension of traditional farming practices [27]. This reflects a profound understanding of ecological balances, where traditional knowledge is leveraged to minimize the use of chemical inputs, promoting a more sustainable and environmentally friendly farming system.

2.2 Crop Selection and Rotation Strategies

Indigenous knowledge practices also play a pivotal role in crop selection and rotation strategies among smallholder arable farmers. Farmers, guided by their deep understanding of the local climate and soil conditions, have developed practices for selecting and cultivating crop varieties that are well-suited to the region [35]. This includes the preservation and cultivation of locally adapted seed varieties that have demonstrated resilience to environmental stressors [36]. The selection of indigenous crop varieties is a deliberate strategy to ensure food security in the face of changing environmental conditions. Crop rotation, another indigenous practice, involves alternating the varieties of crops grown in a particular area over time. Indigenous knowledge practice in crop rotation is often based on observing natural cycles and understanding the ecological balance required for sustainable agricultural production [19]. This practice works to prevent the depletion of specific soil nutrients and reduce the buildup of pests and diseases associated with monocropping, through which it maintains soil fertility, and enhances the long-term viability of farming systems and overall agricultural sustainability.

In addition to preserving local seed varieties, indigenous knowledge in crop selection involves an adequate understanding of the timing and conditions for planting as it relates to weather conditions. In particular, farmers often rely on traditional calendars, local weather indicators, and ecological cues to determine the optimal time for planting specific crops [37]. This temporal aspect of indigenous knowledge is critical for maximizing agricultural productivity and adapting to climate variations. Moreover, the traditional practice of seed saving and exchange plays a crucial role in maintaining biodiversity and resilience within crop varieties. Farmers save seeds from successful harvests and exchange them within the community, contributing to the conservation of genetic diversity. This practice ensures that local seed varieties well-suited to a particular region or ecological zone are perpetuated over a long time, thereby enhancing the adaptability of crops to changing environmental conditions [37].

2.3 Water Management Techniques

Water management techniques based on farmers' indigenous knowledge are critical for addressing the challenges posed by unpredictable and erratic weather patterns and other prevalent shocks and stressors in the agri-food systems by ensuring water availability for crops [38]. Traditional water harvesting methods, such as constructing small dams and reservoirs, are commonly employed to capture and store rainwater during the wet season, and this stored water serves as a valuable resource during periods of drought, ensuring a more reliable water supply for irrigation [39]. Furthermore, indigenous water management practices often involve the use of efficient irrigation systems such as furrow irrigation and basin irrigation, which are adapted to local topography and resource availability [39,40]. These methods are often more sustainable and cost-effective for smallholder farmers compared to modern irrigation systems. By relying on these traditional water management techniques, smallholder farmers are able to navigate the challenges of climate variability and ensure the sustainability of agricultural productivity, as well as contribute to the overall resilience of the farming systems. This is to say that indigenous water management practices showcase the resourcefulness of farmers in adapting to the challenges of climate variability. Importantly, the intricate web of IKPs in agriculture demonstrates the holistic understanding that smallholder arable farmers bring to their farming systems. These practices are not only a reflection of cultural heritage but also practical strategies for sustainable and resilient agriculture.

2.4 Theoretical Underpinnings

This study draws upon theoretical frameworks and methodologies that recognize the importance of indigenous knowledge systems, sustainable agriculture, and their potential impact on food security status. It is important to reiterate that many theories such as sustainable livelihood framework, social capital theory, agro-ecological systems theory, cultural ecology theory, resilience theory, food sovereignty theory, community-based participatory research approach, ethnopedology, intersectionality theory, as well as the political ecology theory, are all applicable within the context of this important discourse, and has been mostly used in isolation to interrogate many related studies, which this study considered as a gap. Hence this study adopts intersectionality theory and ethnopedology method to bridge the gap. Intersectionality theory encompasses most of the listed theories, and the theory, according to Smooth [41], embraces the intricacies of group-based affairs by critically analyzing the variations in social positioning among individuals identifying with different groups, and has permeated various disciplines, evolving into a methodological framework where theoretical considerations guide decisions regarding research design, data analysis, and praxis. In essence, intersectionality posits that multiple socio-demographic factors, including ethnicity, race, sexuality, class, and gender, can interrelate concurrently within systems of power to influence individual experiences [42,43], while ethnopedology is an interdisciplinary approach that integrates elements from natural and social sciences with the primary goal of documenting and enhancing the understanding of local indigenous knowledge for sustainable development [44].

More specifically, the intersectionality theory recognizes that individuals and communities experience multiple interconnected social categories and identities. In the context of smallholder farmers, considering the intersectionality of factors such as gender, ethnicity, and socioeconomic status can indeed provide a more proper knowledge of how IKPs influence farmers' livelihood, food security and other welfare outcomes. Given the sustainable livelihoods framework, the theory provides a holistic approach to understanding the various factors that influence people's livelihoods, including food security. It considers the different assets (human, social, natural, physical, and financial) that individuals and communities use to achieve sustainable livelihoods. In the context of smallholder arable farmers, the framework helps to assess how IKPs contribute to livelihood sustainability and food security. On the other hand, social capital theory emphasizes the importance of social relationships, networks, and community cohesion. In the context of smallholder farmers, the theory can be used to explore how IKPs are embedded in social networks, facilitating information exchange, mutual support, and collaborative efforts that enhance food security. More so, agro-ecological systems theory focuses on the ecological dynamics of agricultural systems and emphasizes the importance of sustainable and environmentally friendly practices. In the context of smallholder arable farmers, the application of IKPs may align with agro-ecological principles, contributing to the resilience and productivity of agro-ecosystems. Further, cultural ecology explores the relationship between culture and the environment. In the context of IKPs, cultural ecology helps to understand how traditional practices, beliefs, and knowledge systems shape smallholder farmers' interactions with their agricultural environments and influence food security outcomes, while the resilience theory is focused on the capacity of systems to absorb shocks, adapt, and transform in the face of disturbances. Conversely, ethnopedology, as outlined by Barrera-Bassole and Zinck [45], stands as a pivotal research methodology aimed at formalizing local indigenous knowledge into classification systems while evaluating the practices of agro-ecological management. Indigenous agricultural knowledge, underscored by Tella [46] as well as Ajayi and Mafongoya [47], has long been a cornerstone of agricultural advancement, representing a structured and communal reservoir of knowledge, practices, and beliefs evolving through adaptation processes and cultural transmission across generations. Through this collective knowledge, as emphasized by Maroyi [48], farmers have adeptly cultivated food crops amidst varying environmental conditions and seasonal fluctuations, devoid of external inputs, resources, and scientific insights. This paradigm could potentially dissuade farmers from resorting to synthetic agrochemicals, instead promoting indigenous methodologies such as crop rotations and closed nutrient cycles for soil fertility restoration, as also supported by Maru et al. [19]. In essence, the application of IKPs by smallholder farmers may contribute to the resilience of their farming systems, helping them cope sustainably with climate variability, environmental issues, and other challenges that impact food security.

2.5 Global Case Studies: Relationship between Food Security and Indigenous Knowledge

Numerous case studies from different regions and countries underscore the positive relationship between indigenous knowledge and food security. For instance, in India, traditional agro-ecological practices like mixed cropping and crop diversification have been crucial in enhancing food security [49]. Similarly, in parts of South Africa and some other countries in Sub-Saharan Africa, indigenous knowledge in water management, such as the construction of terraces and traditional irrigation systems, has played a pivotal role in ensuring consistent agricultural productivity [38–40]. In China, the utilization of traditional crop varieties and indigenous farming practices has contributed to the resilience of agricultural systems, particularly in the face of climatic uncertainties [24]. These case studies collectively emphasize the adaptability, sustainability, and resilience embedded in indigenous knowledge systems, as the studies highlight how indigenous practices contribute not only to immediate food production but also to the long-term food security of communities facing diverse environmental challenges.

Building on the case studies, examples from Ethiopia demonstrate the efficacy of indigenous agricultural knowledge and practices in enhancing food security. In the Ethiopian highlands, farmers employ traditional terracing techniques to prevent soil erosion and conserve water, allowing for more efficient agricultural practices by the farmers [27,50]. The incorporation of livestock into cropping systems, another indigenous practice, provides additional benefits through manure production and draft power, contributing to sustainable farming [50]. These examples highlight the multifaceted nature of indigenous knowledge, addressing not only crop production but also soil health and integrated farming systems. In some parts of Southeast Asia, particularly in Vietnam, agro-ecological practices rooted in indigenous knowledge have played a crucial role in ensuring food security. This indigenous approach has led to increased crop yields, reduced input costs, and enhanced resilience to climatic variations, showcasing the adaptability and sustainability of traditional farming methods with modern farming systems [51,52]. In Uganda and Rwanda, IKPs, particularly traditional rainwater harvesting techniques, have been instrumental in addressing water scarcity challenges, where local communities developed methods to capture and store rainwater during the rainy season, ensuring a more reliable water supply for agriculture during dry periods [18,53]. Apparently, this practice showcases the adaptability of indigenous knowledge to specific environmental conditions.

Conservation agriculture practices in Zimbabwe provide another example of how indigenous knowledge contributes to food security. Techniques such as minimum tillage, crop rotation and cover cropping, deeply rooted in traditional farming practices, enhance soil health, reduce erosion, and enhance water retention, leading to increased agricultural productivity [22]. This illustrates the synergy between farmers' local knowledge, and sustainable conservation agricultural practices as described in Corbeels et al. [54], and Deligious et al. [55]. In Ghana, traditional fisheries management practices among coastal communities have sustained fish stocks for generations. Local knowledge about fish breeding seasons, migration patterns, and restricted fishing areas helps conserve marine resources [53,56]. This demonstrates the importance of incorporating indigenous wisdom into contemporary fisheries management strategies. Also, in Senegal, agroforestry practices exemplify the integration of trees into agricultural systems, where farmers combine traditional crop cultivation with the planting of fruit and nut trees, thereby contributing to increased biodiversity, improved soil fertility, and diversified income sources [20]. This case also highlights the multifaceted benefits of indigenous knowledge in enhancing food security.

While indigenous knowledge is often associated with non-western contexts, Europe also offers insightful case studies where traditional practices contribute to food security. In Switzerland, the maintenance of Alpine transhumance practices has been crucial. Transhumance involves the seasonal movement of livestock between different altitudes to optimize grazing resources. This ancient practice, deeply rooted in local knowledge, not only sustains traditional pastoralism but also enhances the productivity and biodiversity of alpine ecosystems [57]. In Sweden, the revitalization of traditional fishing techniques by the indigenous Sámi people has played a role in sustaining both cultural heritage and food security. The use of traditional fishing methods, such as net fishing through holes in ice, demonstrates an adequate understanding of the local ecology and contributes to the conservation of fish populations [58]. Further, in Greece, the preservation of traditional olive farming practices is emblematic of the importance of indigenous knowledge. The intricate knowledge passed down through generations on olive tree cultivation, harvesting, and processing not only contributes to the unique quality of Greek olive products but also ensures the resilience of this critical agricultural sector [21,59]. These European case studies underline the cross-cultural and global relevance of indigenous knowledge in sustaining food production and zero hunger. More so, the integration of these indigenous practices into modern resource management strategies has shown the relevance of indigenous knowledge for sustainable food systems.

The lessons drawn from the global case studies offer valuable understanding into the relationship between indigenous knowledge and food security, with direct applicability to Nigeria, and South-west Nigeria in particular. Firstly, the importance of maintaining crop diversity through traditional farming methods, as observed in India, aligns with the practice of intercropping and diversified cultivation traditionally seen in South-west Nigeria. Recognizing the efficacy of these practices emphasizes the need to preserve and promote indigenous knowledge to enhance local food security. Secondly, the case studies emphasize the significance of water management techniques in ensuring agricultural sustainability, a critical factor for South-west Nigeria facing climate variability. Lessons from regions like South Africa and other sub-Saharan African countries suggest that indigenous water harvesting and irrigation practices can be effective in mitigating the impacts of irregular rainfall patterns. In addition, the Zimbabwe example of rainwater harvesting also resonates with the region's vulnerability to climate variability. Indigenous water management practices, including the construction of small dams and reservoirs, can help mitigate the impact of erratic rainfall patterns in Nigeria. Furthermore, lessons from Zimbabwe's conservation agriculture practices align with the need for sustainable farming systems in South-Western Nigeria and Nigeria as a whole. Integrating traditional practices like minimum tillage, cover cropping, and crop rotation can enhance soil fertility, reduce the risk of erosion, and improve overall agricultural resilience. Moreover, the conservation of traditional seed varieties, as seen in Latin America (for instance, Mexico), aligns with the IKPs in crop selection and rotation commonly practiced in south-west Nigeria. The importance of preserving local seed banks and the knowledge associated with them becomes evident in the context of ensuring resilient agricultural systems.

Another key lesson is the importance of local adaptation. Indigenous knowledge practices are often finely tuned to the specific ecological and climatic conditions of a region. In the context of south-west Nigeria, understanding and respecting the local demands of the ecosystem are essential for the successful application of IKPs. Additionally, the integration of traditional and modern or scientific knowledge to improve soil health, as exemplified by the system of rice intensification in Vietnam, holds promise for southwest Nigeria. The Swedish case, as well as the Ghanaian examples of traditional fisheries management and agroforestry practices, respectively, emphasize the importance of preserving biodiversity and integrating trees into agricultural landscapes. In Nigeria and particularly the southwestern part of the country, where both fisheries and agriculture are vital, incorporating indigenous knowledge about fish breeding cycles and adoption of agroforestry practices can indeed contribute to long-term sustainability and attainment of food security drive and vision. Nigeria, and southwestern Nigeria in particular, with its rich aquatic resources, can benefit from the integration of indigenous fishing practices into contemporary fisheries management. Understanding fish migration patterns, breeding habitats, and traditional fishing calendars can contribute to the conservation of aquatic biodiversity and ensure the long-term sustainability of fishery resources.

The Swiss example of transhumance highlights the great importance of mobility in optimizing resource use. While the specifics differ, the concept aligns with the adaptability seen in Nigerian pastoralist communities. Given the prevalent conflicts between the farmers and herdsmen (pastoralists), indigenous knowledge about seasonal migration patterns and sustainable grazing practices can inform policies that support the resilience of livestock-based livelihoods, while at the same time addressing the seemingly unending conflicts and promoting peace. In addition, the Greek example underscores the importance of preserving traditional agricultural practices in society. For instance, in southwestern Nigeria, where cassava, maize, and rice are staples, acknowledging and preserving indigenous knowledge about cultivation, harvesting, and processing techniques is crucial. This includes the conservation of local seed varieties and the promotion of sustainable farming practices embedded in the cultural fabric of the region. Applying all these lessons requires a holistic approach that recognizes the intrinsic value of indigenous knowledge and combines this local wisdom with scientific insights from agricultural policies and extension services. Collaboration between local communities, researchers, and policy supports from policymakers to offer a blueprint for enhancing agricultural resilience and it is therefore essential to create a conducive environment that values and integrates indigenous knowledge into the broader framework of sustainable food security.

Collaborative efforts between local communities and farmers, researchers, extension services and policy supports from policymakers offer a blueprint for enhancing agricultural resilience can facilitate the exchange of knowledge and innovations, creating a synergy between indigenous knowledge practices and modern farming systems that can drive food production and ensure sustainable food security. This collaborative approach aligns with the concept of innovation platforms, where diverse stakeholders contribute to the co-creation of sustainable agricultural solutions.

3. Methodology

3.1 Study Area: Overview of South-Western Nigeria

The research was carried out in the South-west region of Nigeria, which constitutes one of the six geographical zones in the country. This region encompasses States such as Osun, Oyo, Ekiti, Ondo, Ogun, and Lagos (as illustrated in Figure 1). Positioned between longitudes 2°31' and 6°00' E as well as latitudes 6°21' and 8°37' N, the area covers 77,818 km^2 in land area, with a population of about 38,257,260 people as of 2016 [60]. Geographically, the study area is bordered to the North by Kwara and Kogi States, to the South by the Atlantic Ocean, to the East by Edo and Delta States, and to the West by the Republic of Benin [61]. The study area has a tropical climate, with distinct dry and wet seasons, and the temperature fluctuates between 25.6 °C and 35.5 °C, while rainfall also varies from 1300 mm to 2500 mm annually. The dry season is linked to the Northeast trade wind originating from the Sahara Desert while the Southwest monsoon wind from the Atlantic Ocean is linked with the wet season. Ecologically, South-west Nigeria features a combination of freshwater swamp and mangrove forest along the coastal belt. This ecological diversity supports the cultivation of various arable crops, including maize, cassava, yam, millet, rice, and plantains, alongside cash crops such as cocoa, oil palm, and cashew [61].

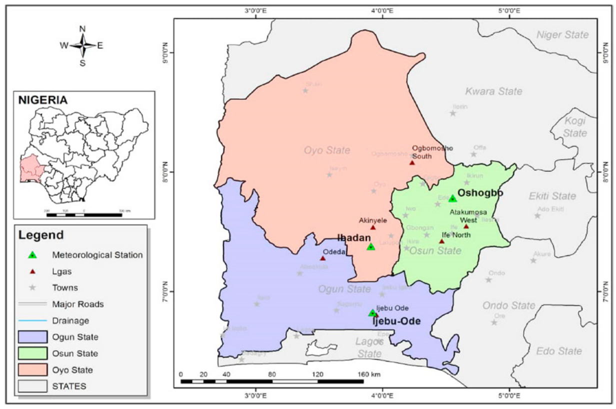

Figure 1. Map of the study area.

Source: Adeagbo et al. [61].

3.2 Sampling Technique and Data Collection Procedure

The selection of respondents for this study was made using a multistage sampling technique. In the first stage, three (3) states namely Ogun, Oyo, and Osun were selected purposively because of the predominance of arable crop farmers in those areas. For the second stage, three (3) Local Government Areas (LGAs) were randomly sampled from each of the selected states, while random proportionate to size technique was used to select one-third of the villages from each of the selected nine (9) LGAs across the three states under consideration in the third stage. Furthermore, the fourth stage employed random proportionate to size technique to select the sample size for this study. The study made use of the list of registered smallholder farmers obtained from the Agricultural Development Program (ADP) office in each of the states, which was helpful in the random-proportionate selection of the sample size used for this research.

The unit of analysis is smallholder farmers. Therefore, a total of three hundred and fifty-five (355) smallholder farmers were randomly selected and interviewed for this study. Cross-sectional data were elicited from these farmers using a well-structured interview schedule, which was developed in line with the study objectives. Information on farmers' personal and socio-economic characteristics, as well as other farm level data were collected from the respondents. The study also elicited information on farmers' indigenous knowledge, capturing the diversity and intricacies of IKPs, given the variations across different communities and environmental contexts in terms of ecological, cultural, and economic dimensions of these practices, so as to uncover the underlying principles and reasons behind their adoption. Additionally, the global standardized Food Insecurity Experience Scale Survey Module (FIES-SM) questions [62,63] were also adapted and incorporated into the interview schedule to assess direct experiences of food security vis-à-vis food insecurity of the sampled respondents in the study area. The FIES-SM comprises eight fundamental questions, each eliciting dichotomous responses. This survey instrument is designed to yield data that can be utilized for the generation of measures positioned on a scale, capturing a spectrum of food insecurity severity. It is imperative to underscore that the analysis of FIES items should be conducted collectively, and individual items should not be examined in isolation when formulating and presenting food insecurity estimates and status. The FIES-SM stands out as a versatile instrument and is characterized by its adaptability, offering both individual-referenced and household-referenced versions. The choice between these versions is contingent on the specific objective of the assessment, whether it is to evaluate food insecurity within the population based on individual or household-level data. Additionally, the tool allows for an examination of food insecurity experiences over different time frames, specifically over the past year, the past 30 days, or both, providing flexibility in addressing diverse temporal dimensions of food security assessment. In lieu of this, and given the nature of this study, an individual-referenced version which covers the past 30 days reference period was adopted.

Given the FIES scores, and following the guidelines of FAO [62], WFP [63], as well as Ballard, Kepple and Cafiero [64], the categorization of farmers' food security vis-à-vis food insecurity status, are as follows:

- Raw score 0–1: High food security (Food secure/Food surplus)
- Raw score 2–3: Marginal food security (Mild food insecurity/Food break-even)
- Raw score 4–6: Low food security (Moderate food insecurity/Transitory FIS)
- Raw score 7–8: Very low food security (Severe food insecurity/Chronic FIS)

The food security status of individuals can also be computed with the raw scores of between 0–1 and 2–3 points, which correspond to "high food security" and "marginal food security" respectively, been described as "food secure" category, while the combination of individuals' raw scores of between 4–6 and 7–8 points, which correspond to "low food security" and "very low food security" respectively, been described as "food insecure" category.

Furthermore, it is worthy of note to inform that during the analysis stage, 349 of the 355 copies of the instruments administered to the respondents were found to have complete and reliable information for analyses, thereby suggesting a response rate of approximately 98%.

3.3 Data Analytical Procedure

The first objective of this study which identified the farmers' specific personal and socio-economic characteristics and the IKPs employed by the farmers in South-Western Nigeria, was captured using descriptive statistics such as frequency distribution and percentages, mean, and standard deviation. The second objective which also assessed the farmers' perception of the effectiveness of the IKPs was captured through descriptive statistics. For the third objective, the global standardized FIES survey module was adopted to investigate the farmers' food security status and categorize them into the levels of food insecurity vis-à-vis food security status. A multivariate probit regression model was applied to examine the factors (including farmers' food security drive) influencing farmers' use of IKPs in the study area. In addition, the post-hoc test was carried out to establish the robustness, reliability, and validity of the fitted model.

Model Specification: Multivariate Probit Regression

The multivariate probit regression model is a statistical technique used to analyze the relationship between multiple categorical dependent variables and a set of predictor variables [65,66]. Unlike its univariate counterpart, which deals with a single dependent variable, the multivariate probit regression model accommodates situations where multiple dependent variables are interrelated [67]. Hence, the model provides a valuable tool for analyzing the simultaneous relationships among multiple categorical dependent variables [67]. The model estimates the correlation among the latent variables, allowing for the joint analysis of multiple outcomes, where each categorical dependent variable is assumed to follow a latent continuous variable, which is then transformed into observed categories through a threshold mechanism [67,68]. In essence, through the method of simulated maximum likelihood models, multivariate probit estimates M-equation probit models, where the variance-covariance matrix of the cross-equation error terms has values of 1 on the leading diagonal, and the off-diagonal elements are correlations to be estimated (ρ_{jk}=ρ_{kj}), and (ρ_{kj}= 1 for j = k, for all j, k = 1,..., M) [69]. Therefore, farmers' use of IKPs is considered as a system of a multiple choice equation with respect of each of the three broad groups of IKPs.

Mathematically, the relationships are expressed as follows:

IKP-traditional farming methods:

$$Y_1^* = X_1'\beta_1 + \varepsilon_{1i} \quad (1)$$

IKP-weather, crop selection and rotation strategies:

$$Y_2^* = X_2'\beta_2 + \varepsilon_{2i} \quad (2)$$

IKP-water management techniques:

$$Y_3^* = X_3'\beta_3 + \varepsilon_{3i} \quad (3)$$

Note that:

$$E(\varepsilon \backslash X) = 0,\ Var(\varepsilon \backslash X) = 1,\ Cov(\varepsilon \backslash X) = \rho \quad (4)$$

where:

Y_i^* = Latent response variables (the three broad IKPs, where: i = 1, 2, 3),

IKP-traditional farming methods, IKP-weather, crop selection and rotation strategies, and IKP-water management techniques are dichotomous variables with the value of 1 when i^{th} farmer selects any of the 3 IKPs respectively, and 0, otherwise,

X_1 to X_3 are the vectors of explanatory variables influencing the farmers' use of IKPs,

ρ's are the vectors of the simulated maximum likelihood parameters to be estimated,

ε_1 to ε_3 = correlated error terms in a seemingly unrelated multivariate probit model,

ρ's = tetrachoric correlations between endogenous variables.

4. Results

4.1 Farmers' Personal Characteristics and Key Indigenous Knowledge Practices Identified

The results of farmers' selected personal characteristics and key IKPs commonly employed by the farmers are presented in Table 1. The findings revealed that most (68.2%) of the farmers in the study area are of male gender, while 31.8 percent are female by gender. Furthermore, few proportion of the farmers are young, as about 7 percent and almost 12 percent fall within the age range of less or equal to 30 years and age range of 31–40 years, respectively. Then, almost 21 percent of them are middle age, who fall within the age bracket of 41–50 years. In addition, the aged population appeared to be predominantly involved in farming in the study area owing to the fact that 41.3 percent and about 19 percent of the farmers fall within the age range of 51–60 years and above 60 years. The estimated mean age is 50.6 which suggests that on average, a farmer in the study area is about 50 years of age. The import of the findings is that there is apathy of youths' participation in farming activities in the study area. The estimated average years of formal schooling by farmers was found to be 6.3 years, which implies that most of them had primary education, which also translates to having an elementary level of formal schooling based on the Nigerian educational system. Specifically, about 31 percent of the farmers' population had no formal education, while 12.9 percent of them had between less or equal to 6 years of education. It is noteworthy to point out that more than half (51.9%) of the farmers reportedly had between 7–12 years of formal schooling which according to the Nigerian educational system is a secondary school level of education (post-primary), while very few proportion (4.5%) of the farmers had above 12 years of formal schooling which is a tertiary level of education. From the results, almost one-third (32.4%) of the sampled farmers reported a household size of within 5 family members, while most (55.3%) had between 6–10 members in their respective households. More so, only a very few proportion (12.3%) of the farmers had more than 10 members in their respective households. Given the years of experience in farming, the majority (69%) of the farmers had more than 10 years of farming experience, 23 percent of them reported having between 6–10 years of experience, while only 8 percent of the farmers had farming experience in the range of 5 years. On average, the farmers had about 15 years of experience in farming activities which speaks well to the level of human capacity development among the farmers in the study area. Farmers' local level institutions (farmers' group) appeared to be an important source of information where most (66.5%) of the farmers share and transmit relevant ideas and experience on farming practices. Then, 20.3 percent of the farmers obtained information from the extension service personnel, while a few (13.1%) of them reportedly obtained information through the media outlet (especially the radio stations).

In terms of farmers' awareness of IKPs, about 59.3 percent of them are aware of what indigenous practices are, while the rest 40.7 percent claim unaware. Albeit, most of the farmers who reported non-awareness are in fact using at least one form of IKPs or the other, but did not know the specific term for it. Given the results, and consistent with Nnadi et al. [17] and Habakubaho et al. [25] reported in Southern African countries, the key IKPs commonly employed by most of the farmers are usage of traditional rain harvesting method, application of organic manure, crop rotation practice, usage of local knowledge for weather prediction, local strategy for pest and disease control, adoption of cover cropping, inter cropping and agroforestry systems, as well as local construction of small dams and reservoirs. Other IKPs reported by the few other farmers include the selection of crops that are best suited for the area and the usage of furrow and basin irrigation methods. All these indigenous practices constitute important decisions taken by the farmers in the course of their livelihood operations.

Table 1. Farmers' personal characteristics and key indigenous knowledge practices (n = 349).

Variables	Frequency	Percent	Mean	Std. Dev.
Gender			-	-
Female	111	31.8		
Male	238	68.2		
Age-group (years)			50.6	11.8
< 30	24	6.9		
31–40	41	11.8		
41–5	73	20.9		
51–60	144	41.3		
Above 60	67	19.2		
Years of formal education (years)			6.3	4.7
No formal	107	30.7		
< 6	45	12.9		
7–12 (post primary)	181	51.9		
Above 12 (post-secondary)	16	4.5		
Household size			7.2	2.7
< 5	113	32.4		
6–10	193	55.3		
Above 10	43	12.3		
Years of farming experience (years)			14.9	6.1
< 5	28	8.0		
6–10	79	23.0		
Above 10	242	69.0		
Awareness of IKPs			-	-
No	142	40.7		
Yes	207	59.3		
Sources of information on farming practices			-	-
Farmers' group	232	66.5		
Media	46	13.1		
Extension service personnel	71	20.3		
* **Indigenous knowledge practices (IKPs)**			-	-
IKP-traditional farming methods				
Intercropping	117	33.5		
Organic fertilizer manure	166	47.6		
Agroforestry	112	32.1		
Cover cropping	117	33.5		
Local pest and disease controls	132	37.8		
IKP-Crop selection & rotation strategies				
Crop preservation & selection (suited to the region)	88	25.2		
Crop rotation technique	151	43.3		
Local knowledge for weather prediction	144	41.3		
IKP-Water management techniques				
Construction of small dams and reservoirs	112	32.1		
Furrow and basin irrigation methods	74	21.2		
Traditional rain water harvesting method	190	54.4		

Source: Data analysis, 2024.

4.2 Farmers' Perception on the Effectiveness of IKPs

The findings in Table 2 revealed how the farmers rate the effectiveness of the IKPs employed on their livelihood outcome (agricultural production). The majority (55.6%) of the farmers perceived that the IKPs are effective, while nearly one-third (30.1%) of them reported the practices to be very effective. Very few (12%) of the farmers appeared to have an undecided opinion on the effectiveness of those practices, while only 2.3 percent of the farmers reported that the IKPs were ineffective. The implication of the findings is that the majority of the respondents seemed to have a positive perception about the effectiveness of the IKPs usage in their livelihood operations, which is in agreement with Anyan [70].

Table 2. Farmers' perception on the effectiveness of IKPs on agricultural production (n = 349).

Perception	Frequency	Percentage
Very ineffective	0	0.0
Ineffective	8	2.3
Undecided	42	12.0
Effective	194	55.6
Very effective	105	30.1

Source: Data analysis, 2024.

4.3 Farmers' Food Security Status

The findings in Table 3 show the food security status of the farmers in the study area. The results indicated that almost 11 percent of the farmers were in the severe food insecurity category, while the majority (79%) of them were found to be moderately food insecure. Likewise, approximately 9 percent of the farmers were found to be in the mild food insecurity group, while only 1 percent of them were found to be food secure. Given the findings, most of the farmers are moderately food insecure, while an insignificant proportion of them can be said to be food secure. The current state of food insecurity among the farmers is troubling, and this could also drive the farmers to adopt IKPs to mitigate the impact of climatic and other environmental stressors and shocks in a bid to boost agricultural production outcomes.

Table 3. Farmers food security/insecurity status (n = 349).

Food security status	Frequency	Percentage
Severe FIS/Chronic FIS	37	10.6
Moderate FIS/Transitory FIS	277	79.4
Mild food insecurity/Food break-even	31	8.9
Food secure/Food surplus	4	1.1

Note: FIS—Food insecurity status.

Source: Data analysis, 2024.

4.4 Determinants of Farmers' Use of Indigenous Knowledge Practices: Does Food Security Drive Matter?

The results of the multivariate probit regression model as presented in Table 4 showed that the likelihood ratio test is statistically significant at $p < 0.05$, suggesting that the null hypothesis of all the correlation coefficient (rho) values are jointly equal to zero ($\rho21 = \rho31 = \rho32 = 0$). Suffice it to say that all the three broad categories of IKPs used by the farmers are independently determined and are not accepted. As shown in Table 4, the chi-squared test value indicated that the separate estimation of the three broad categories of IKPs used by the farmers would have been biased and that the farmers' use of the three broad categories of IKPs is interdependent decisions made by the farmers. This further lends credence to the use of MVP model. In addition, the individual rho values which suggest the degree of correlation between each pair of the dependent variables showed that the correlation between farmers' use of indigenous crop selection/rotation strategies and indigenous farming methods ($\rho21$), as well as the correlation between the farmers' use of water management techniques and indigenous crop selection/rotation strategies ($\rho32$) are both positive and statistically significant at $p < 0.05$. This suggests that farmers using indigenous knowledge of crop selection/rotation strategies are more likely to use traditional farming methods too, while farmers using water management techniques are also more likely to use indigenous knowledge of crop selection/rotation strategies. Conversely, the correlation between farmers using water management techniques and traditional farming methods ($\rho31$) is negative and statistically significant at $p < 0.05$, suggesting that farmers using water management techniques are less likely to use traditional farming methods.

Given the variables' estimates from the fitted MVP model, the findings indicated a statistically significant and simultaneous influence of farmers' food security status (proxy by its index) (all at $p < 0.1$), household size ($p < 0.05$, $p < 0.05$ and $p < 0.1$, respectively), and dependency ratio ($p < 0.05$, $p < 0.01$ and $p < 0.1$, respectively) on the farmers' use of the use traditional farming methods, crop selection/rotation strategies, and water management techniques. By implication, and as expected, farmers' food security attainment drive is more likely to influence the use of IKPs, given that the majority of these farmers are food insecure in the study area by virtue of being moderately food insecure or being in the transitory food insecurity category. This result agrees with the submission of Ghebreyohannes et al. [50] where it was reiterated that the major focus of IKPs is to boost food security, while at the same time, farmers' food security can drive the use and/or continuing usage of IKPs. Likewise, an increase in household size is less likely to determine the use of traditional farming methods, crop selection/rotation strategies, and water management techniques. This does not align with a-priori expectations, and goes against what Ominikari and Okringbo [71] reported in their study conducted in the South-South region of Nigeria where household size was affirmed to have a direct influence on the use and sharing of IKPs. All else equal, an increase in household size should present the farmers with family labour advantage, and this is also expected to motivate the farmers to use more of these practices to boost food production for households consumption. However, a plausible explanation for this deviation could be because of the smallholding nature of the farmers, coupled with meagre resources the farmers operate with. Following up to the results on the household size, an increase in dependency ratio was also found to exert a less likely influence on the use of traditional farming methods and water management techniques, while dependency ratio was also indicated to induce a more likely influence on the farmers' use of crop selection/rotation strategies. The findings also revealed a statistically significant (all at $p < 0.1$) and simultaneous influence of awareness of IKPs on the use of traditional farming methods and crop selection/rotation strategies, suggesting that farmers' awareness of IKPs is more likely to influence the use of these two IKPs. This finding is in tandem with the results from the study by File and Nhamo [26] in Ghana, which highlighted the importance of awareness of the IKPs practices for the farmers derive maximum benefits. The study also emphasized that awareness can drive information dissemination among the farmers, possibly through peer groups where farmers share ideas based on experiences acquired over time. The age of the farmers was also found to have a statistically significant (all at $p < 0.05$) influence on the farmers' use of traditional farming methods and water management techniques. By implication, this suggests that ageing is less likely to influence the use of these two IKPs. Consistent with life cycle hypothesis, and in agreement with Anyan [70] and Melash et al. [27], this is expected, and understandable because as one age, the tenacity to engage in farming operations tends to diminish, given the drudgery nature of farming, which thus affects farmers' overall productivity. Also, farmers' years of experience in farming is statistically significant ($p < 0.1$, $p < 0.05$, respectively), and simultaneously determined farmers' use of traditional farming methods and water management techniques, which suggests that an increase in farmers' years of experience in farming is more likely to influence the use of traditional farming methods, while it was also found less likely to determine the use of water management techniques. The findings are supported by what File and Nhamo [26] as well as Melash et al. [27] reported in their separate studies in Ghana and Ethiopia respectively, where the studies reported the influence of years of farming experience on the use of indigenous practices by the farmers. Furthermore, access to extension service delivery exerts a statistically significant (all at $p < 0.05$) influence on farmers' use of traditional farming methods and crop selection/rotation strategies, respectively, which aligns with File and Nhamo [26] as well as Melash et al. [27]. The study by File and Nhamo [26] showed the influence of access to extension services on the use decision of IKPs, while that of Melash et al. [27] also advocated for the support of extension service personnel to assist in harnessing the use of IKPs with modern farming practices by the farmers in a bid to boost crop output. The implication is that good and timely extension service delivery is more likely to influence farmers' use of traditional farming practices, and crop selection/rotation strategies.

In addition, the results indicated that the frequency of visits by the extension personnel has a statistically significant (all at $p < 0.05$) and simultaneous influence on the use of crop selection/rotation strategies, and water management techniques by the farmers, which suggests that frequent visit by extension personnel is less likely to influence farmers' use of both IKPs mentioned. Apparently, this finding negates a-priori expectations because frequent visit of extension personnel should positively influence farmers' use of crop selection/rotation strategies, and water management techniques in the study area. Meanwhile, the deviation could perhaps be a result of more emphasis placed on modern farming practices by the extension personnel during their visits, which was cautiously flagged by Melash et al. [27] where it was emphasized that IKP represents a neglected human-based resource to achieve sustainable development, and this has created an intergenerational gap in utilization of IKPs and farming systems suffer for this.

Overall, the results revealed that farmers' specific characteristics, food security attainment drive and institutional arrangement in lieu of extension service delivery drive farmers' use of the three broad classifications of IKPs in the study area.

Table 4. MVP estimates: Determinants of farmers-use of indigenous knowledge practices.

Variable	**Coefficient**	**Std. error**	**z-value**	**p > |z|**
IKP-Traditional Farming Methods				
Food security index	0.4576	0.2657	1.72*	0.085
Awareness of IKP	0.2605	0.1494	1.74*	0.081
Gender	0.0478	0.1534	0.31	0.755
Age	−0.0794	0.0374	−2.12**	0.034
Years spent on formal education	0.0137	0.0151	0.90	0.367
Household size	−0.0728	0.0350	−2.08**	0.038
Dependency ratio	−0.0246	0.0106	−2.32**	0.020
Years of farming experience	0.0245	0.0144	1.70*	0.090
Access to labour	0.0948	0.1456	0.65	0.515
Access to extension services	0.2009	0.0890	2.26**	0.024
Frequency of extension visit	0.0577	0.1047	0.55	0.581
Constant	−2.6382	1.2529	−2.11	0.035
IKP-Crop Selection and Rotation Strategies				
Food security index	0.0553	0.0290	1.90*	0.057
Awareness of IKP	0.4949	0.2535	1.95*	0.051
Gender	0.1943	0.1568	1.24	0.215
Age	−0.0100	0.0068	−1.47	0.143
Years spent on formal education	−0.0139	0.0157	−0.88	0.378
Household size	−0.2467	0.1206	−2.05**	0.041
Dependency ratio	0.5434	0.1822	2.98***	0.003
Years of farming experience	0.0104	0.0149	0.70	0.486
Access to labour	−0.0441	0.1516	−0.29	0.771
Access to extension services	0.3557	0.1494	2.38**	0.081
Frequency of extension visit	−0.2507	0.1090	−2.30**	0.021
Constant	0.7046	0.5182	1.36	0.174
IKP-Water Management Techniques				
Food security index	0.1723	0.0934	1.84*	0.065
Awareness of IKP	−0.0915	0.1557	−0.59	0.557
Gender	−0.0302	0.1632	−0.19	0.853
Age	−0.0116	0.0056	−2.08**	0.037
Years spent on formal education	0.0184	0.0158	1.16	0.245
Household size	−0.0158	0.0090	−1.76*	0.078
Dependency ratio	−0.1821	0.1022	−1.78*	0.075
Years of farming experience	−0.0316	0.0156	−2.02**	0.043
Access to labour	0.2058	0.1529	1.35	0.179
Access to extension services	0.0092	0.1516	0.06	0.951
Frequency of extension visit	−0.0353	0.0176	−2.00**	0.046
Constant	0.9370	0.5135	1.82	0.068
/atrho21	0.2192	0.1002	2.19**	0.029
/atrho31	−0.3160	0.1742	−1.81*	0.070
/atrho32	0.0960	0.0511	1.88*	0.060
rho21	0.1265	0.0562	2.25**	0.024
rho31	−0.0433	0.0178	−2.43**	0.665
rho32	0.3088	0.1388	2.23**	0.026

Note: MVP—multivariate probit regression analysis.

Likelihood ratio test of rho21 = rho31 = rho32 = 0: $chi^2(3) = 2.31082^{**}$

Source: Data analysis, 2024.

5. Discussion

Several key findings have emerged after analyzing the determinants of farmers' use of indigenous knowledge practices, particularly focusing on the significance of food security drive, using the multivariate probit regression model estimates presented in Table 4. Specifically, the results focused on three indigenous knowledge practices which are the traditional farming methods, crop selection and rotation strategies, and water management techniques. The fitted model took into consideration the substantial influence of the farmers' food security status, their awareness of indigenous knowledge practices, gender, age, years spent on formal education, household size, years of farming experience, access to labour, access to extension services, frequency of extension visit as well as dependency ratio on their use of traditional farming methods. It is important to note that the intricate interplay of demographic factors shows that the farmers with higher food security attainment are more inclined to use IKPs, even as a significant portion of the respondents experienced moderate or transitory food insecurity. This result is in tandem with the findings of Ghebreyohannes et al. [50] where findings showed that farmers' food security influences the use of IKPs, while at the same time, IKPs have the potential to boost food production output, which by extension drives food security status.

5.1 IKP-Traditional Farming Methods (TFM)

The result of the determinants of farmers' use of indigenous knowledge practices expressed as Traditional Farming Methods (TFM) revealed that the food security status of the respondents has a significant influence in determining the use of traditional farming methods. This is not unexpected as the majority of the farmers in the study area are food insecure, and many of these smallholder farmers would want to engage in productive practices, including the use of IKPs to improve productivity and sustainability. The findings reported by Taye and Megento [72] in related research in Ethiopia corroborated the finding of this study where it was established that smallholder farmers utilized IKPs for the development of resilient farming systems for improved food production, which also influences food security condition. The contribution of the awareness of IKPs to the use of TFM by farmers is positive and significant. One could infer that the positive contribution of awareness of indigenous knowledge practices (IKPs) to the use of traditional farming methods suggests that farmers who are more aware of these practices are more likely to embrace traditional methods in their agricultural activities, which is in agreement with what File and Nhamo [26] reported in their study in Ghana where it was reported that awareness drives information dissemination among the farmers through peer group influence. In essence, this further highlights the importance of information/knowledge gathering as a key driver in promoting the deployment of traditional agricultural practices.

Household size has a negative effect on the use of TFM, suggesting that larger households are less likely to use these methods compared to smaller ones, and it has earlier been established that on average, farmers have about 7 individuals in their respective households. The finding does not agree with Ominikari and Okringbo [71] in a related study in Nigeria, where it was reported that larger household size has a direct effect on the use of IKPs. The implication of this deviation is that there may be challenges related to resource allocation, as larger households may face greater competition for resources within the household, leading to reduced use of traditional farming methods. Additionally, larger households may require more labor-intensive farming practices, which could deter them from using traditional methods as they might be perceived as less efficient. The negative effect of the dependency ratio on the use of TFM also suggests that as the dependency ratio increases, the odds of farmers using these methods reduce. With a higher dependency ratio, a larger percentage of dependent relatives to individuals of working age in a household, are associated with reduced use of TFM. Perhaps, this could mean that households with more dependents struggle in their allocation of labor or other productive resources needed towards implementing traditional farming practices, consequently leading to a decline in the use of IKPs.

Another factor that positively influences the use of TFM is years of farming experience. This suggests that there's a positive correlation between accumulated farming knowledge and the preference for traditional farming practices, because farmers who are experienced are believed to have a better understanding about this practice as well as leveraging on it for improved yield. In support of our findings, Melash et al. [27] also made it clear in their study conducted in Ethiopia on IKPs that years of experience in farming influences the use of indigenous practices by the farmers. In the same vein, the positive contribution of access to extension services to the use of TFM indicates that the respondents having access to extension agents are likely to use traditional practices in their farming activities.

This result reinforces the submission of Melash et al. [27] where it was stated that access to extension services influences the use decision of IKPs. By implication, this suggests that extension services and the frequency of visits by extension personnel play a crucial role in disseminating basic information and knowledge about traditional farming methods, thereby aiding their acceptance among farmers. Additionally, it also implies that every effort channeled to improving access to extension services can significantly contribute to the promotion of traditional agricultural practices for sustainable and resilient food production.

5.2 IKP-Crop selection and rotation strategies

The result of the determinants of farmers' use of indigenous knowledge practices expressed as crop selection and rotation strategies pinpoints that the food security status of the respondents in the study area has a positive and significant relationship with the use of crop selection/rotation strategies. This implies that as the farmers' food security status improves, they are more inclined to implement these strategies. This further tells that achieving food security is not only a necessity for achieving the smallholder farmer's adequate nutritional needs but equally influences their decision-making strength for varied and sustainable cropping practices in the study area.

In addition, awareness of indigenous knowledge practices has a positive and significant relationship to the use of crop selection/rotation strategies used by the respondents in the study area. This means that smallholders who are aware of traditional agricultural practices have a high likelihood of using crop selection and rotation techniques. This is an indication that an increase in the awareness and knowledge dissemination about IKPs has a potential pathway for interventions aimed at enhancing the fertility of the soil, crop diversity, as well as the management of pests, which are vital to a sustainable food system. Also, it underscores the fact that education is important in advancing the use of sound and resilient agricultural systems.

The contribution of household size to the use of crop selection/rotation strategies is negative, implying that households with a large number are less likely to use these practices. This could be a result of increased demands for labour within the farming household as well as the stress to coordinate/manage individual needs of the respondents. Furthermore, households with a large number of household members might be challenged in terms of management of crop rotation systems efficiently.

From the result obtained in Table 4, access to extension services is positive and significant. This further underscores the need for continued access to education from the extension agents to provide services and support for large households in order to overcome the challenges of the use of crop selection/rotation strategies. The dependency ratio of the respondents is positive with a significant relationship to the acceptance of crop selection/rotation strategies. This infers that the more the dependency ratio increases, there will be a parallel increase in the probability of the smallholders' rate of use of these methods. Households with many dependents compared with the working population, are prone to prioritize the IKP-crop selection and rotation. Factors responsible for this could be the need for the optimization of the use of land, improvement of soil fertility, as well as the desire to meet the farming household's nutritional demands.

Unexpectedly, the frequency of extension agent's visits to the respondents has a negative influence on their chances of using crop selection/rotation as strategy. Further to that, the result of the study suggests that increased interaction with extension agents does not automatically result in the acceptance of these strategies. This finding disagrees with what Melash et al. [27] put forward that extension service delivery is expected to motivate the use of IKPs because these practices represent a neglected local knowledge that is needed to drive sustainable development in the agri-food sector. This deviation could be attributed to a potential mismatch between the information needed by the smallholder farmers and the ones by the extension agents in relation to crop selection and rotation. It's important to note that extension services should always align their knowledge with the exact needs of the farmers.

5.3 IKP-Water management techniques (WMT)

The result of the determinants of farmers' use of indigenous knowledge practices expressed as water management techniques illustrates that the food security status of the respondents in the study area has a significant and positive relationship with the use of IKP-water management techniques (WMT). This signposts that an improvement in the respondent's food security condition increases their odds of using WMT. It is important to note that as the farmers strive to improve their food security condition, they are equally incentivized to accept methods that enhance water use, with potential improvement in food productivity. Therefore, addressing the food insecurity situation in the study area through appropriate agricultural development policy can be a means of boosting sustainable water management practices.

The negative influence of age on the use of IKP-WMT indicates that the younger farmers in the study area are more likely to use this technique compared to older counterparts. Consistent with the submission of Anyan [70] where it was established that given the drudgery nature of farming and its related activities, the capacity to engage in operations declines as ageing sets in. One could also infer that there is a generational gap in the use pattern of agricultural practices which may also be influenced by factors like familiarity with technological devices and openness to change. In addition, it underscores the importance of targeted interventions to bridge this generational gap and promote the use of water management techniques among older farmers, ensuring the sustainability and efficiency of agricultural practices across different age groups.

Awareness of indigenous knowledge practices (IKP) has a positive relationship with to the use of water management techniques and this indicates that an increase in the awareness level of the respondents will inspire their willingness to utilize traditional approaches to water management. This could also infer that as the farmers in the study area become informed about IKPs, they have more chances to accept practices that enhance water management on their farmlands. Also, this emphasizes the significance of education and awareness programs to foster indigenous knowledge among farmers, which can lead to more sustainable and efficient water management practices in agricultural systems.

The results also indicated a negative but significant impact of household size on the farmers' use of IKP-water management techniques. This means that with every increase in the number of members of the household, there is a reduced likelihood of using this IKP. Larger households may be subjected to severe constraints while trying to implement water management practices. Also, increased demand for water as well as the implementation of water management policies within a large number of households' members in the study area could potentially contribute to the negative relationship. Given the resource constraints nature of the smallholder farmers, it is assumed that larger households may have inadequate resources, as well as the capability to make investments in water management infrastructure. In addition, the dependency ratio is positive in terms of contribution to the use of water management techniques in the study area. The implication of this is that every increase in the farmers' dependency ratio triggers the likelihood of employing this IKP. This is to say that farmers with a very high dependency ratio may prioritize the acceptance of water management practices to ensure sustainable agricultural production.

Both years of farming experience and frequency of extension visits are significant but have inverse effects on the use of water management techniques by the farmers in the study area. By implication, with any increase and improvement in these important factors, the chances of using IKP-water management techniques decrease. Expectedly, farmers with more years of experience in farming and those who receive regular extension personnel's visitation should be associated with the use of water management techniques. A possible explanation for this deviation could perhaps be a result of rigid approach by farmers to farming practices, inadequate innovative methods, as well as the perceived awareness of existing practices as adequate. These factors are perceived to be associated with these negative relationships. In identifying these barriers, a much-tailored methodological approach is essential to enhance the adoption of efficient water management techniques amongst experienced farmers as well as those receiving frequent extension visits in the study area.

5.4 Post-hoc Estimation: Test for Equality of 2 Group Means (by Gender)

The results of the test for equality of 2 group means differentiated by gender, as shown in Table 5 leads to the non-acceptance of the null hypothesis that the means for the two groups (male and female farmers) are equal. This is to say that with the exception of Wilks' lambda value, the two groups of farmers are unlikely to have equal means with regard to the use of indigenous knowledge at Pillai's Trace value, Lawley-Hotelling trace value and Roy's largest root value statistics. Therefore, the alternative hypothesis of unequal means for the two groups (male and female) of farmers is hereby accepted.

Table 5. Test for equality of 2 group means (by gender).

	Statistic	*F(df1,*	*df2) =*	*F*	*Prob > F*
Wilks' lambda	0.9929	3.0	345.0	0.83	0.4798 e
Pillai's trace	0.0071	3.0	345.0	0.83	0.4798 e
Lawley-Hotelling trace	0.0072	3.0	345.0	0.83	0.4798 e
Roy's largest root	0.0072	3.0	345.0	0.83	0.4798 e

Note: e = exact, a = approximate, u = upper bound on F.

6. Conclusions

In exploring the intricate relationship between farmers' utilization of indigenous knowledge practices (IKPs) within agri-food systems and leveraging on the contribution of farmers' food security attainment drive, it becomes evident that indigenous knowledge plays a pivotal role in sustaining agricultural practices and indirectly enhancing farmers' food security drive across diverse contexts. This research explored the multifaceted dimensions of IKPs within the agri-food systems, by identifying the prevalent IKPs employed by the farmers, and examining farmers' perception of the efficacy of IKPs, and their food security status. Through an in-depth analysis of existing literature and empirical evidence, several key insights have emerged, shedding light on the significance of indigenous knowledge in fostering resilient and sustainable food production systems. Firstly, the research underscores the inherent benefits of information acquisition on the indigenous knowledge systems, which have been cultivated and refined over generations through intimate interactions between the farmers through their local level I institutions. These knowledge systems encapsulate a rich content of traditional practices, local ecological wisdom, and cultural beliefs that are deeply intertwined with agricultural production and food security. Moreover, the research elucidates the instrumental role of indigenous knowledge used by farmers in promoting biodiversity conservation, agro-ecological sustainability, and soil fertility management. Indigenous farming practices, ranging from crop diversification and intercropping to agroforestry and water harvesting techniques, exemplify the intricate synergy between traditional knowledge and ecological resilience. These practices not only enhance soil health and fertility but also mitigate the adverse impacts of monoculture farming and chemical-intensive agriculture, thereby fostering greater agricultural diversity and ecosystem stability. Furthermore, the research highlights the profound socio-cultural significance of indigenous knowledge within farming communities, serving as a repository of cultural identity, social cohesion, and intergenerational learning. This is to say that the transformative potential of indigenous knowledge practices in shaping more resilient, equitable, and sustainable agri-food systems that prioritize food security, environmental stewardship, and social justice cannot be over emphasized. Therefore, by preserving and transmitting indigenous knowledge from one generation to the next, farmers and rural communities at large can uphold ancestral traditions, ecological wisdom, and indigenous cosmologies, thereby safeguarding cultural heritage and promoting social resilience amidst rapid social and environmental change.

- Based on the findings, the following policy recommendations are of importance to the farmers, the research community and the policy makers:
- Development of targeted interventions aimed at improving food security among vulnerable farming populations by promoting the adoption of indigenous knowledge practices, as well as the implementation of food security programs that integrate indigenous crop varieties, traditional farming techniques, and agro-ecological approaches to enhance resilience to climate variability and resource constraints.
- Designing extension programs that cater to the specific needs and priorities of households with larger sizes and higher dependency ratios, providing tailored support and resources to enhance their capacity to adopt indigenous knowledge practices.
- Launch targeted awareness campaigns and knowledge-sharing initiatives to increase farmers' awareness and understanding of indigenous knowledge practices. This can be done through collaboration with local community organizations, farmer associations, and educational institutions to facilitate training workshops, demonstration farms, and experiential learning opportunities that promote the adoption and dissemination of indigenous knowledge.
- Recognize and valorize the expertise and traditional wisdom accumulated by experienced farmers through years of engagement in agricultural practices. This is necessary to foster intergenerational learning and knowledge exchange platforms that facilitate dialogue and collaboration between elder farmers and younger generations, leveraging the complementary strengths of age diversity within farming communities.
- Scaling up accessibility and availability of extension service delivery by expanding outreach efforts and improving infrastructure in rural areas. In addition, investment in mobile extension units, community-based extension workers, and digital platforms should be prioritized to enhance farmers' access to timely information, technical assistance, and advisory services.
- The need is sacrosanct for government to improve the frequency and regularity of extension visits

to farming communities, ensuring that extension personnel are accessible and responsive to farmers' needs in a timely manner. Complimentarily, the government can establish monitoring and evaluation mechanisms to track the frequency and quality of extension visits, prioritizing areas with limited access to extension services and marginalized farming populations.

- Fostering multi-stakeholder partnerships and dialogue platforms to foster synergies between indigenous knowledge and modern scientific approaches, harnessing the complementary strengths of both knowledge systems to address contemporary agricultural challenges.

This study was limited to the smallholder farmers in the South-West region of Nigeria. Generalization of the research findings to a wider space of the country may be misleading because of the inherent culture, norms and values attached to indigenous knowledge practices, which differ across the regions in Nigeria. Therefore, further research may consider the investigation of cross-regional and cross-country application of and the types of IKPs employed by the farmers, as well as the reverse implication on food security status.

Author Contributions

Conceptualization, Seyi Olawuyi, Olusegun Ijila and Tosin Olawuyi; Data curation, Adedeji Adegbite, Tosin Olawuyi and Charles Farayola; Formal analysis, Seyi Olawuyi; Investigation, Charles Farayola; Methodology, Seyi Olawuyi, Olusegun Ijila and Adedeji Adegbite; Supervision, Seyi Olawuyi; Writing—original draft, Seyi Olawuyi and Olusegun Ijila; Writing—review & editing, Adedeji Adegbite, Tosin Olawuyi and Charles Farayola.

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Data Availability

The data presented in this study are available on request from the corresponding author.

Conflict of Interest

The authors declared no conflict of interest.

Ethical Considerations

The dataset were collected from the research subjects in line with global research ethics, as outlined in the Helsinki declaration on research protocol by the World Medical Association (WMA) [73] which are: "anonymity, informed consent, privacy, confidentiality and professionalism".

References

[1] Fonte, M., 2002. Food systems, consumption models and risk perception in late modernity. International Journal of Sociology of Agriculture and Food. 10(1), 13–21.

[2] Sumner, J., 2012. Conceptualizing sustainable food systems. Critical perspectives in food studies. Oxford University Press: Don Mills, ON. pp. 326–336.

[3] Chiaka, J.C., Zhen, L., Yunfeng, H., et al., 2022. Smallholder farmers contribution to food production in Nigeria. Frontiers in Nutrition. 9, 916678. DOI: https://doi.org/10.3389/fnut.2022.916678

[4] Adebayo, O., Olagunju, K., Ogundipe, A., 2016. Impact of agricultural innovation on improved livelihood and productivity outcomes among smallholder farmers in rural Nigeria. DOI: http://dx.doi.org/10.2139/ssrn.2847537

[5] Olorunfemi, T., Olorunfemi, O., Oladele, O., 2020. Determinants of the involvement of extension agents in disseminating climate smart agricultural initiatives: Implication for scaling up. Journal of the Saudi Society of Agricultural Sciences. 19(4), 285–292. DOI: https://doi.org/10.1016/j.jssas.2019.03.003

[6] Nwaobiala, C., Alozie, E., Anusiem, C., 2019. Gender differentials in farmers' involvement in cassava production activities in Abia State, Nigeria. Agrosearch. 19(1), 72–86. DOI: https://doi.org/10.4314/agrosh.v19i1.6

[7] Oluwatayo, I.B., 2018. Vulnerability and adaptive strategies of smallholder farmers to seasonal fluctuations in production and marketing in southwest Nigeria. Climate and Development. 11(8), 659–666. DOI: https://doi.org/10.1080/17565529.2018.1

521328

[8] Kehinde, M.O., Shittu, A.M., Oriade, O.A., et al., 2023. Land tenure, land use antecedents, and willingness to embrace resilient farming practices among smallholders in Nigeria. Frontiers in Sustainable Food Systems. 7, 999905.

[9] Tesfay, G.B., Abidoye, B., 2019. Shocks in food availability and intra-household resources allocation: evidence on children nutrition outcomes in Ethiopia. Agricultural and Food Economics. 7, 3.
DOI: https://doi.org/10.1186/s40100-019-0120-1

[10] Kugbega, S.K., Aboagye, P.Y., 2021. Farmer-herder conflicts, tenure insecurity and farmer's investment decisions in Agogo, Ghana. Agricultural and Food Economics. 9, 19.
DOI: https://doi.org/10.1186/s40100-021-00186-4

[11] Matemilola, S., Elegbede, I., 2017. The challenges of food security in Nigeria. Open Access Library Journal. 4(12), 81175.
DOI: https://doi.org/10.4236/oalib.1104185

[12] Mereu, V., Santini, M., Cervigni, R., et al., 2018. Robust decision making for a climate-resilient development of the agricultural sector in Nigeria. Climate smart agriculture. Natural resource management and policy. Springer: Cham.
DOI: https://doi.org/10.1007/978-3-319-61194-5_13

[13] Ponge, A. (editor), 2013. Integrating indigenous knowledge for food security: Perspectives from the millennium village project at Bar-Sauri in Nyanza Province in Kenya. The International Conference on Enhancing Food Security in the Eastern and Horn of Africa Regions; 2011 Nov 16–17; Kampala, Uganda.

[14] Mutandwa, E., Gadzirayi, C., 2007. Comparative assessment of indigenous methods of sweet potato preservation among smallholder farmers: Case of grass, ash and soil based approaches in Zimbabwe. African Studies Quarterly. 9(3), 85–98.

[15] Adikwu, S.G., 2013. Farmer-oriented coping strategies for minimizing climate variability impact on agricultural production in Ghana. Ghana Policy Journal. 5, 58–67.

[16] Shumetie, A., Alemayehu, M., 2017. Effect of climate variability on crop income and indigenous adaptation strategies of households. International Journal of Climate Change Strategies and Management. 10(4), 580–595.
DOI: https://doi.org/10.1108/IJCCSM-04-2016-0039

[17] Nnadi, F., Chikaire, J., Ezudike, K., 2013. Assessment of indigenous knowledge practices for sustainable agriculture and food security in Idemili south local government area of Anambra State, Nigeria. Journal of Resources Development and Management. 1, 14–21.

[18] Kisakye, V., Akurut, M., Bruggen, B., 2018. Effect of climate change on reliability of rainwater harvesting systems for Kabarole District, Uganda. Water. 10(1), 71.
DOI: https://doi.org/10.3390/w10010071

[19] Maru, Y., Gebrekirstos, A., Haile, G., 2019. Farmers' indigenous knowledge of tree conservation and acidic soil amendments: The role of "baabbo" and "Mona" systems: Lessons from Gedeo community, Southern Ethiopia. Cogent Food and Agriculture. 5(1), 1645259.
DOI: https://doi.org/10.1080/23311932.2019.1645259

[20] Faye, J.B., 2020. Indigenous farming transitions, sociocultural hybridity and sustainability in rural Senegal. NJAS: Wageningen Journal of Life Sciences. 92(1), 1–8.
DOI: https://doi.org/10.1016/j.njas.2020.100338

[21] Michalopoulos, G., Kasapi, K.A., Koubouris, G., et al., 2020. Adaptation of Mediterranean olive groves to climate change through sustainable cultivation practices. Climate. 8(4), 54.
DOI: https://doi.org/10.3390/cli8040054

[22] Sithole, P.M., 2020. Indigenous knowledge systems in crop management and grain storage in Chimanimani District of Zimbabwe. Southern African Journal of Environmental Education. 36, 21–32.

[23] Abdulmumini, L., Saddiq, N., Ahmed, S., 2021. Application of indigenous knowledge systems in agricultural extension and rural development programmes/projects in Nigeria. Dutse International Journal of Social and Economic Research. 6(1), 146–152.

[24] Guo, T., García-Martín, M., Plieninger, T., 2021. Recognizing indigenous farming practices for sustainability: A narrative analysis of key elements and drivers in a Chinese dryland terrace system. Ecosystems and People. 17(1), 279–291.
DOI: https://doi.org/10.1080/26395916.2021.1930169

[25] Habakubaho, T., Mhache, E., Saria, J., 2023. Investigating indigenous knowledge developed by agro-pastoralists to cope with climate change and variability in the agro-pastoralism region

of Rwanda. Ghana Journal of Geography. 15(3), 48–91.
DOI: https://dx.doi.org/10.4314/gjg.v15i3.3

[26] File, D.J.M., Nhamo, G., 2023. Farmers' choice for indigenous practices and implications for climate-smart agriculture in northern Ghana. Heliyon. 9(11), e22162.
DOI: https://doi.org/10.1016/j.heliyon.2023.e22162

[27] Melash, A.A., Bogale, A.A., Migbaru, A.T., et al., 2023. Indigenous agricultural knowledge: A neglected human based resource for sustainable crop protection and production. Heliyon. 9(1), e12978.
DOI: https://doi.org/10.1016/j.heliyon.2023.e12978

[28] Brokensha, D., Warren, D., Werner, O., 1980. Indigenous knowledge systems and development. University Press of America: Lanham, MD.

[29] Maslow's Hierarchy of Needs [Internet]. Simply Psychology. [cited 2024 Apr 23]. Available from https://www.simplypsychology.org/maslow.html

[30] Maslow, A.H., 1943. A theory of human motivation. Psychological Review. 50(4), 370–396.

[31] Rome Declaration on World Food Security [Internet]. World Food Summit (WFS); 1996. Available from: https://www.fao.org/3/w3548e/w3548e00.htm

[32] Food Security Policy Brief. Issue 2 [Internet]. Food and Agriculture Organization of the United Nations. Available from: https://www.fao.org/fileadmin/templates/faoitaly/documents/pdf/pdf_Food_Security_Cocept_Note.pdf

[33] Degaga, J., Angasu, B., 2017. Assessment of indigenous knowledge of smallholder farmers on intercropping practices in west Hararghe Zone; Oromia National Regional State, Ethiopia. Journal of Agricultural Economics and Rural Development. 3(3), 270–278.

[34] Gotora, T., Masaka, L., Sungirai, M., 2014. Effect of cow urine on the growth characteristics of Fusarium lateritium, an important coffee fungus in Zimbabwe. International Journal of Agronomy. 986068.
DOI: https://doi.org/10.1155/2014/986068

[35] Balemie, K., Singh, R.K., 2012. Conservation of socio-culturally important local crop biodiversity in the Oromia region of Ethiopia: A case study. Environmental Management. 50, 352–364.
DOI: https://doi.org/10.1007/s00267-012-9883-9

[36] Louette, D., Smale, M., 2000. Farmers' seed selection practices and traditional maize varieties in Cuzalapa, Mexico. Euphytica. 113, 25–41.
DOI: https://doi.org/10.1023/A:1003941615886

[37] Sherpa, T.O., 2023. Indigenous people's perception of indigenous agricultural knowledge for climate change adaptation in Khumbu, Nepal. Frontier in Climate. 4, 1067630.
DOI: https://doi.org/10.3389/fclim.2022.1067630

[38] Maponya, P., Mpandeli, S., 2012. Climate change and agricultural production in South Africa: Impact and adaptation options. Journal of Agricultural Science. 4(10), 48–60.
DOI: https://doi.org/10.5539/jas.v4n10p48

[39] Kom, Z., Nethengwe, N.S., Mpandeli, S., et al., 2023. Indigenous knowledge indicators employed by farmers for adaptation to climate change in rural South Africa. Journal of Environmental Planning and Management. 66(13), 2778–2793.
DOI: https://doi.org/10.1080/09640568.2022.2086854

[40] Mugambiwa, S.S., 2018. Adaptation measures to sustain indigenous practices and the use of indigenous knowledge systems to adapt to climate change in Mutoko rural district of Zimbabwe. Jamba. 10(1).
DOI: https://doi.org/10.4102/jamba.v10i1.388

[41] Smooth, W.G., 2013. Intersectionality from theoretical framework to policy intervention. Situating intersectionality. The politics of intersectionality. Palgrave Macmillan: New York.
DOI: https://doi.org/10.1057/9781137025135_2

[42] Collins, P.H., Bilge, S., 2016. Intersectionality. Polity Press: Cambridge.

[43] Few-Demo, A.L., Hunter, A.G., Muruthi, B.A., 2022. Intersectionality theory: A critical theory to push family science forward. Sourcebook of family theories and methodologies. Springer: Cham.
DOI: https://doi.org/10.1007/978-3-030-92002-9_31

[44] Capra, G.F., Ganga, A., Buondonno, A., et al., 2015. Ethnopedology in the study of toponyms connected to the indigenous knowledge on soil resource. PLoS One. 10(3), e0120240.
DOI: https://doi.org/10.1371/journal.pone.0120240

[45] Barrera-Bassols, N., Zinck, J.A., 2002. Ethnopedology: A worldwide view on the soil knowledge of local people. Geoderma. 111(3–4), 171–195.
DOI: https://doi.org/10.1016/S0016-7061(02)00263-X

[46] Tella, R.D., 2007. Towards promotion and dissemination of indigenous knowledge: A case

of NIRD. The International Information & Library Review. 39(3–4), 185–193.
DOI: https://doi.org/10.1016/j.iilr.2007.06.002

[47] Ajayi, O.C., Mafongoya, P.L., 2017. Indigenous knowledge systems and climate change management in Africa. CTA: Wageningen. pp. 316.

[48] Maroyi, A., 2012. Enhancing food security through cultivation of traditional food crops in Nhema communal area, Midlands Province, Zimbabwe. African Journal of Agricultural Research. 7(39), 5412–5420.

[49] Sharma, I., Kanta, C., Dwivedi, T., et al., 2020. Indigenous agricultural practices: A supreme key to maintaining biodiversity. Microbiological advancements for higher altitude agro-ecosystems & sustainability. Springer: Singapore.
DOI: https://doi.org/10.1007/978-981-15-1902-4_6

[50] Ghebreyohannes, T., Nyssen, J., Negash, E., et al., 2022. Challenges and resilience of an indigenous farming system during wartime (Tigray, North Ethiopia). Agronomy for Sustainable Development. 42, 116.
DOI: https://doi.org/10.1007/s13593-022-00812-5

[51] Lathsakid, S., 2018. Indigenous knowledge and good agricultural practices in climate change adaptation. ALiSEA: Myanmar.

[52] Manh, N.T., Ahmad, M.M., Pal, I., et al., 2023. Indigenous farmers' perception of climate vulnerability, barriers and factors influencing farmers' adaptation intention: Evidence from mountainous area of Vietnam. Frontiers in Sustainable Food Systems. 7, 1039562.
DOI: https://doi.org/10.3389/fsufs.2023.1039562

[53] Habakubaho, T., Mhache, E., Saria, J., 2023. Investigating indigenous knowledge developed by agro-pastoralist to cope with climate change and variability in the agro-pastoralist region of Rwanda. Ghana Journal of Geography. 15(3), 48–91.
DOI: https://dx.doi.org/10.4314/gjg.v15i3.3

[54] Corbeels, M., Apina, T., Koala, S., et al. (editors), 2010. Impact and adoption of conservation agriculture in Africa: A multi-scale and multi-stakeholder analysis. 5th World Congress of Conservation Agriculture incorporating 3rd Farming Systems Design Conference; 2011 Sep; Brisbane, Australia.

[55] Deligios, P.A., Tiloca, M.T., Sulas, L., et al., 2017. Stable nutrient flows in sustainable and alternative cropping systems of globe artichoke. Agronomy for Sustainable Development. 37, 54.
DOI: https://doi.org/10.1007/s13593-017-0465-3

[56] Ayilu, R.K., Fabinyi, M., Barclay, K., et al., 2023. Blue economy: Industrialisation and coastal fishing livelihoods in Ghana. Reviews in Fish Biology and Fisheries. 33, 801–818.
DOI: https://doi.org/10.1007/s11160-022-09749-0

[57] Jurt, C., Haberli, I., Rossier, R., 2015. Transhumance farming in Swiss mountains: Adaptation to a changing environment. Mountain Research and Development. 35(1), 57–65.
DOI: https://doi.org/10.1659/MRD-JOURNAL-D-14-00022.1

[58] Larsson, J., Sjaunja, E., 2020. Freshwater fishing strategies in early modern Sami households. Arctic Anthropology. 57(2), 197–211.
DOI: https://doi.org/10.3368/aa.57.2.197

[59] Berg, H., Maneas, G., Engström, A., 2018. A comparison between organic and conventional olive farming in Messenia, Greece. Horticulturae. 4(3), 15.
DOI: https://doi.org/10.3390/horticulturae4030015

[60] Nigerian Gross Domestic Product Report [Internet]. National Bureau of Statistics (NBS). Available from: https://www.nigerianstat.gov.ng/pdfuploads/GDP%20Q1%202016%20ICI%20Merged%20finalvs2.pdf

[61] Adeagbo, O.A., Ojo, T.O., Adetoro, A.A., 2021. Understanding the determinants of climate change adaptation strategies among smallholder maize farmers in South-west, Nigeria. Heliyon. 7(2), e06231.
DOI: https://doi.org/10.1016/j.heliyon.2021.e06231

[62] Voices of the Hungry [Internet]. FAO. Available from: https://www.fao.org/3/i5019e/i5019e.pdf

[63] The Power of Gender Equality for Food Security: Closing Another Gender Data Gap with a New Quantitative Measure [Internet]. World Food Programme (WFP). Available from: https://reliefweb.int/attachments/37283d44-184a-3cd2-b10e-611186f9c647/WFP-0000112500.pdf

[64] The Food Insecurity Experience Scale: Development of a Global Standard for Monitoring Hunger Worldwide [Internet]. FAO. Available from: http://www.fao.org/fileadmin/templates/ess/voh/FIES_Technical_Paper_v1.1.pdf

[65] Mardia, K.V., Kent, J.T., Bibby, J.M., 1979. Multivariate analysis. Academic Press: London.

[66] Greene, W.H., 2008. Econometric analysis, sixth edition. Prentice Hall: Upper Saddle River, NJ.

[67] Greene, W.H., 2012. Econometric analysis, seventh edition. Pearson Hall: New Jersey.

[68] Cappellari, L., Jenkins, S.P., 2003. Multivariate probit regression using simulated maximum likelihood. The State Journal. 3(3), 278–294. DOI: https://doi.org/10.1177/1536867X0300300305

[69] Adugna, M., Ketema, M., Goshu, D., et al., 2019. Market outlet choice decision and its effect on income and productivity of smallholder vegetable producers in Lake Tana Basin, Ethiopia. Review of Agricultural and Applied Economics. 22(1), 83–90. DOI: https://doi.org/10.15414/raae.2019.22.01.83-90

[70] Anyan, F.Y., 2018. Farmers' perceptions and attitudes towards the use of agricultural indigenous knowledge in farming. Journal of Agriculture and Crops. 4(6), 63–67.

[71] Ominikari, A.G., Okringbo, J.I., 2022. Factors influencing indigenous knowledge sharing among rural farmers in South-South Nigeria. FUDMA Journal of Agriculture and Agricultural Technology. 8(2), 210–215. DOI: https://doi.org/10.33003/jaat.2023.0802.28

[72] TAYE, A., MEGENTO, T.L., 2017. The role of indigenous knowledge and practice on water and soil conservation management in Albuko Woreda, Ethiopia. International Journal of Bonorowo Wetlands. 7(2), 95–107. DOI: https://doi.org/10.13057/bonorowo/w070206

[73] World Medical Association (WMA), 2001. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bulletin of the World Health Organization. 79(4), 373–374.