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Peer Learning and Technology Adoption in Cashew Nut Production: Evidence from APPEALS Cluster Farmers in Kogi State, Nigeria

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ABSTRACT

In the context of increasing global demand for cashews and the need for sustainable agricultural innovation, this study examines how peer learning facilitates the adoption and diffusion of cashew production technologies among farmers within a World Bank-supported Nigeria Agro Processing, Productivity Enhancement, and Livelihood Support (APPEALS) project. A cluster sampling technique was used to select 180 cashew nut farmers. A questionnaire, direct interviews, records from focus group discussions, and field trips were used to collect data. Data collected were analyzed using descriptive statistics and the Tobit regression model. Results showed that there

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was active participation in the sharing and exchange of ideas, technologies, information, and innovations among farmers through one-on-one contact with fellow farmers, technical advisory/extension visits by the APPEALS team, Focus Group Discussions (FGDs), and field trips and demonstrations. Most of the technologies, such as Integrated Pest Management (IPM), fire terracing, nursery preparation techniques, and marketing, were at the interest, trial, and adoption stages, except for the soil sampling technique, which was at the awareness stage. Education, farming experience, marital status, and household size significantly influenced the probability of intensifying the adoption of cashew production technologies. It is recommended that efforts should be made to strengthen the adoption of technologies.

Keywords: APPEALS; Adoption Intensity; Cashew Nuts; Education; FGD; Peer Learning

JEL codes: D83; O33; Q12; Q16

1. Introduction

Agricultural development remains a cornerstone of economic growth and rural transformation in sub-Saharan Africa, especially in Nigeria, where agriculture contributes approximately 25% to the GDP and employs around 70% of the rural population (World Bank, 2023). Within this context, the cashew sub-sector has emerged as one of Nigeria's most promising non-oil export commodities, contributing significantly to household income, employment generation, and foreign exchange earnings. Nigeria ranks among the top cashew-producing countries globally, with Kogi State recognized as one of the leading producers due to its favourable agro-ecological conditions and a longstanding tradition of cashew cultivation^[1].

Despite the growing importance of cashew production, productivity remains low due to a combination of factors, including poor adoption of improved technologies, inadequate extension services, and weak linkages among stakeholders in the cashew value chain^[2]. The adoption and diffusion of agricultural technologies remain critical for enhancing productivity; they ensure improved welfare and sustainable rural development^[3]. Cashew nut (*Anacardium occidentale*) production, a key agro-industrial activity in tropical and subtropical regions, has gained prominence due to its economic potential and contribution to rural livelihoods^[4]. In the last decade, Cashew (*Anacardium occidentale*) has become a crop of commerce to which the Nigerian government has directed its searchlight. It thrives well in the Guinea savanna and the rainforest vegetation belts of the country,

where the best nuts are said to be mostly found, particularly in North-central Nigeria, such as in Kogi State. The cashew enterprise took a quick paradigm shift in the last few years with the entry of foreign investors (*Chinese, Lebanese, and Indians*) who now buy directly from the farmers.

Farmers in Kogi State, Nigeria, have benefited from several World Bank intervention programmes, including the National Fadama Development Projects, the Commercial Agricultural Development Project (CADP), and the APPEALS (Agro Processing, Productivity Enhancement, and Livelihood Support) projects. The Agro Processing, Productivity Enhancement and Livelihood Improvement Support (APPEALS) is a six-year project developed by the Federal Ministry of Agriculture and Rural Development (FMARD) in collaboration with the World Bank and other stakeholders. The project was built on the legacy of the Agricultural Transformation Agenda (ATA) and plans to support policy thrusts on food security, local production, job creation, and economic diversification, focusing on cassava, rice, and cashew in six (6) beneficiary States of Kogi, Cross River, Kaduna, Kano, and Lagos^[5]. Despite the availability of improved production technologies, such as high-yielding varieties, integrated pest management (IPM), and climate-resilient practices, adoption rates among smallholder farmers remain suboptimal^[6]. This is often attributed to limited access to information, inadequate extension services, and socioeconomic constraints^[7].

To address yield gaps, targeted interventions such as the Agro Processing, Productivity Enhancement, and Livelihood Support (APPEALS) project have been imple-

mented. The APPEALS project aims to enhance the productivity of small and medium-scale farmers by promoting technology adoption, market access, and value addition through cluster-based approaches^[8]. One of the innovative strategies employed by the APPEALS project is the Peer Learning and Exchange Programme (PLEP), which seeks to facilitate horizontal knowledge transfer among farmers within clusters. Peer learning, as conceptualized by Bandura's social learning theory, emphasizes learning through observation, imitation, and interaction with knowledgeable peers^[9]. Empirical studies suggest that peer learning can significantly improve farmers' uptake of new technologies, particularly in contexts where formal extension systems are weak or under-resourced^[10, 11]. The PLEP leverages the experiential knowledge of early adopters and lead farmers to stimulate wider diffusion of cashew production technologies, including grafting, pruning, spacing, integrated pest management, and post-harvest handling innovations.

Learning is an integral part of human endeavour that is essential for human development in all facets of life. The adoption of technologies by farmers is made a lot easier if they are well-equipped with all the necessary learning aids, in a favourable and enabling environment that facilitates knowledge and skill acquisition through the exchange of ideas, information, or innovations. Knowledge or ideas can further be preserved and spread to those who do not have them through diffusion. The farmer-to-farmer extension model has been seen to be efficient in terms of knowledge sharing and the diffusion of innovations or technologies^[12]. This model allows farmers to exchange ideas and knowledge covering a wide range of farm management technologies.

Traditional top-down extension models have been criticized for their inefficacy in addressing the diverse and context-specific needs of farmers^[13]. In response, participatory approaches such as peer learning and farmer exchange programmes have gained traction as effective strategies for technology dissemination^[14, 15]. These approaches emphasize social learning, collective problem-solving, and the leveraging of local knowledge networks to facilitate technology adoption^[16]. According to Maertens and Barrett^[17], peer learning, in partic-

ular, has been shown to enhance trust, reduce perceived risks, and foster a sense of ownership among farmers, thereby accelerating the diffusion of innovations.

The cashew nut value chain has multiple stages, including cultivation, harvesting, processing, and marketing. Recent advancements in production technologies, such as improved grafting techniques, precision agriculture, and digital tools for pest monitoring, have demonstrated significant potential to boost yields and quality^[18, 19]. However, the adoption of these technologies remains uneven, particularly among resource-constrained farmers in developing countries^[20]. Peer learning and exchange programmes provide a platform for farmers to observe, experiment with, and adapt technologies within their local contexts, thereby bridging the gap between research and practice^[21].

In Kogi State, where the APPEALS cashew clusters are operational, the integration of peer learning into the project's implementation strategy presents an opportunity to assess the effectiveness of this approach in enhancing the adoption and diffusion of modern cashew production and knowledge-based technologies. However, empirical evidence on the outcomes of such farmer-led dissemination mechanisms remains limited. This study, therefore, seeks to evaluate the adoption and diffusion dynamics of cashew nut production and knowledge-based technologies through the Peer Learning and Exchange Programme among APPEALS cluster farmers in Kogi State, Nigeria. The specific objectives include the following:

1. Examine the effectiveness of the learning and exchange methods adopted to educate the farmers on the adoption of cashew production technologies.
2. Analyze the levels of adoption of cashew production and knowledge-based technologies by farmers under the APPEALS project in the study area.
3. Determine the intensity of adoption of cashew production technologies by farmers under the APPEALS project in the study area.

2. Methodology

The study area is Kogi State, Nigeria. Kogi State is located within Nigeria's Middle Belt region and

is widely recognized as one of the leading cashew-producing states in the country. According to the National Agricultural Extension and Research Liaison Services (NAERLS)^[22], Kogi accounts for a substantial share of Nigeria's annual cashew output, making it a key stakeholder in the country's tree crop value chain. The state's agroecological conditions—characterized by well-drained sandy-loam soils and a tropical climate with distinct wet and dry seasons—are particularly favourable for cashew cultivation^[23]. Beyond ecological suitability, the choice of Kogi State as the study location is further justified by the intensity of cashew-based interventions under the Agro Processing, Productivity Enhancement, and Livelihood Support (APPEALS) Project. Kogi is one of the six states selected to implement APPEALS due to its comparative advantage in priority value chains, notably cashew, rice, and aquaculture^[24]. The project in Kogi has established multiple cashew production clusters and farmer cooperatives, many of which have benefited directly from peer learning and exchange activities facilitated by the APPEALS framework. Moreover, cashew production in Kogi is dominated by small-holder farmers who face diverse socio-economic challenges, including limited access to improved planting materials, extension services, mechanized tools, and market linkages^[1, 25]. These realities present an ideal context for assessing how peer learning mechanisms influence the uptake of technology and the diffusion of innovation within resource-constrained farming communities. Among the three zones of Kogi East, Kogi West, and Kogi Central, Kogi East is known for cashew nut production. Hence, data for the study were specifically obtained from cashew nut farmers in the Eastern part of Kogi State, Nigeria.

Kogi East covers a landmass of about 16,000 sq km and is located within the Guinea savanna of the nation's vegetation belt. Kogi East consists of nine (9) Local Government Areas, which include: Dekina, Bassa, Idah, Olamaboro, Ibaji, Igalamela, Ofu, Ankpa, and Omala. In this research, the above areas were delineated by APPEALS into Farmer Clusters, which include Abejukolo, Egume, Ibana, Iyale, Ofejiji, Ojogba Abocho, Umomi, Ugwolawo, Imane 1, Imane 2, and Ochaja. Cashew farming is a significant enterprise in the study area, where farm-

ers own farms of various sizes according to their production capacities. It has an estimated population of over 3,278,487 people, out of which 1,691,737 are males and 1,586,750 are females, with an average of 172,000 farming families. Rivers Niger and Benue form a confluence, creating alluvial, fertile soil that supports crop and livestock production.

A multi-stage sampling technique was used for this study. The first stage involved the random selection of four (4) clusters out of the 12 cashew farmer clusters in the study area. The selected clusters include Umomi, Ochaja, Imane 1, and Imane 2 (**Appendix A**). The second stage involved the random selection of 45 cashew nut farmers from each selected cluster, bringing a total sample size of 180 farmers for the study. Data for this study were obtained from primary sources, including structured and pretested questionnaires, face-to-face interviews, focused group discussions, and personal observations. The data collected were analyzed using descriptive and inferential statistics.

2.1. Learning Methods and Adoption of Cashew Production Technologies

The perceived effectiveness of the Learning and exchange programme methods was measured on a 3-point Likert-type Rating Scale (LRS). The Likert rating scale is a psychometric tool used to measure respondents' attitudes, perceptions, or behaviours to assess agreement or satisfaction across a range of items. The common Likert scale options include 5-point, 4-point, and 3-point. Others are 8-point, 7-point, frequency, and importance-based scales. This study employed a 3-point Likert-type scale to measure effectiveness, with ratings as follows: "very effective" = 3, "effective" = 2, and "Not effective" = 1. The mean response to each item was calculated using Equation (1):

$$X = \frac{\sum Fx}{n} \quad (1)$$

Where:

$\bar{X}$ = Mean response

Σ = Summation

F = number of respondents choosing a particular scale point,

x = numerical value of the scale point

n = total number of responses to the item.

A mean score of 2.5 and above was used as the cut-off point. Thus, a mean score of 2.5 and above was effective, while those with a mean score below 2.5 were not serious constraints.

The level of adoption rate was put on a 5-point Likert scale (Adoption 1 = 1 point, Adoption 2 = 2 points, Adoption 3 = 3 points, Adoption 4 = 4 points, and Adoption 5 = 5 points based on their compliance in the use of technologies introduced to them as observed by the researcher). The stages of adoption of technologies in cashew production were determined by the decision rule based on the real limits from the mean: awareness (1), interest (2), evaluation (3), trial (4), and adoption (5). To determine the mean of the adoption stages, the mean score x of each item was calculated by multiplying the frequency of each response pattern by its corresponding normal value and then dividing the sum by the total number of respondents to the items.

This can be summarized with Equation (2):

$$X = \frac{\sum X}{N} \quad (2)$$

Where X = mean score

$\sum$ = summation

N = frequency

2.2. Decision Rule

The decision rule, following Adejo et al.^[26] and Adah et al.^[27], is given as:

1.0–1.49 = Awareness stage of the technology.

1.50–1.99 = Interest stage of the technology.

2.0–2.49 = Evaluation stage of the technology.

2.50–2.99 = Trial stage of the technology.

3.00 and above = Adoption stage of the technology.

2.3. Intensity of Adoption

This study employed the Tobit regression model to examine the socioeconomic and institutional factors influencing the intensity of adoption of improved cashew production technologies among APPEALS cashew farmers in Kogi State, Nigeria. The Tobit model was applied since the dependent variable is not fully observed and

censored at zero values for part of the sample. The Tobit model, as proposed initially by Tobin (1958), is given in Equation (3):

$$Y_i = \begin{cases} X_i\beta + \mu_i & \text{if } X_i\beta + \mu_i > 0 \\ 0 & \text{if } X_i\beta + \mu_i \leq 0 \end{cases} \quad (3)$$

$i = 1, 2, 3, \dots, N$

where i represents individual observation (cashew farmer), N is the number of observations, Y_i is the dependent variable, X_i represents the vectors of explanatory variables, β is the estimated parameter, and μ_i is the error term. The basic assumption of the Tobit model is that there is an underlying, random index equal to $X_i\beta + \mu_i$ which is observable only when it is greater than or equal to zero, and then qualifies as an observed, latent variable. The above model, as used in this study, is explicitly given in Equation (4):

$$IDC_i = \beta_0 + \beta_1 AGE + \beta_2 SEX + \beta_3 MTS + \beta_4 EDU + \beta_5 FS + \beta_6 EXP + \beta_7 INC + \beta_8 EXT + \mu_i \quad (4)$$

where IDC_i is the dependent variable $\rightarrow$ intensity of adoption of cashew production technologies. The rationale for including the independent or explanatory variables (factors) was based on theoretical foundations and frameworks related to the adoption of agricultural innovations, as well as a priori expectations from the agricultural technology adoption literature. These variables include:

AGE = Age of the respondent (years)

SEX = Sex of the respondent (dummy; male = 1, female = 0)

MTS = Marital status of the respondent (dummy; married = 1, otherwise = 0)

EDU = Education (number of years spent schooling)

HSS = Household size (number of persons under the same roof)

EXP = Farming experience (number of years spent in cashew farming)

INC = Income (income from cashew production in Naira)

EXT = Extension (number of extension visits)

3. Results and Discussion

3.1. Socioeconomic Characteristics of the Cashew Farmers

The distribution of respondents according to socioeconomic characteristics is presented in **Table 1**. The analysis reveals that 56.11% of the cashew farmers were males, while 43.89% were females. This male predominance reflects the prevailing land tenure system and

socio-cultural norms in Nigeria, where fewer women own land and agricultural assets. Ibitoye et al.^[28] observed that similar trends exist in oil palm production, where women are underrepresented due to the physical demands of production and constraints on land ownership. Consequently, women's lower participation in cashew production may not stem from a lack of interest but from structural barriers that limit their access to land and extension services^[29].

Table 1. Distribution of respondents according to socio-economic characteristics (n = 180).

Variables	Frequency	(%)	Mean
Age			
Below 30	20	2.5	46.71
31–40	30	19.2	
41–50	65	45.8	
51–60	40	29.2	
60 and above	25	3.3	
Sex			
Male	101	56.11	
Female	79	43.89	
Marital status			
Single	45	4.1	
Married	125	87.5	
Divorce	4	1.7	
Widow	6	6.7	
Household size			
1–5	46	35.8	6.29
6–10	132	62.5	
11 and above	2	1.7	
Farming Experience			
1–10	20	16.7	18.33
11–20	56	46.7	
21–30	34	28.3	
31 and above	10	8.3	
Education			
No formal education	99	82.5	
Primary	16	13.3	
Secondary	5	4.2	
Tertiary	0	0	

Source: Field survey, 2024.

In terms of marital status, the results indicate that the majority (88.2%) of the respondents were married. This marital composition suggests that most respondents likely have dependent family members and are responsible for the welfare of their households. Idrisa et al.^[30] noted that married farmers often benefit from spousal and family labour, which contributes signifi-

cantly to agricultural activities. Furthermore, large family sizes often associated with marriage can influence livelihood strategies, including diversification and investment in labour-intensive crops such as cashew. In this study, the mean household size was 6 persons, reinforcing the potential of household labour utilization in cashew farming.

The age distribution of the respondents shows that the mean age was 50 years, indicating that the majority of household heads were still within their productive years. Most respondents fell within the 41–50 and 51–60-year categories (45.8% and 29.2%, respectively). This demographic group is often considered the most active and experienced in farming, combining physical vigour with accumulated knowledge. Enwelu et al.^[31], in a study on oil palm farmers in Ekiti State, reported similar age dynamics, aligning with the United Nations' classification of middle age (40–60 years). Farmers in this age bracket are more likely to adopt agricultural innovations, provided the technologies are accessible and perceived as beneficial^[32].

The findings on education status indicate that a significant proportion of respondents (82.5%) had no formal education, with only 13.3% and 4.2% having attained primary and secondary education, respectively. The complete absence of tertiary education among respondents reflects a critical human capital challenge in rural agricultural communities. Low literacy levels can hinder access to information, hinder understanding of improved agricultural technologies, and limit participation in capacity-building initiatives. According to Asfaw and Admassie^[33], farmers with higher education levels are more likely to adopt new technologies due to better

comprehension of technical information and openness to innovation. Therefore, the APPEALS programme's use of peer learning and exchange platforms may serve as a practical method to bridge the knowledge gap among low-literate farmers in the study area.

Farming experience is another important determinant of technology adoption. The data showed that 46.7% of respondents had between 11 and 20 years of experience, while 28.3% had 21–30 years of experience. The mean farming experience was 18.33 years, indicating a well-rooted engagement in farming. Long-standing farming experience often correlates with better decision-making, more efficient resource use, and greater openness to innovation, especially when complemented by social learning processes^[34, 35]. This suggests that experienced cashew farmers in the study area are well-positioned to benefit from and contribute to the diffusion of improved production technologies.

3.2. Effectiveness of Learning and Exchange Methods on Cashew Production Technologies

The effectiveness of learning and exchange methods on cashew production technologies among farmers is presented in **Table 2**.

Table 2. Methods of learning and exchange of cashew production technologies among farmers.

Learning and Exchange Methods	Not Effective (1)	Effective (2)	Very Effective (3)	Total Sum of Score	Mean ($\bar{X}$)	Remark
Ono-on-one Contact with fellow Farmers (farmer-to-farmer extension)	46	50	84	398	2.21	Effective
APPEAL's Technical Team/ Extension visits	0	65	125	505	2.81	Effective
APPEAL's WhatsApp Platform	169	21	0	211	1.17	Not effective
Group Discussion	12	108	60	408	2.27	Effective
Field Visits//Demonstration (Study tours)	2	177	6	374	2.08	Effective

Source: Field survey, 2024.

The analysis of the various learning and knowledge exchange methods employed by the APPEALS project, as presented in **Table 2**, reveals the differential effectiveness of each approach as perceived by cashew farmers in the study area. Technical advisory services and extension visits by the APPEALS team were rated highest (Mean = 2.81), suggesting that personalized expert support was particularly valued by the farmers. This was followed by group discussions (Mean = 2.27), one-on-

one interactions among farmers (Mean = 2.21), and field visits or study tours (Mean = 2.08). Farmers reported that the technologies and practices introduced through these methods significantly enhanced cashew production outcomes across their respective clusters. The feedback gathered indicated a noticeable improvement in yield during the most recent cashew season, which was attributed to the application of improved practices disseminated through the APPEALS programme. These

accounts are consistent with the theoretical underpinnings of the diffusion of innovations, which emphasize the importance of interpersonal communication and demonstration in influencing adoption decisions.

Field demonstrations, in particular, served as critical sites of knowledge co-production and validation. These visits were conducted jointly by the APPEALS team, designated resource persons, and selected lead farmers. True to the adage “seeing is believing,” these field-based engagements facilitated hands-on learning and reinforced the credibility of the introduced technologies. Interestingly, farmers not only adopted the formal technologies promoted by the programme, but they also shared indigenous practices that contributed to knowledge exchange among peers. For instance, a farmer in the *Imane* cluster described his practice of burning shredded cashew leaf debris beneath the trees as a traditional method of pest control. While unconventional, the farmer claimed that the resulting smoke effectively

repelled insect pests.

Another noteworthy case involved a farmer who advised intercropping yams under cashew trees, based on observations of enhanced yam tuber development due to improved soil fertility resulting from the decay of cashew leaves. While this practice was contextually innovative, extension personnel provided cautionary guidance. They explained that yam vines could potentially overgrow and cover cashew branches, thus impeding flowering and fruiting, and complicating the harvesting process. Such interactions underscore the interplay between local knowledge systems and formal agronomic advice in shaping farmer decisions.

3.3. Adoption of Cashew Nut Production and Knowledge-Based Technologies

Table 3 presents the levels of adoption of cashew nut production and knowledge-based technologies among cashew nut farmers in the study area.

Table 3. Stages of adoption of cashew nut production and knowledge-based technologies/practices among the cashew farmers.

Technologies	Awareness Score 1 (1)	Interest Score 2 (2)	Evaluation Score 3 (3)	Trial Score 4 (4)	Adoption Score 5 (5)	Sum of Scores	Mean	Remark
Pruning	36	80	20	30	17	461	2.56	Trial
Coppicing	120	20	30	8	2	292	1.62	Interest
Integrated Pest Management (IPM)	15	25	80	40	20	565	3.14	Adoption
Fire Terracing	5	20	65	71	19	619	3.43	Adoption
Soil Sampling Techniques	150	23	6	1	0	219	1.21	Awareness
Thinning	50	42	23	43	16	455	2.53	Trial
Gapping up	50	46	22	24	38	494	2.74	Trial
Nursery preparation techniques	10	40	27	80	23	606	3.37	Adoption
Shade management	50	22	39	49	20	507	2.82	Trial
Financial literacy/management	80	46	50	3	1	339	1.88	Interest
Home management	40	48	39	20	33	498	2.77	Trial
Storage/warehousing	105	57	9	6	3	285	1.58	Interest
Marketing	18	30	20	76	36	622	3.46	Adoption

3.3.1. Pruning

The findings regarding the adoption of cashew nut production technologies reveal that pruning has been embraced by most farmer clusters at the trial stage of adoption ($\bar{x} = 2.56$). Pruning, as an agronomic practice, is essential for improving tree structure, promoting aeration, enhancing sunlight penetration, and increasing overall productivity. During field visits organized by the APPEALS team, it was observed that farmers who implemented pruning techniques had healthier and more productive cashew trees. In contrast, cashew trees

left unpruned often exhibited overgrown and drooping branches, which not only compromised air circulation but also created visibility and security challenges on the farm.

This disparity in practices reflects varying perceptions among farmers, with some—particularly the less innovative or “laggard” adopters—believing that allowing branches to grow unchecked was optimal. However, hands-on demonstrations during the field visits, led by resource persons, provided empirical evidence of the benefits of pruning. These demonstrations played a cru-

cial role in reshaping farmers' perceptions and encouraging further adoption. Moreover, the APPEALS project supported the material dimension of this technology by distributing motorized saws to production clusters. These tools significantly reduced the labour burden and increased the efficiency of pruning activities, thereby enhancing the likelihood of sustained adoption.

3.3.2. Coppicing

In the case of coppicing—the practice of cutting old or unproductive trees to stimulate regeneration—adoption was generally at the interest stage ($\bar{x} = 1.62$). Farmers initially expressed skepticism toward this relatively uncommon and seemingly drastic method of rejuvenating cashew trees. However, those who implemented the technique reported promising outcomes, including vigorous regrowth and accelerated development of new shoots. The observable success of coppiced trees served as a strong testimonial to the practice's efficacy.

While the practice was unfamiliar to many farmers, peer learning during cluster activities and visual evidence from demonstration sites helped to overcome initial resistance. Over time, as farmers observed the positive outcomes, such as improved tree vigour and increased future yield potential, their attitudes shifted in favour of the technology. This gradual process of persuasion and trial highlights the importance of experiential learning and local validation in promoting the adoption of innovative agricultural practices.

3.3.3. Integrated Pest Management (IPM)

Integrated Pest Management (IPM) refers to an ecosystem-based strategy that focuses on the long-term prevention and control of pests through a combination of techniques, such as biological control, habitat manipulation, modification of cultural practices, and the use of resistant varieties. The technology, as introduced by APPEALS, included training farmers in both cultural and chemical pest management practices, alongside the provision of material support such as knapsack sprayers, Lara Force pesticide, protective eyeglasses, and gloves. Results showed that most cashew farmers were at the adoption stage of this technology ($\bar{x} = 3.41$), affirming its widespread acceptance and practical util-

ity.

Farmers in *Ochaja*, *Imane*, and *Umomi* clusters shared compelling testimonials on the efficacy of IPM, particularly highlighting Lara Force's ability to eliminate pests across all life stages—egg, larva, pupa, and adult. Furthermore, the provision of motorized sprayers significantly enhanced the reach of application, particularly for tall cashew trees, which manual sprayers could not adequately cover. These tools not only increased effectiveness but also promoted safety during application. The most effective learning method supporting the adoption of IPM was the technical advisory visits by the APPEALS team and extension workers. These personalized, hands-on training sessions ensured proper demonstration and immediate feedback, thereby fostering confidence among farmers and leading to the rapid diffusion of the technology.

3.3.4. Terracing

Fire terracing, also known as fire line construction, involves creating a cleared or ploughed strip of land to prevent the spread of wildfire, a recurrent threat in dry-season agriculture in Nigeria. Before APPEALS' intervention, fire outbreaks were common and had led to significant losses of cashew trees and yields. Through its awareness and training efforts, APPEALS introduced this technique as a preventive measure. The mean adoption score ($\bar{x} = 1.62$) suggests that most farmers were still in the interest stage of adoption, but reports indicate growing enthusiasm due to increased understanding of fire risks and management. The farmers affirmed that learning about appropriate timing and methods for creating firebreaks opened their eyes to practices that could safeguard their livelihoods.

Given the nature of this knowledge, field visits and study tours were the most effective methods for fostering its adoption through peer learning. The physical demonstration of firebreak creation and the visual evidence of protected cashew stands convinced farmers of the benefits more than classroom-based instructions would have.

3.3.5. Soil Sampling Techniques

Soil sampling is the process of collecting and analyzing soil samples to determine their fertility status, pH

levels, and nutrient availability. This enables farmers to make informed decisions regarding crop suitability, fertilizer application, and overall farm planning. Surprisingly, most farmers were at the awareness stage of adopting this technology ($\bar{x} = 1.21$), indicating minimal prior exposure.

Before the APPEALS intervention, many cashew farmers did not test their soils and were unaware of its implications for yield optimization. By learning to use soil sampling as a diagnostic tool, they are now better equipped to match cashew varieties to suitable soil types and address underlying soil fertility issues—factors crucial to commercial-scale production.

To promote widespread adoption of this technique, group discussions emerged as a vital method. During these sessions, farmers shared their challenges and successes regarding soil testing, and the presence of extension officers helped demystify the scientific aspects of soil analysis in a farmer-friendly language.

3.3.6. Thinning

Thinning involves the strategic removal of excess or poorly spaced trees in a plantation to reduce competition for sunlight, nutrients, and water. In cashew orchards, it is essential to ensure optimal growth, especially during the early stages of tree development. In this study, the adoption level of thinning was rated at the trial stage ($\bar{x} = 2.53$), with several farmers reporting significant improvements in tree vigour and canopy development after thinning was practiced.

Field observations revealed that before APPEALS' involvement, many farms had trees planted at irregular and sub-optimal spacing—some as close as 3 or 4 meters apart instead of the recommended 9m x 9m spacing. This hindered airflow, reduced sunlight penetration, and ultimately limited the yield of nuts. Farmers who applied thinning reported enhanced growth and improved nut quality, indicating strong potential for impact.

One-on-one contact with fellow farmers, combined with field visits, proved most effective in facilitating the adoption of thinning practices. Farmers who had successfully implemented thinning practices served as practical case studies, showcasing the visible benefits to their peers and motivating wider replication.

3.3.7. Gapping

Gapping, in the context of cashew orchard management, refers to the selective and complete removal of overcrowded or poorly spaced trees to ensure optimal plant population, especially when the existing layout deviates from the recommended spacing of 9m x 9m. This intervention creates room for vigorous growth and maximum yield of the remaining trees. According to the findings, most farmers were at the trial stage of adopting gapping ($\bar{x} = 2.74$), indicating that while the practice was initially perceived as drastic, trials facilitated by APPEALS demonstrated its merit. Before the intervention, most farmers were reluctant to remove existing cashew trees, even those that contributed to overcrowding, largely due to the cultural and economic sentiments associated with tree cutting. However, practical demonstrations and field evidence convinced many of the benefits, including improved canopy development, higher yields per tree, and easier orchard management. The provision of motor saws and herbicides further supported the effective implementation of this practice.

The most impactful learning method here was on-farm demonstration and experiential learning, where farmers witnessed firsthand the transformation of orchards that had undergone gapping. These visual proofs, coupled with real-life testimonials during exchange visits, were instrumental in shifting perceptions and promoting trial adoption.

3.3.8. Nursery Preparation

Nursery preparation involves raising cashew seedlings in a controlled environment (nursery bags or beds) before transplanting them to the field. This technology helps ensure seedling health, allows for early growth monitoring, and empowers farmers to select and propagate desirable varieties. Results showed that farmers had reached the adoption stage for nursery preparation ($\bar{x} = 3.37$), highlighting a positive response to this technology.

Historically, direct seeding was common among farmers in the study area, often resulting in low germination rates and high seedling mortality. With APPEALS' intervention, farmers learned how to raise healthy cashew seedlings in nurseries, thereby reducing field transplant

shock and increasing survival rates. This method also enabled farmers to control varietal choice, leading to increased consistency and quality in orchard performance.

The farmer-to-farmer exchange visits, supported by APPEALS, were most effective for this technology. Observing nursery techniques being practiced in real-time, asking practical questions, and receiving nursery bags boosted farmer confidence and enhanced widespread adoption. Peer testimonies about reduced mortality and better plant uniformity further encouraged acceptance.

3.3.9. Improved Financial Management

Improved financial management refers to the capacity of farmers to plan, budget, save, and invest their income wisely, especially from cashew sales. Although primarily a non-material (knowledge-based) technology, it plays a critical role in ensuring the sustainability of agricultural livelihoods. The study found farmers were at the interest stage of adopting improved financial management practices ($\bar{x} = 1.88$).

Before the APPEALS intervention, many farmers lacked formal financial education and often mismanaged sudden earnings from bumper cashew harvests. These poor practices included unplanned spending, failure to save, and dependence on middlemen for seasonal loans, sometimes resulting in farm mortgage or loss of autonomy over harvest decisions. With financial literacy training provided during the programme, farmers reported improved budgeting, better savings culture, and the ability to cater to household needs, such as school fees, food, and health bills.

The most effective peer learning approach for this subject was focus group discussions (FGDs) and cluster-based financial training sessions, where farmers engaged in open dialogue about their income use patterns, challenges, and successes. These discussions provided relatable, real-life examples and mutual encouragement, demonstrating that financial discipline was both necessary and achievable. Additionally, the involvement of facilitators with expertise in farm-based finance created a credible learning atmosphere.

3.3.10. Home Management

Home management refers to the proper planning, organizing, and utilization of household resources—

such as income, time, food, and energy—to enhance family welfare. Although often overlooked in extension programmes, APPEALS recognized its significance as a cornerstone for farm productivity. The emphasis is that only a well-fed, mentally balanced, and healthy farmer can be productive. This intervention was primarily focused on equipping farmers with skills in budgeting, food planning, health, sanitation, and overall home resource management. Before the intervention, many households struggled with poor resource allocation, often resulting in food insecurity, health issues, or mismanagement of seasonal income. Farmers acknowledged during feedback sessions that they had become better managers of their homes after the training, which had a positive impact on their productivity and family well-being.

The most effective method was the cluster-based interactive sessions, where farmers, especially women and heads of households, engaged in practical case discussions and problem-solving exercises. Sharing of experiences through peer storytelling and group learning circles made the knowledge more relatable and implementable at the household level.

3.3.11. Improved Storage/Warehousing

Improved storage and warehousing techniques were introduced to address the perennial problem of post-harvest losses and quality degradation of cashew nuts. Traditionally, poor storage facilities exposed cashews to spoilage due to their high moisture content, insect infestations, and mould growth, which led to a loss of quality, rejection by buyers, and a low market value. APPEALS addressed this by educating farmers on the importance of controlling humidity, temperature, and moisture levels in storage. Through training, farmers were exposed to modern storage techniques, such as well-ventilated storage structures, the use of jute sacks instead of nylon bags, elevated platforms, and timely sun-drying. They were also taught to understand quality thresholds for nuts to fetch premium prices.

The adoption of this practice was best supported through on-farm demonstration and hands-on technical training, where farmers not only observed but also participated in setting up proper storage systems. During exchange visits, farmers could compare outcomes

between well-stored and poorly stored nuts, which served as strong visual motivation to adopt the new methods.

3.3.12. Improved Marketing

Improved marketing strategies were crucial for helping farmers transition from being price-takers at the mercy of exploitative middlemen to becoming price-influencers through access to better market information and structured buyer networks. Before APPEALS' intervention, many farmers lamented low income due to asymmetric market information, lack of bargaining power, and dependency on unreliable local buyers. APPEALS revolutionized the market access landscape by linking farmers directly to credible off-takers who offered prices up to 20% higher than those in the open market. This increase in farmer income and encouragement of fair competition ultimately improved the overall cashew market in the region. The ripple effect of this intervention also benefited non-APPEALS farmers who began to enjoy better prices due to the enhanced market competition.

The most effective peer learning method here was market exposure through learning visits and exchange

meetings with off-takers. Farmers were able to interact directly with buyers, understand grading standards, and negotiate prices. Additionally, knowledge-sharing sessions with successful marketers among the clusters provided grassroots marketing tips that were both practical and impactful.

3.4. Analysis of the Intensity of Adoption of Cashew Production Technologies by the Respondents

The effects of socioeconomic characteristics of cashew farmers on the intensity of adoption of cashew nut production technologies are presented in **Table 4**. The Tobit model was adopted because of the censored nature of the dependent variable. The study hypothesized that the adoption of production technologies by cashew farmers is influenced by some sets of socioeconomic and institutional factors. In the Tobit model framework, the interpretation of the coefficient is associated with the latent variable that is observed when it falls within the uncensored range. The intensity of adoption in this study is a continuous variable that ranges between certain limits.

Table 4. Result of the Tobit model analysis of the intensity of adoption of cashew production technologies by the respondents.

Variables	Coeff	Std. Error	t	p > [t]	[95% Conf. interval]	
AGE	−0.0062827	0.0199562	−0.32	0.753	−0.0454562	0.0329307
SEX	−0.2419743	0.393303	−0.62	0.539	−1.018296	0.5343476
MTS	0.8695159	0.5656666	1.71	0.088*	−0.1470263	2.086058
EDU	0.0829632	0.0308227	2.69	0.008***	0.0221237	0.1438027
HSS	−0.0935862	0.523209	−1.79	0.075*	−0.1968599	0.096875
EXP	0.0448242	0.0222559	2.01	0.046**	−0.0008943	0.0887541
INC	0.0120478	0.1901395	0.06	0.950	−0.3632594	0.387355
EXT	0.0450631	0.0937929	0.48	0.632	−0.1400702	0.2301965
_CONS	3.259689	1.40027	2.33	0.021**	0.4957628	6.023616
var(e,----	4.412956	0.4651664	-	-	3.584011	5.433628

Note: LR Chi2 = 18.64; Prob > Chi2 = 0.0169; Pseudo-R2 = 0.0234; Loglikelihood = −389.01796. ***, **, and * = coeff. significant @ 1%, 5%, and 10% levels of significance, respectively.

Source: Field survey, 2024.

Four (4) of the included explanatory or independent variables significantly influenced the intensity of adoption of cashew production technologies among the respondents. These are education, farming experience, marital status, and household size. The estimated variance of the error term is 4.413, and the associated standard deviation of the error term (square root of the

variance) is 2.101. The variance of the error term measures the variability of the unobserved factors that affect the adoption of cashew production technologies. The estimated variance of error terms suggests that the variability in the latent or unobserved variables of the outcome variable (adoption of cashew production technologies) is relatively low. It further suggests that

the Tobit model can capture variability in the dependent variable, given the explanatory or independent variables. The estimated likelihood ratio Chi-Squared value, significant at the 1% level of significance, provides further confirmation that the model is a good fit and the included explanatory variables have a joint effect on the intensity of adoption of cashew production technologies.

The coefficient of education is positively signed and significant at the 1% level of significance. This implies that an increase in the number of years spent in schooling will increase the intensity of the adoption of cashew production technologies by 0.083, all else being equal. Cashew farmers with higher levels of education or those who can read and write are more likely to adopt these production technologies than their counterparts with lower educational levels. This finding aligns with the *a priori* expectation. Education is expected to play a major role in driving innovation and technology adoption. This finding aligns with Nthantumbo et al.^[2], who reported that education has a significant and positive impact on the intensity of cashew production technology adoption among farmers in Mozambique. Farmers with higher education levels may have better access to information, critical thinking skills, and a willingness to adopt new and improved technologies in cashew production. Policies should be geared towards investing in education programmes and initiatives that can contribute to more widespread and intensive adoption of modern technologies, with their multiplier effect of increased productivity and sustainability.

The coefficient of experience was positive and significant at a 5% level of significance. This indicates that a one-year increase in the number of years spent in cashew production is expected to increase the intensity of adoption, as measured by the number of technologies adopted, by 0.045. This result is also in line with the *a priori* expectation. A similar result was reported among farmers in Ethiopia^[36]. As cashew farmers gain more experience, there is an expected increase in the number of cashew production technologies adopted. This finding aligns with the idea that experience in farming may enhance farmers' ability to understand, appreciate, and effectively adopt new agricultural tech-

nologies.

Table 4 further reveals an inverse relationship between household size and the intensity of adoption of cashew production technologies among the cluster farmers. This relationship is statistically significant at the 10% level of significance. This implies that an increase in the number of persons living under the same roof will reduce the intensity of adopting cashew production technologies. For each person added to the household size, there is an expected decrease in the latent intensity of adoption by about 0.094, holding other variables constant. This result is not surprising, as it suggests that within larger households with more individuals, the allocation of resources towards adopting cashew production technologies might be relatively lower. The finding on household size agrees with John et al.^[37] and Shaibu and Shaibu^[38], who reported an inverse relationship between household size and the adoption of improved production technologies among rice farmers in Ogun State and Kogi State, respectively.

The coefficient of marital status is positive and significant at a 10% level of significance. This implies that holding all other factors constant, the adoption of improved cashew production technologies is higher among married cashew farmers than among unmarried ones. This finding may be related to the decision-making dynamics within farming households. The findings of this study on marital status may suggest that married cashew farmers, compared to unmarried farmers, exhibit certain characteristics or advantages that contribute to a greater intensity of adoption. This could include shared resources, collaborative decision-making, or other socioeconomic factors associated with being in a marriage. The findings of this study on marital status are in tandem with a similar study conducted among plantain farmers in Anambra State, Nigeria, by Olumba and Rahji^[39].

4. Conclusion

The study concludes that the APPEALS programme significantly influenced the adoption of cashew production and knowledge-based technologies among farmers in the study area. Most farmers adopted and applied

the introduced technologies, while a few remained at the awareness or trial stages. The variation in adoption levels was shaped by factors such as education, farming experience, marital status, and household size. Notably, education, experience, and marital status had a positive influence on adoption intensity, whereas a larger household size had a negative effect.

Although the programme provided both technical knowledge and material support, some farmers still face barriers such as poor financial management, insecurity, and limited access to inputs. These challenges slowed adoption for a few farmers who preferred to observe results before committing fully. Nonetheless, the programme has improved farmers' capacity to produce, manage, and market cashew efficiently. Continued support and targeted interventions are needed to sustain adoption and address lingering constraints.

5. Recommendations

The following recommendations abound from the Learning and Exchange programme:

1. More reinforcement and continued capacity building among farmers on financial education should be sustained so that the knowledge acquired can be diffused by cashew farmers beyond APPEALS beneficiaries.
2. Monitoring and evaluation by APPEALS should be consolidated to ensure that farmers move from the awareness stage to adopting the technologies introduced to them and continue to practice what they have been taught.
3. Conscious effort by stakeholders in the cashew enterprise (Government, APPEALS, Marketers, and Farmers) to ensure that farmers are protected from gullible middlemen who put farmers at their mercy at every production season.
4. Flexible measures for continuity and an enabling environment should be implemented to accelerate the adoption of cashew production technologies among APPEALS beneficiary farmers in Kogi State and even beyond.

Author Contributions

Conceptualization, S.O.A., P.E.A., O.M.U., E.A.S., and E.G.A.; methodology, P.E.A., G.O., and U.M.S.; software, G.O. and U.M.S.; validation, O.J.S., S.O.A., and P.E.A.; formal analysis, G.O. and U.M.S.; data curation, P.E.A., E.G.A., O.M.U., E.A.S., and G.O.; writing—original draft preparation, P.E.A., E.G.A., G.O., and U.M.S.; writing—review and editing, O.J.S., S.O.A., P.E.A., and U.M.S.; visualization, G.O. and U.M.S.; supervision, O.J.S., S.O.A., and P.E.A.; project administration, S.O.A., P.E.A., O.M.U., and E.A.S. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Informed consent was obtained from all respondents involved in the study.

Data Availability Statement

Data for this study are available upon request, subject to valid approval due to ethical concerns.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

Appendix A



Figure A1. A cross-section of farmer clusters, APPEALS team and resource person after the interactive session at Umomi.

Source: WhatsApp platform for KG APPEALS Learning and Exchange Programme (2021).



Figure A2. A cross section of Farmer Clusters, APPEALS team and resource person after the interactive session at Ochaja.

Source: WhatsApp platform for KG APPEALS Learning and Exchange Programme (2021).



Figure A3. Interactive session at imane together with Ochaja clusters.

Source: WhatsApp platform for KG APPEALS Learning and Exchange Programme (2021).



Figure A4. Interactive session at Umomi together with Imane clusters.

Source: WhatsApp platform for KG APPEALS Learning and Exchange Programme (2021).



Figure A5. Interactive session at Ochaja together with Imane clusters lead by the cashew value chain facilitator.

Source: WhatsApp platform for KG APPEALS Learning and Exchange Programme (2021).

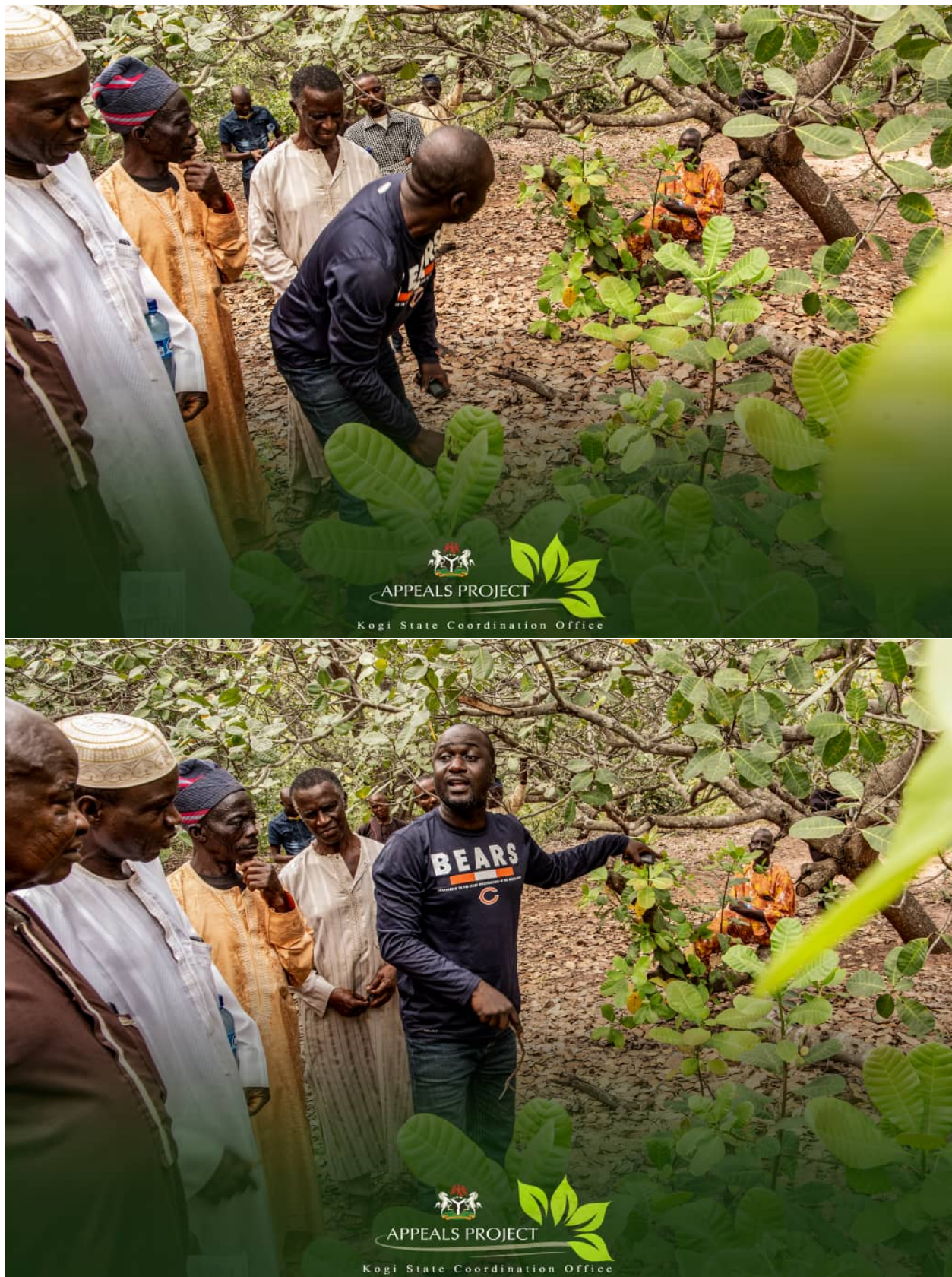


Figure A6. Resource person interacting with farmers during a field visit at the Umomi cluster.

Source: WhatsApp platform for KG APPEALS Learning and Exchange Programme.



Figure A7. The APPEALS team and resource person are interacting with cashew farmers at Ochaja on the field, inspecting the adoption of coppicing technology.

Source: WhatsApp platform for KG APPEALS Learning and Exchange Programme (2021).

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