ADOPTION OF AGRO-ECOSYSTEM ANALYSIS TECHNIQUES AMONG COCOA FARMERS IN SOUTHWESTERN NIGERIA

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ABSTRACT
The study examined the awareness and adoption intensity of Agro-Ecosystem Analysis (AESA) techniques among cocoa farmers in Southwestern Nigeria. A multistage sampling procedure was used to select 300 cocoa farmers, and data were collected on awareness, adoption intensity, and factors influencing AESA adoption using a structured interview schedule. Data was analysed using descriptive statistics (frequency counts, percentages, means, and standard deviations) and multiple regression analysis. The results revealed generally high awareness of AESA techniques, particularly for farm hygiene and sanitation (95.0%), planting of resistant cocoa varieties (95.0%), and safety precautions in pesticide application (94.7%). Adoption patterns showed selective uptake of AESA practices, with higher adoption for farm sanitation (39.3%), planting resistant varieties (36.3%), and responsible pesticide use (35.3%). However, more analytically demanding practices, such as pest monitoring and understanding vulnerable pest stages, recorded lower adoption. The Tried/Practised Index (0.367) and grand mean adoption score (1.097) indicate partial rather than comprehensive implementation of AESA techniques. Multiple regression results showed that the age of the cocoa farm ($\beta = 0.233$), cocoa farm size ($\beta = -0.268$), and membership of farmers' organisations ($\beta = -0.173$) significantly influenced AESA adoption. These findings suggest that AESA adoption is driven more by structural and institutional factors than by knowledge alone. The study recommends strengthening experiential AESA training, promoting farmer organisation membership, and aligning extension strategies with farm characteristics to enhance sustainable and climate-smart cocoa production in Nigeria.
Keywords: Agro-Ecosystem Analysis (AESA), Cocoa Farmers, Integrated pest management, Technology Adoption. Sustainable cocoa production

INTRODUCTION

Agro-Ecosystem Analysis (AESA) is a participatory, field-based decision-making approach that enables farmers to observe, analyse, and manage their Agroecosystems more sustainably. Developed under the Integrated Pest Management (IPM) and Farmer Field School (FFS) frameworks, AESA aims to enhance farmers' ecological literacy and reduce dependence on chemical pesticides (FAO, 2023 FFS guidance). In cocoa production systems, where pest and disease pressures are high, AESA techniques can help farmers make timely, informed management decisions, ultimately improving productivity and sustainability (Adebiyi *et al*., 2021). The approach integrates scientific knowledge with farmers' indigenous experience, fostering ecological resilience (Ramirez-Santos *et al*., 2023). In cocoa-based systems of Southwestern Nigeria, where mirids and black pod disease are major constraints, AESA techniques provide an adaptive framework for pest control while reducing pesticide misuse (Agulanna, Williams, & Adebiyi, 2025).

The FFS model, within which AESA is typically implemented, has been introduced by agencies such as FAO, IITA, and the Cocoa Research Institute of Nigeria (CRIN) to improve smallholder decision-making capacity. The integration of AESA into cocoa training curricula is designed to promote sustainable production through ecological pest management, reduced input costs, and enhanced yields (Orimogunje *et al*., 2020).

Empirical evidence suggests that AESA enhances farmers' analytical and problem-solving capacities, resulting in reduced pesticide use and lower production costs (Farmer Field School case studies, 2020). In Ghana and Côte d'Ivoire, where cocoa Farmer Field School programmes incorporating AESA and integrated pest management principles have been implemented, participatory training has been linked to improved pest management practices and reduced reliance on chemical pesticides (Farmer Field School case studies, 2021). Comparable results are emerging from Nigeria, where farmers exposed to AESA demonstrated improved knowledge of pest identification and ecosystem interactions (Akinbode & Lawal, 2021).

Beyond ecological and economic gains, AESA also contributes to social learning. Group-based observation and analysis encourage collaboration and the exchange of local knowledge. This participatory dimension strengthens community cohesion and facilitates the diffusion of improved practices (FAO, 2023).

Cocoa production remains a vital source of income and foreign exchange in Southwestern Nigeria, yet its sustainability is increasingly threatened by persistent pest infestations, diseases, and soil fertility decline. Farmers' overreliance on chemical pesticides has contributed to increased production costs, environmental contamination, and public health risks (Omohwovo & Cheke, 2025). To overcome this, CRIN introduced Agro-Ecosystem

Analysis (AESA) to farmers in Southwest Nigeria. The AESA technique offers an ecologically sound approach that emphasizes observation, analysis, and informed decision-making to manage pest–crop interactions (FAO, 2023). Despite its potential to enhance sustainable cocoa production, the farmers' production level has not improved significantly. Also, there is no noticeable reduction in the use of pesticides. Many farmers still rely on calendar-based pesticide application rather than evidence-based decisions derived from AESA observations (Amoah-Yeboah, Nyantakyi-Frimpong, & Kyei-Boateng, 2023). The study was embarked upon to foster the design of effective extension interventions that promote sustainable cocoa production and environmental health in Southwestern Nigeria.

Hence, the primary aim of this study is to investigate the adoption of AESA Techniques among Cocoa Farmers in Southwestern Nigeria. The specific objectives include to

1. Ascertain the awareness of AESA techniques by cocoa farmers in southwest Nigeria.
2. Determine the level of adoption of AESA by the farmers.
3. Determine the factors influencing AESA adoption.

METHODOLOGY

The study was carried out in Southwest Nigeria. The area is situated between latitude 5^0 and 9^0 north and longitude 2^0 and 7^0 east of the equator, and consists of six states, namely Ogun, Oyo, Osun, Ondo, Ekiti and Lagos. A multistage sampling procedure was employed to select the respondents for the study. Stage one involved the purposive selection of three states among the six states in Southwest Nigeria based on areas where AESA trainings were conducted. These included Oyo, Osun, and Ondo States. At Stage two, two Local Government Areas with a high level of participation in the AESA training programme were purposively selected from each state. At stage three, two communities were selected purposively where farmers' organisations participated in the AESA training programme. At the fourth stage, from each of the communities, ten per cent (10%) of the trained cocoa farmers on AESA techniques were selected randomly using a table of random numbers among the cocoa farmers. Consequently, a total of 300 respondents were selected and interviewed using a structured interview schedule. The awareness of the AESA technique was measured by asking respondents to indicate whether they were aware of each of the ten AESA techniques listed. Each correct response was scored as 1, giving a maximum possible score of 10 and a minimum of 0. Percentages were also computed to show the proportion of respondents aware of each technique. The mean scores for individual AESA techniques were calculated, and a grand mean was computed to assess overall awareness.

The level of AESA adoption was measured by asking respondents to indicate the extent to which they had adopted each AESA technique. Scores were allocated as follows: never tried (0), some trials (1), and full trial (2), yielding a minimum possible score of 0 and a maximum of 20. The mean and standard deviation were calculated, and respondents were classified into high, medium, and low adoption levels using the criterion of mean ± 1 standard deviation.

Data were analyzed using frequency counts, percentages, means, standard deviations, and multiple regression analysis to examine the relationships between awareness, attitude, and adoption of AESA techniques.

RESULTS AND DISCUSSIONS

The findings in Table 1 revealed a generally high level of awareness of most AESA techniques among cocoa farmers, as evidenced by the high proportions of respondents who reported awareness of key practices. Techniques related to farm hygiene/sanitation and planting resistant cocoa varieties ranked jointly highest, with 95.0% awareness each. This suggests that farmers are particularly familiar with practices that are routinely promoted through extension services and are visibly linked to yield protection and disease prevention in cocoa production systems. Similar studies in West Africa indicate that extension programmes often prioritize sanitation and resistant varieties because they are relatively easy to demonstrate and align with farmers' immediate production goals (FAO, 2023; Amoah-Yeboah *et al.*, 2023).

Closely following in rank were safety precautions in insecticide application (94.7%) and identification of pests and diseases of cocoa (94.0%), indicating that most farmers possess basic operational knowledge related to pesticide handling and pest recognition. High awareness of these practices reflects sustained sensitization efforts around pesticide safety and pest identification, particularly in cocoa-growing areas where pest pressure and chemical use are high (FAO, 2023). However, previous research cautions that high awareness does not necessarily translate into correct or consistent application in practice, especially where training is episodic rather than continuous (Amoah-Yeboah *et al*., 2023).

Awareness levels declined slightly for more regulatory and knowledge-intensive components of AESA. For instance, identification of recommended chemicals (89.3%), regulatory control (87.3%), and identification of banned chemicals (83.7%) ranked fifth, sixth, and seventh, respectively. While these

percentages still indicate relatively high awareness, the downward trend suggests weaker farmer familiarity with regulatory frameworks governing pesticide use. This pattern aligns with recent evidence showing that smallholder farmers often have limited access to up-to-date regulatory information and rely heavily on agrochemical dealers for advice, which can undermine compliance with pesticide regulations (FAO, 2023).

Lower awareness was observed for responsible pesticide use (80.0%) and pest monitoring (78.6%), ranking eighth and ninth, respectively. These techniques require regular observation, record-keeping, and analytical decision-making, core principles of AESA that are less intuitive than routine spraying. Studies have shown that farmers are less likely to internalize these practices without sustained experiential learning and facilitation, even when they are familiar with basic pest control measures (Amoah-Yeboah *et al.,* 2023).

The lowest-ranked AESA technique was understanding the vulnerable stages of pests, with only 46.3% of respondents aware of this component. This substantial gap highlights a critical weakness in farmers' ecological understanding of pest life cycles, which is central to evidence-based decision-making under AESA. Recent literature emphasizes that limited knowledge of pest population dynamics often leads farmers to depend on calendar-based pesticide applications rather than targeted interventions, thereby reducing the effectiveness of AESA and increasing unnecessary chemical use (FAO, 2023).

Table 1: Distribution of the respondents according to the level of awareness of AESA techniques

Rank	AESA Technique	Aware F (%)	Mean	Remark
1	Farm hygiene / sanitation	285 (95.0)	0.95	High awareness
1	Planting resistant cocoa varieties	285 (95.0)	0.95	High awareness
3	Safety precautions in insecticide application	284 (94.7)	0.95	High awareness
4	Identification of pests and diseases of cocoa	282 (94.0)	0.94	High awareness
5	Identification of recommended chemicals in cocoa production	268 (89.3)	0.89	High awareness
6	Regulatory control	262 (87.3)	0.87	High awareness
7	Identification of banned chemicals in cocoa production	251 (83.7)	0.84	High awareness
8	Responsible pesticide use (RPU)	240 (80.0)	0.80	High awareness
9	Pest monitoring	236 (78.6)	0.79	High awareness
10	Understanding the vulnerable stages of pests	139 (46.3)	0.46	Low awareness

Grand Mean Awareness =0.85
Source: Field Survey, 2024

Level of adoption of AESA

Table 2 presents the level of adoption of specific AESA techniques among cocoa farmers, showing clear differences in the extent to which individual practices have been tried or integrated into routine farm management. The results indicate that the most frequently adopted practices were farm hygiene/sanitation**,** safety precautions in insecticide application**,** and planting resistant cocoa varieties**,** which were fully tried by 39.3%, 36.3%, and 35.3% of farmers, respectively, with high mean scores of 1.30, 1.27, and 1.26, respectively. These findings align with existing literature, as they suggest that farmers tend to adopt practices that offer visible, immediate benefits or those strongly emphasised through extension campaigns (Rahman *et al.*, 2022). For example, sanitation practices and resistant varieties are often promoted as simple, low-cost measures that significantly reduce pest incidence, making them more appealing to smallholders (Fatai *et al*., 2024).

Lower proportions of full adoption were observed for responsible pesticide use (31.7%), identification of pests and diseases (32.7%), and identification of banned chemicals (27.3%) compared with other AESA techniques. Although these practices were fully tried by a substantial number of farmers, their relatively lower adoption rates suggest that they are less extensively embedded in routine farm management decisions. This pattern reflects a broader challenge in pest management interventions, where knowledge related to pesticide safety and pest diagnosis is widely disseminated, yet translating such knowledge into widespread and consistent practice often requires sustained training, follow-up, and institutional monitoring (Khan *et al.,* 2022). Similar patterns, where full adoption occurs but at lower prevalence relative to other practices, have been reported in studies on the implementation of integrated pest management strategies among smallholder farmers (Campbell Collaboration, 2024).

In contrast, the least adopted AESA components were understanding the vulnerable stages of pests and pest monitoring**,** where only 20.7% and 19.3% of farmers fully tried the practices, and 40.7% and 35.7% had never tried them. These

low mean scores (0.84 and 0.80) suggest significant gaps in farmers' ecological literacy, consistent with evidence that ecological observation and analysis are among the most difficult AESA skills to teach and sustain without intensive hands-on training (Fatai *et al*., 2024). Such techniques require regular field scouting, record-keeping, and interpretation of pest–crop interactions, skills that traditional extension methods often fail to effectively transmit (Rahman *et al.*, 2022).

The grand mean of 1.097 and practice index of 0.367 indicate a moderate but uneven adoption of AESA techniques, with farmers predominantly adopting simpler and more familiar practices, while struggling with more technical, analysis-based components. This pattern reinforces the need to intensify the experiential extension approaches of the Farmer Field Schools, which have been shown to significantly enhance farmers' ability to apply ecosystem-based decision-making rather than relying solely on chemical control (Campbell Collaboration, 2024). Strengthening such participatory training models is essential to deepen adoption intensity and move farmers towards more sustainable cocoa production systems.

Table 2: Distribution of the respondents based on the level of AESA adoption

AESA techniques	Fully tried F (%)	Occasionally tried F (%)	Never tried F (%)	Mean	Std
Responsible Pesticide Use (RPU)	95(31.7)	132(44.0)	73(24.3)	1.07	.746
farm hygiene/Sanitation	118(39.3)	154(51.3)	28(9.3)	1.30	.631
Safety precautions in insecticide application	106(35.3)	167(55.7)	27(9.0)	1.26	.613
Identification of pests and diseases of cocoa	98(32.7)	166(55.3)	36(12.0)	1.21	.637
identification of banned chemicals in cocoa production	82(27.3)	161(53.7)	57(19.0)	1.08	.677
Understanding the vulnerable stages of pests	62(20.7)	116(38.7)	122(40.7)	0.80	0.758
Pest monitoring	58(19.3)	135(45.0)	107(35.7)	0.84	.725
Identification of recommended chemicals in cocoa production	70(23.3)	175(58.3)	55(18.3)	1.05	0.645
Regulatory control	84(28.0)	158(52.7)	58(19.3)	1.09	0.684
Planting resistant cocoa varieties	109(36.3)	162(54.0)	29(9.7)	1.27	0.625
Mean Total				10.97	
Grand Mean				1.097	
Tried/Practiced /Index				0.367	

Factors influencing the Adoption of AESA techniques

Table 3 presents the results of the multiple regression analysis examining the factors influencing cocoa farmers' adoption of AESA techniques. The model explains approximately 34.8% of the variance **i**n AESA adoption (R^2 = 0.348; Adjusted R^2 = 0.319), indicating a moderately strong explanatory capacity for the model. Among the ten predictors included, only three variables, age of cocoa farm**,** cocoa farm size**,** and membership of an organization**,** significantly influenced AESA adoption at the 5% level.

Age of cocoa farm was positively significant (β = 0.233), suggesting that farmers with older cocoa farms are more likely to adopt AESA techniques. Older plantations are typically more prone to pest and disease pressure, prompting farmers to seek more sustainable and analytical approaches to crop management. This finding aligns with evidence that farmers managing ageing perennial crops often adopt integrated pest management (IPM) and ecological practices to maintain productivity (Asamoah *et al*., 2021).

Conversely, cocoa farm size showed a negative and significant influence on adoption (β = –0.268). This implies that farmers with larger farms adopt AESA techniques less intensively, possibly because AESA practices, such as pest monitoring, ecological observations, and sanitation, are labour-intensive and difficult to implement uniformly across extensive farm areas. Studies in West Africa similarly report that ecological-based pest management is more feasible on small to medium-sized plots (Khan *et al.*, 2022; Rahman *et al.*, 2022).

Membership of farmer organizations was also significant and negative (β = –0.173). While counterintuitive, this may reflect situations where group activities emphasize yield-oriented interventions or reliance on chemical control promoted through cooperatives and agro-dealer networks, thereby reducing adoption of more analytical AESA practices. Previous research noted that farmer groups sometimes become channels for

pesticide marketing rather than for ecological knowledge sharing (Amoah-Yeboah *et al*., 2023).

The findings highlight that adoption of AESA is driven more by farm characteristics and farmers' perceptions than by personal attributes or awareness levels. Strengthening AESA adoption, therefore, requires extension strategies that emphasize practical demonstrations, problem-solving on ageing farms, and cooperative reorientation toward ecological management rather than chemical dependency.

Table 3: Multiple regression analysis of factors influencing the AESA adoption among respondents

Variables	Std. error	Beta	t-value	p-value	Decision
(Constant)	0.590		3.658	0.000	
Age	0.007	0.036	0.538	0.591	NS
Educational attainment	0.194	-0.021	-0.405	0.686	NS
Cocoa farming experience	0.007	-0.004	-0.053	0.958	NS
Household size	0.029	-0.045	-0.739	0.461	NS
Age of cocoa farm	0.004	0.233	4.052	0.000	S
Cocoa farm size	0.024	-0.268	-5.040	0.000	S
Membership of organization	0.185	-0.173	-3.141	0.002	S
Extension visits	0.130	-0.063	-1.263	0.208	NS
Awareness	0.024	0.011	0.187	0.852	NS
Attitude	0.010	-0.040	-0.642	0.522	NS

$R = 0.590$, $R^2 = 0.348$, Adjusted $R = 0.319$

Source: Field Survey,2024.

CONCLUSION AND RECOMMENDATIONS

The study concludes that cocoa farmers exhibit high awareness but only partial and inconsistent adoption of Agro-Ecosystem Analysis (AESA) techniques. While basic and compliance-oriented practices such as farm sanitation, safety precautions, and planting resistant varieties are relatively well adopted, core analytical components of AESA, particularly pest monitoring and understanding pest life-cycle vulnerabilities, remain weakly practiced. Regression results further indicate that structural farm characteristics (age and size of cocoa farms) and organizational membership significantly influence AESA adoption, whereas socio-demographic factors, awareness, attitude, and extension visits do not. This confirms that knowledge alone is insufficient to drive sustained AESA adoption without enabling institutional and farm-level conditions.

Based on the findings, the study recommends that:

1. Extension delivery should be refocused towards experiential learning by strengthening hands-on AESA training approaches that emphasize pest monitoring and ecosystem analysis rather than information dissemination alone.
2. Farmers with younger and smaller cocoa farms should be targeted with tailored AESA support, as these farm characteristics significantly shape adoption intensity.
3. There is a need to leverage farmer organizations and cooperatives as primary platforms for AESA capacity building, given their significant influence on adoption.
4. The quality and depth of extension engagement should be improved, shifting from visit frequency to skill-oriented, follow-up-based training that supports consistent practice.
5. AESA should be integrated into routine cocoa farm management guidelines and monitoring frameworks to encourage sustained rather than occasional application of the techniques.

REFERENCES

Adebiyi, T., Adeoye, F., & Ogunleye, S. (2021). Determinants of agricultural technology adoption among smallholder farmers in Southwestern Nigeria. *Journal of Rural Social Sciences, 36*(2), 45–60.

Agulanna, F. T., Williams, O. A., & Adebiyi, S. (2025). Perception and adoption of integrated pest management for the enhancement of cocoa production and income among cocoa farmers in Osun State, Nigeria. *Journal of Research in Management and Social Sciences, 11*(1).

Akinbode, S., & Lawal, R. (2021). Adoption of ecological farming practices among smallholder cocoa farmers in Nigeria. *African Journal of Agricultural Extension, 29*(1), 22–35.

Amoah-Yeboah, E., Nyantakyi-Frimpong, H., & Kyei-Boateng, K. (2023). Knowledge, perception, and pesticide application practices among smallholder cocoa farmers in Ghana. *PLOS ONE, 18*(4), e0285581.

https://doi.org/10.1371/journal.pone.0285581

Asamoah, F., Mensah, P., & Boateng, S. (2021). Determinants of integrated pest management adoption in cocoa production. *Agricultural Systems, 189*, 103056.

Campbell Collaboration. (2024). *Farmer field schools for improving farming practices and farmer outcomes in low- and middle-income countries: A systematic review*. Campbell Collaboration. https://www.campbellcollaboration.org/review/farmer-field-schools-systematic-review/

Food and Agriculture Organization of the United Nations. (2023). *Monitoring, evaluation and learning in farmer field school programmes: A framework and toolkit*. FAO.

Farmer Field School case studies. (2020). Impacts of farmer field schools in the human, social, natural and financial domain: A qualitative review. *Food Security*. https://doi.org/10.1007/s12571-020-01046-7

Farmer Field School case studies. (2021). *What is the impact of Farmer Field School programs on farming practices?* International Initiative for Impact Evaluation (3ie).

Fatai, K., Abdullahi, H. A., Oba, A. I., & Bijani, M. (2024). Assessment of the Farmer Field Schools activities as a strategy to enhance the capacity building of smallholder rural cocoa farmers in Kwara State, Nigeria. *Indonesian Journal of Agricultural Research, 7*(1), 60–67. https://doi.org/10.32734/injar.v7i1.11439

Khan, M., Rahman, S., & Alam, M. (2022). Farmers' ecological knowledge and adoption of integrated pest management. *Crop Protection, 156*, 105969.

Omohwovo, S. O., & Cheke, R. A. (2025). Farmers' pesticide use, disposal behavior, and pre-harvest interval: A case study from Nigeria. *Frontiers in Sustainable Food Systems*.

Orimogunje, A. O., Ogundeji, B. A., Ademola, T. I., Balogun, S. T., Awodumila, D. J., Olorunmota, R. T., & Oyeledun, K. O. (2020). Cocoa farmers' coping strategies for climate change adaptation in Ogun State, Nigeria. *Journal of Scientific Research & Reports, 26*(2), 44–51.

Rahman, M. M., Sarker, M. A. R., & Ahamed, K. U. (2022). Impact of farmer field school on crop income, agro-ecology, and farmer behaviour in farming: A case study on Cumilla District in Bangladesh. *Sustainability, 14*(7), 4190. https://doi.org/10.3390/su14074190

Ramirez-Santos, A. G., Ravera, F., & Rivera-Ferre, M. G. (2023). Gendered traditional agroecological knowledge in agri-food systems: A systematic review. *Journal of Ethnobiology and Ethnomedicine, 19*, Article 11. https://doi.org/10.1186/s13002-023-00576-6