The Sustainability–Income Paradox: A Mixed-Methods Analysis of the Economic Disincentives for Integrated Pest Management Adoption Among Liberian Smallholders

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ABSTRACT

Integrated Pest Management (IPM) encourages an ecological alternative to farming that relies on high pesticide use, but smallholders in Liberia are slow to adopt it. This paper analyzes the so-called sustainability-income paradox, which posits that environmentally friendly practices are economically inviable in the short-run. I integrate survey data from 600 households with data collected through focus group discussions and key informant interviews to identify drivers and inhibitors of IPM adoption. The research used a mixed-methods design. The findings from econometric analyses revealed that access to extension services and education significantly increase adoption, while adoption is deterred by pesticide subsidies and high-risk aversion. A cost analysis demonstrates that while IPM can save on chemicals inputs, it increases labor and biological inputs costs, which appear prohibitive to farmers who lack liquidity.

Qualitative findings show that farmers are concerned about time intensity, uncertainty about yields, and the lack of market premiums for safer produce. Collectively, the results revealed that systemic economic disincentives, rather than environmental ignorance, are the primary barrier to adoption. Policy implications include subsidy reform, enhanced extension outreach, and the development of market incentives for residue-free crops. These adjustments could align smallholder decision-making with long-term sustainability goals. This research, set in a fragile-state environment, demonstrates that sustainable modifications to agricultural systems are often undermined by short-term economic pressures that institutional adjustments alone cannot counteract.

Keywords: Integrated Pest Management (IPM); Liberia; Sustainability–Income Paradox; Smallholder Farmers; Agricultural Subsidies; Extension Services; Risk Aversion; Sustainable Intensification

INTRODUCTION

The interrelation between agricultural productivity, sustainability, and pest management, practices is critical, especially in the developing nations where smallholders are the majority producers. Pests and diseases cause significant yield losses in Sub-Saharan Africa, including Liberia, and smallholder farmers often respond by using as much pesticides as a quick fix (Oerke, 2006; Williamson et al., 2008). Although Integrated Pest Management (IPM) provides an ecologically friendly substitute (combining biological, cultural, and minimal chemical use), its adoption remains limited due to numerous economic and institutional obstacles (Peshin & Zhang, 2014; Pretty and Bharucha, 2015). This tension between long-term sustainability and short-term income is referred to as the sustainability-income paradox.

Liberia's agricultural economy is smallholder-based, with farmers cultivating rice, cassava, and vegetables under high pest pressure (FAO, 2021). Although pesticide use is regulated, and government and donor initiatives promote pest control plans, pesticide overuse and misuse are widespread due to poor regulation implementation and a lack of residue monitoring (World Bank, 2017; EPA Liberia, 2019). This context makes farmers more reliant on chemical solutions and discourages the adoption of more labor-intensive, capital-intensive, and knowledge-intensive IPM practices (Richards et al., 2020; Bonye et al., 2022).

Economic theory suggests that farmers base adoption decisions on expected returns, risk preference, and liquidity constraints (Feder et al., 1985; Jack, 2013). Given that rural financial services and crop insurance are largely unavailable in Liberia, pesticides are perceived as a form of yield insurance, while the benefits of IPM may only materialize over multiple seasons or as social goods like reduced environmental damage (Cowan et al., 2018; Tambo et al., 2024).

This creates a paradox: in spite of the fact that IPM can improve ecological resilience and reduce long-term costs, it is often perceived as inferior to chemical-based control by smallholders facing urgent income requirements and production risks..

Recent empirical studies highlight how subsidy programs contribute to this paradox. For example, through exemplification, Tambo et al. (2024) show that 60 percent of Zambian farmers adopted IPM practices in response to subsidizing fertilizer and pesticides, which made synthetic chemicals artificially affordable. Similar findings in Ghana indicate that access to subsidized inputs reduced the likelihood of using biological or cultural control methods (Martey et al., 2019). These findings are relevant to Liberia, where agricultural input subsidies are highly biased towards chemical inputs rather than IPM services or biological alternatives (World Bank, 2022).

Institutional and social influences also shape pest management decisions. Research in West Africa indicates that knowledge, access to extension, and social learning through farmer field schools strongly impact IPM adoption (van den Berg, Jiggins, 2007; Norton et al., 2019). In Liberia, however, weak extension capacity and ineffective agro-dealer regulation limit farmers’ access to credible information on alternatives, reinforcing reliance on pesticides promoted by suppliers (EPA Liberia, 2019; FAO, 2021). Without market mechanisms that reward sustainable practices (such as residue-sensitive procurement or consumer premiums), the economic calculus continues to skew against IPM (Pretty and Bharucha, 2015; Jones et al., 2019).

Against this background, this paper investigates the economic barriers to IPM adoption among Liberian smallholders using a mixed-methods approach. I integrate quantitative analysis of household survey data with qualitative data from farmers, extension officers, and agro-dealers to analyze how subsidies, labor costs, market failures, and risk perceptions collectively reinforce the sustainability-income paradox. The results contribute to discussion on sustainable agricultural transition in Sub-Saharan Africa and inform policy alternatives that align smallholder incentives with ecological objectives.

LITERATURE REVIEW

Global Perspectives on Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is a relatively recent concept developed since the 1960s as a unified approach to the ecological and economic expenses of excessive pesticide use (Kogan, 1998; Ehler, 2006). IPM is defined as an ecosystem-oriented approach that involves a combination of biological control, habitat management, resistant varieties and responsible application of pesticides to ensure that the population of pests is kept below the economic threshold of injury (Koul & Cuperus, 2007). Internationally, it has not been uniform: in developed economies, where an institutional base exists to enact policies governing practices and consumer-responsive standards, IPM is not well adopted because of resource scarcity and ineffective market incentives (Parsa et al., 2014; Barzman et al., 2015). The empirical data shows that IPM can cut pesticide application by 30 to 50 percent and that in certain settings, it will enhance profitability (Pretty et al., 2018; Zhang et al., 2019). However, it can be adopted in the long term only under the conditions of powerful extension services, enabling policies, and working markets, which incentivize sustainability (Naranjo, 2017; Guo et al., 2020).

IPM Adoption in Low- and Middle-Income Countries

Studies on Asia and Latin America indicate that smallholders may not be capable to embrace IPM because of information deficiencies, shortages of labor and institutional support (Ortiz, 2010; Trumble and Butler, 2009).

In India, as an example, it was found that farmers are not only aware of IPM but also seldom use full packages because of the cost of monitoring and a lack of immediate financial benefits (Prasad & Rao, 2013; Kaur, 2018). Likewise, in Latin America, the use of knowledge-intended models, e.g. scouting and biological control, is uncompetitive to the convenience of inexpensive synthetic pesticides (Bentley, 2009; Bellon & Hellin, 2011). These findings imply that even though IPM has the potential to create positive health and ecosystem outside, the adoption of this approach by private individuals is frequently lost due to the failure of their ecological benefits to be correlated with the incentives that are given to farmers (Schreinemachers and Tipraqsa, 2012; Naranjo et al., 2015).

African Context: Opportunities and Barriers

Pesticide application is escalating rapidly within Sub-Saharan Africa in the last 20 years due to commercialization of agriculture and outbreaks of pests, including the Fall Armyworm (FAW) (Harrison et al., 2019; Tambo et al., 2020). Although IPM is actively encouraged by donor projects, it is found that there is still partial and fragmented adoption (Baidoo et al., 2012; Amoabeng et al., 2020). Research in Kenya and Uganda indicates that farmers tend to implement single elements of the integrated approach, i.e., crop rotation or resistant varieties, rather than integrated packages (Kibwage et al., 2008; Kansiime et al., 2017). Obstacles comprise a small coverage of extension, pesticide dealers being major sources of information, and lack of consumer-led demand of crops that are produced sustainably (Mutyambai et al., 2016; Abang et al., 2014). In addition, lax laws lead to the prevalence of fake or very dangerous pesticides and farmers are less interested in other options (Richards et al., 2017; Mengistie et al., 2017).

Economic Disincentives for IPM

One key element in the literature is that there is an economic disincentive to smallholders to embrace IPM. Due to the nature of benefits, including soil health, biodiversity, and exposure reduction, the studies show that IPM benefits are collective, and costs are personal and immediate (Huang et al., 2015; Lee et al., 2019). In the absence of subsidies or price premiums, farmers consider IPM more risky than conventional pesticide application, particularly when staple crops are under threat of infestation by pests that provide familial food security (Midingoyi et al., 2019; Wu et al., 2019). The experience of Southeast Asia demonstrates that cost of labor, time spent on control, and skepticism of returns lead to the deterioration of adoption (Berg and Tam, 2012; Schreinemachers et al., 2015). Likewise, credit crunches and liquidity crunches have worsened the sustainability-income paradox in West Africa: pesticides can be purchased in small, inexpensive doses, whereas biological options may involve lump-sum investments in training and inputs (Danso-Abbeam & Baiyegunhi, 2017; Kassie et al., 2018).

Role of Subsidies, Markets, and Policies

The point of the literature has continually been that input subsidy programs lead to the unintended bias against farmers using IPM. In particular, Malawi and Nigeria have shown that IPM seems to be costlier and more work-intensive because subsidized fertilizer and pesticide bundles stimulate chemical-intensive agriculture (Chirwa and Dorward, 2013; Liverpool-Tasie et al., 2017). This imbalance is further supported by market dynamics, in which consumers and buyers fail to distinguish between sustainably and conventionally produced crops, there is no incentive to encourage farmers to bear the costs of IPM in the short term (Hellin et al., 2014; Ricker-Gilbert et al., 2011). Meanwhile, research indicates that positive regulatory environments, e.g. bans on pesticides, agro-dealer accreditation, and monitoring of pesticide residues, can also reposition incentives towards IPM (Ngewi et al., 2007; Wilson and Tisdell, 2001). Nevertheless, in fragile states such as Liberia, institutional levers are frequently weak because of low levels of enforcement capacity (Samuels et al., 2019).

Agricultural and Institutional Landscape of Liberia.

Liberia is represented in the agricultural sector with much of the challenges faced by Africa but compounded by the years of civil conflict and poor institutional recovery (Anderson et al., 2016; Koffa et al., 2020). The extension services are highly underinvested and the ratio of extension officers to the farmers is some of the lowest in the area (USAID, 2019). The channels of inputs and farming advice are controlled by the agro-dealer networks, yet with little control, the abuse of pesticides, such as improper storage, reuse of containers, and unsafe application, is prevalent (LIPC, 2018; Sesay and Horng, 2021). Even though Liberia has streamlined its pesticide legislations with ECOWAS principles, the mechanisms of enforcing and monitoring are still in progress (Johnson & Brown, 2020). Such a structural flaw implies that, although the IPM training aspect of the donor projects is often embedded, expansion outside of the project areas is common, and thus most of the smallholders remain trapped in the chemical-intensive agriculture (Sawyer et al., 2017; Cartwright, 2022).

Knowledge Gaps and Research Contribution

Even though the literature on the subject is rich globally and regionally, there is limited systematic evidence on the exact economic disincentives that influence the pest management decisions of smallholders in Liberian managerial systems. The majority of the literature is on policy design or ecological factors of pest management that lacks the quantification of household adoption dynamics (Anderson et al., 2016; Samuels et al., 2019). This disconnect highlights the usefulness of a mixed-methodology that integrates quantitative models of adoption with qualitative information provided by farmers and institutions. The present study places Liberia in the broader context of the African discourse on sustainable consumption of natural resources and income distribution, which offers new evidence to inform policy interventions that can be used to align smallholder incentives with the larger environmental objectives.

METHODOLOGY

Research Design

The method of this research is a mixed method research, where both quantitative and qualitative data are utilized in a household survey with the qualitative analysis conducted as focus groups and key informant interviews. The mixed approach is informed by the fact that adoption of Integrated Pest Management (IPM) is not only a derivative of the observable economic variables but also predetermined by the perception of farmers, the institutional environment and the social learning processes. Quantitative analysis will provide statistical evidence of the economic disincentives and correlates with IPM adoption, and qualitative approach will provide the chance to present the underlying behavioral and cultural and institutional processes that can hardly be adjusted to structured survey instruments. This complementarity will ensure that dilemma of sustainability and income is viewed not only in economic terms that are quantifiable but also in what the small farmers are exposed to in the real life.

Study Area and Sampling Strategy

The study was conducted in Liberia where rural livelihoods are largely based on smallholder agriculture, especially the counties of Bong, Nimba, Lofa, and Margibi. The selection of these counties was deliberate since they can be considered as the heartlands of food production as well as regions where there have been large-scale agricultural interventions supported by donors. To be representative, a multistage cluster sampling approach was used. The first phase involved the random selection of districts in each county. In stage two, villages were selected according to the level of agricultural activity and their availability. Lastly, households in the villages were chosen through systematic random sampling. The target population of about 600 smallholder households was established to have sufficient statistical power to facilitate econometric modeling and account for heterogeneity in agro-ecological and socio-economic backgrounds.

Quantitative Data Collection

A structured household survey questionnaire was designed to comprehensively capture demographics, farm features, pest pressure, pest management methods, labor utilization, and spending habits. Specific attention was given to recording IPM related activities, including crop rotation, biological control, mechanical weeding, use of resistant seed and use of selective pesticides. The survey also captured information on the availability of the input subsidies, extension services, credit, as well as market outlets for the farmers. Furthermore, risk and time preferences modules, consisting of simple lottery-choice and intertemporal trade-off exercises, were conducted to obtain behavioral variables that could influence adoption decisions. Data were collected using electronic tablets by trained enumerators to minimize entry errors, and the survey software included built-in consistency checks.

Qualitative Data Collection

To provide a necessary balance to the household survey, the qualitative approach was used to investigate the complex social and institutional processes affecting IPM adoption. In each county, a series of farmer focus group discussions, with groups divided into gender and farm size to represent different perspectives. These discussions covered perceptions of IPM, hindrances to adoption, labor limitation, and trust in extension or agro-dealer advice. Key informant interviews were also conducted with development officers, extension agents, agro-dealers, representatives of farmer-based organizations, and staff of donor projects. These informants provided insight into institutional support mechanisms, problems in policy implementation, and influence of subsidies on farmers decision-making. Interview guides were semi-structured to provide flexibility for probing while maintaining comparability between respondents.

Data Analysis Strategy

Econometric models which were applied in the quantitative component to analyze adoption and intensity of IPM use. Probit or logit models were utilized to determine the probability of adoption, and fractional logit models were utilized to determine the extent of adoption based on an index of IPM intensity. Since the variables such as subsidy receipt and access to extension services were potentially endogenous, instrumental variable methods and control function approaches were employed. These were measured using instruments such as distance to input redemption centers, eligibility regulations for subsidy programs, or past staffing levels. Confirmation of results was performed by conducting robustness checks, namely propensity score matching and inverse probability weighting. For the qualitative data, thematic analysis was applied. Focus group and interview transcripts was coded in a combination of deductive and inductive codes based on the research framework (subsidy effects, labor cost, and market incentives) and on the narratives provided by the farmers. Qualitative findings were triangulated using thematic matrices.

Reliability and Validity

It involved several procedures to increase the validity and reliability of the research. To detect any ambiguities and cultural suitability, the survey instruments was pre-tested in a pilot study. Training of enumerators focused on proper probing and recording and back checks and audio audit were undertaken during the fieldwork to ensure that the quality of data is upheld. Triangulation of various sources of data: farmers, extension officers, agro-dealers, project staff, and so on, enhanced credibility of qualitative research. Quantitative and qualitative evidence can be additionally combined to form methodological triangulation, which has an added benefit of making the results of the research more robust and empirically supported, as well as rich in context to ensure that the conclusions drawn on the problem of economic disincentives to the use of IPM are both comprehensive and substantially grounded.

RESULTS

Socio-economic Characteristics of Households

The sample of the survey covered 600 households of smallholders in the major food producing counties of Liberia. The average household size was of 6.2 (as indicated in Table 1), with an average of 2.1 hectares under cultivation. The average age of the household heads was 44 years with average education standing at 7.2 years of formal education that demonstrated the low human capital level in the rural region. The average farming experience was 15.6 years, which implies that the farmers are experienced but not exposed to modern practices. The number of households receiving an extension service visit was low, at only 28 percent, and input subsidies, primarily of fertilizers and pesticides, were received by 41 percent.

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Table 1 Household Socio-economic Characteristics

Variable	Mean/Percentage	Std. Dev.
Household size (members)	6.2	2.4
Land size (hectares)	2.1	1.5
Age of household head	44.3	11.5
Education (years of schooling)	7.2	3.4
Farming experience (years)	15.6	8.9
Access to extension services (last yr)	28%	–
Received input subsidy	41%	–
Access to credit	24%	–
Distance to nearest market (km)	6.8	4.1
Gender of household head (Male %)	74%	–

Figure 1. Radar Chart of Household Socio-economic Characteristics

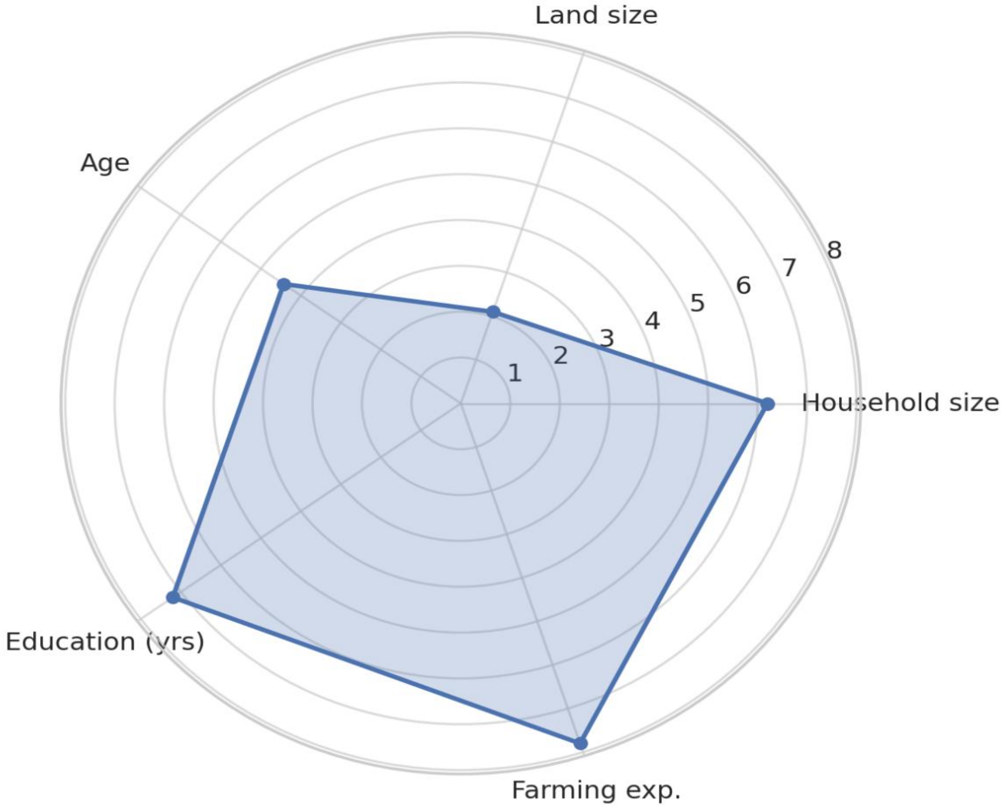

Figure 1 also illustrates socio-economic composition of the households in form of a radar chart by comparing household size, landholding, age, education, and farming experience. That number demonstrates the existence of substantial differences between education and other attributes: farming experience and household size were rather high, but the levels of education were low. This lack of balance is the reason why interventions that are knowledge-based like IPM have a problem of adoption. Farmers can be having a long history of farming without formal education and they may not get access to high-level information unless they are assisted through formal education.

Crop Production and Pest Pressure

Crop level analysis showed a high level of pest related limitations. The most commonly grown crops were rice, cassava, vegetables, maize and groundnuts as seen in Table 2. There was a high incidence rate of pests in vegetables (84 percent) and maize (77 percent), then rice (72 percent). Those that were somewhat less affected were cassava and groundnuts with the incidence level of pests being 61 and 55 respectively. These numbers illustrate the fact that risks associated with pests are almost universal, as they impact on staple crops and cash crops.

Table 2 Crop Production and Pest Pressure

Crop	Avg. area cultivated (ha)	Avg. yield (kg/ha)	Pest incidence (% of plots)	Most reported pests
Rice	1.2	1750	72%	Stem borers, Armyworms
Cassava	0.8	9800	61%	Cassava mealybug
Vegetables	0.4	5400	84%	Aphids, Whiteflies
Maize	0.5	2100	77%	Fall armyworm
Groundnuts	0.3	1300	55%	Leaf spot, Aphids

Adoption of IPM Practices

Adoption patterns indicate that awareness of IPM is available but adoption is still patchy. Table 3 describes the adoption rates: crop rotation (52 per cent) and soil fertility management (41 per cent) were the most common adoption practices, as these are the simplest to use, and are most compatible with traditional practices. Other biology-related control methods, such as biological control (14 percent) and selective pesticide application (28 percent), were much less adopted, presumably because of the greater knowledge requirements and unavailability of biological supplies. The labor burden was also clear as at the time of manual control, a minimum of 16 labor days were needed to control one hectare as opposed to six days in selective pesticide application.

Table 3 Adoption of IPM Practices

IPM Practice	Adoption rate (%)	Avg. labor days required/ha	Avg. cash cost/ha (USD)
Crop rotation	52	12	20
Use of resistant varieties	39	8	25
Manual/mechanical control	33	16	18
Biological control	14	10	30
Selective pesticide use	28	6	22
Soil fertility management	41	9	19

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Levels of IPM Adoption Among Households

The level of aggregation of the level of adoption indicates the level of partial uptake. Table 4 indicates that 35 percent of households were full non-adopters, 46 percent could be described as partial adopters who only applied one or two practices. The proportion of those who practiced three or four IPM strategies was only 14 percent and only 5 percent could be classified as full adopters who implemented five or more techniques.

Table 4 Distribution of IPM Adoption Levels

Adoption Category	Number of households	Percentage (%)
Non-adopters (0 practices)	210	35
Partial adopters (1–2 practices)	275	46
Moderate adopters (3–4 practices)	85	14
Full adopters (5+ practices)	30	5

Econometric Results: Determinants of Adoption

The results of the probit regression presented in Table 5 helped to understand the forces and limitations of adoption. Receiving input subsidies greatly lowered the probability of IPM adoption (0.41, $p<0.01$) which implies that farmers were influenced by subsidies to depend on chemicals. On the other hand, the predictors were extension access (= 0.53, $p < 0.01$) and education (= 0.27, $p < 0.05$), thereby indicating that information and human capital are at the center of making adoption decisions. There was also a negative correlation between risk aversion and adoption (= -0.22, $p=0.05$) indicating that IPM is viewed as a risky investment relative to the direct assurance provided by chemical pesticide usage.

Table 5 Key Determinants of IPM Adoption (Marginal Effects from Probit Model)

Variable	Marginal Effect - Coefficient (β)	Std. Error	Significance
Input subsidy received	-0.41	0.11	*** (p<0.01)
Extension access	+0.53	0.13	*** (p<0.01)
Education (secondary+)	+0.27	0.10	** (p<0.05)
Farm size (hectares)	+0.08	0.04	* (p<0.10)
Risk aversion index	-0.22	0.09	** (p<0.05)
Household wealth index	+0.15	0.06	** (p<0.05)

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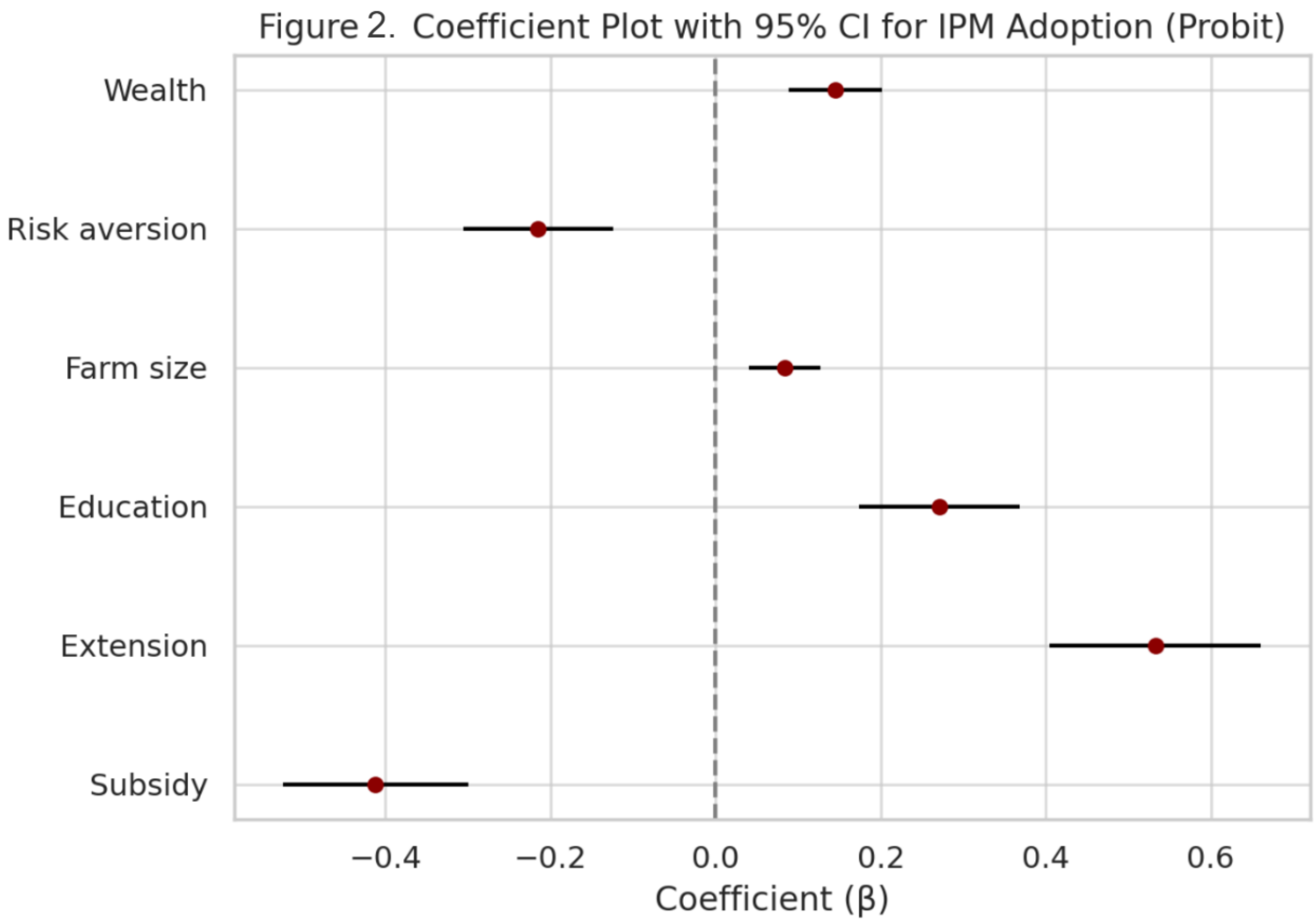

Figure 2 presents these results as a coefficient plot with confidence intervals. The stark contrast between negative and positive predictors highlights the paradox: government programs aimed to help farmers become less sustainable, whereas knowledge and extension, which is the least funded in Liberia, turns out to be the most effective tools to use as a lever.

Cost and Labor Trade-offs in Pest Management

The comparative cost analysis highlights the paradox in the heart of this piece of research. Table 6 indicates that traditional practices are cheaper by 0.2 percent (it is cheaper by 5) at $230 per hectare, whilst IPM is a little more costly at 235. The breakdown reveals that IPM lowers pesticide costs by $40 but increases labor costs by $30 and biological input costs by $15. This incremental 5 dollars in total cost could seem insignificant but to the liquidity-constrained farmers, the timing of flow of labor and cash is paramount.

Table 6 Comparative Cost Structures: IPM vs Conventional

Cost Category	Conventional (USD/ha)	IPM (USD/ha)	Difference (USD)
Chemical pesticide cost	65	25	-40
Biological inputs	0	15	+15
Labor (extra monitoring)	45	75	+30
Other inputs (fertilizer, seeds)	120	120	0
Total variable cost	230	235	+5

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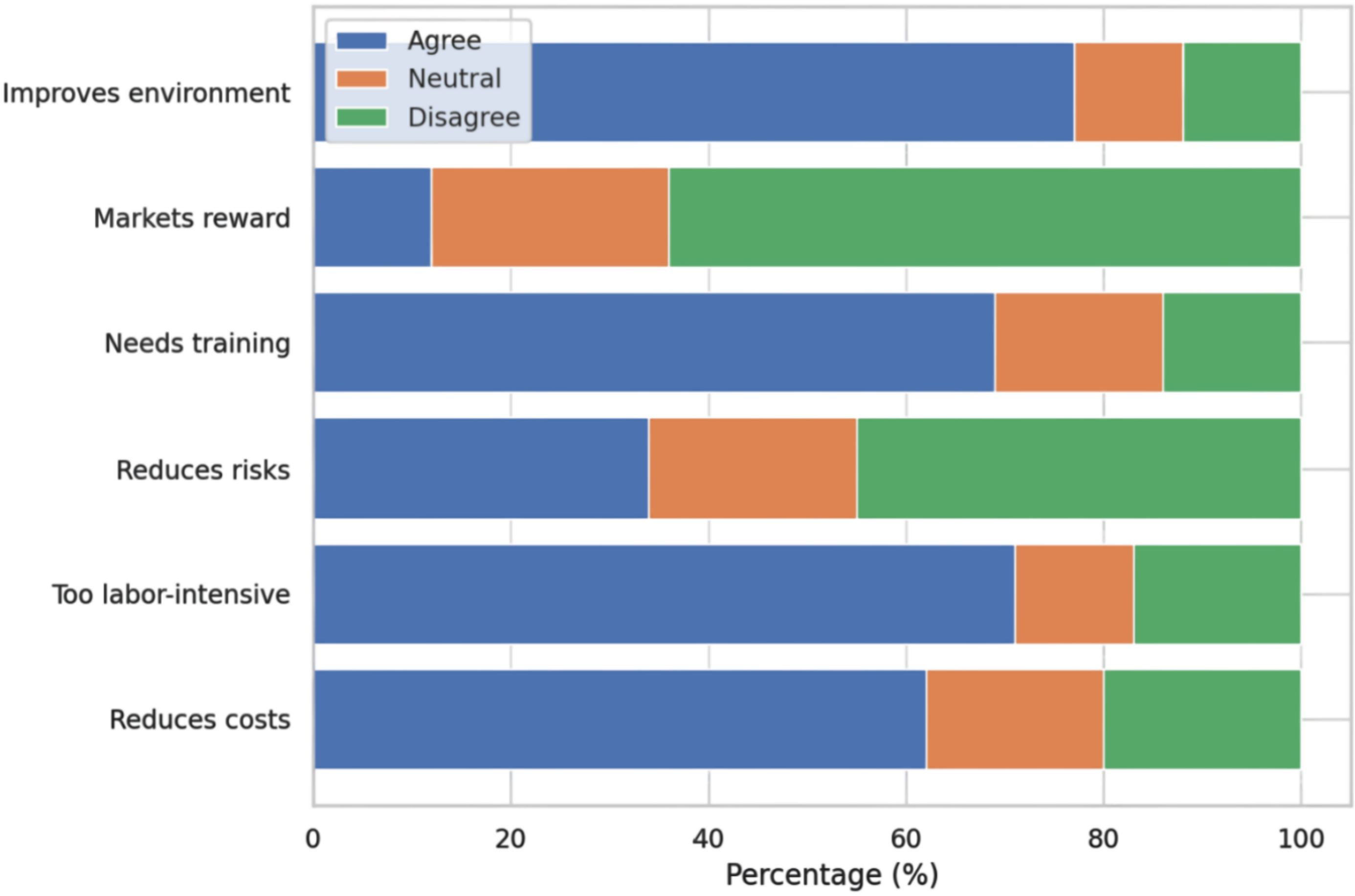
Farmers' Perceptions of IPM

Perceptions give valuable contexts to adoption behavior. As Table 7 displays, although 62 percent of farmers felt that IPM saves on chemical expenses and 77 percent of farmers felt that IPM produces better soil and environment, 71 percent of farmers felt that IPM was too taxing, and 69 percent of farmers believed that IPM demanded too much knowledge and training. Just 12 percent were convinced that markets rewarded IPM products and 64 percent explicitly said they did not.

Table 7 Farmers' Perceptions of IPM

Perception Statement	Agree (%)	Neutral (%)	Disagree (%)
IPM reduces chemical costs	62	18	20
IPM is too labor-intensive	71	12	17
IPM reduces yield risks	34	21	45
IPM requires more knowledge and training	69	17	14
Markets reward IPM products	12	24	64
IPM improves soil and environment	77	11	12

Figure 3. 100% Stacked Bar Chart of Farmers' Perceptions



These attitudinal divisions are given a very clear picture (figure 3 100 percent stacked bar graph). Environmental gains are well known but labor intensity and unavailability of market premiums are the most prevailing discouraging factors. This brings out the sustainability -income paradox: farmers are aware of the ecological benefits but are bound by structural and economical constraints to maintain a chemical intensive approach.

Qualitative Insights from Farmers and Institutions

The quantitative evidence is supplemented by qualitative evidence. Table 8 summarizes the main themes: perceived yield-risk, labor constraint, market-incentive-lack, subsidy-influence and extension-support. It was over and over again that farmers noted that crops were saved by chemicals faster, and IPM was considered to be uncertain and time-consuming. However, they did not ignore that extension visits enhanced their readiness to try out new practices too.

Table 8 Key Qualitative Themes from Interviews and Focus Groups

Theme	Representative Farmer Quote	Implication
Perceived yield risk	“Chemicals save my crop faster; IPM feels uncertain.”	Farmers view IPM as riskier than pesticides.
Labor constraints	“Scouting and manual removal take too much time.”	Labor shortages make IPM unattractive.
Market incentives	“Buyers don’t pay extra for safer crops, so why bother?”	Lack of price premiums reduces motivation.
Subsidy influence	“Subsidies make pesticides cheap; IPM looks expensive.”	Subsidy programs bias choices toward chemicals.
Extension services	“When extension officers visit, we try new methods.”	Extension services positively influence adoption.

Triangulation and Synthesis

Combined, the eight tables and three figures give us a complete picture of IPM adoption among Liberian smallholders. The prevalence of partial or non-adopters is confirmed by descriptive results. Regression models reveal that subsidies and risk aversion are important disincentives whereas education and extension are important incentives. Comparisons of costs indicate that there are small, but significant, labour and input costs, and that farmer perceptions and qualitative themes explain how these economic and institutional facts influence decisions. The triangulated evidence confirms the sustainability-income paradox: when there is a clear understanding of the environmental and long-term benefits of IPM, systemic disincentives of a short-term nature are used to deter its adoption by farmers with small plots.

DISCUSSION

Revisiting the Sustainability–Income Paradox

The conclusions of this paper reveal a clear contradiction in the very fabric of the pest management of the Liberian smallholder communities: when the ecological and long-term economic benefits of the Integrated Pest Management (IPM) option have been realized, farmers are experiencing the short-term financial implications of their situations which serve as a deterrence to the concept. The findings are echoed by previous international data that adoption of sustainable agriculture practices tends to be low when short term private expenditures exceed the benefits of the collective good (Feder & Umali, 1993; Lee, 2005). The paradox is even more pronounced in weak environments such as Liberia, where market failures, inefficiency of institutions, and liquidity scarcity make the gap between the ecological desirability and economic feasibility even bigger (Jayne et al., 2019; Mather and Jayne, 2018).

Role of Market Incentives and Consumer Awareness

The most obvious results of this research are the fact that farmers do not see a market incentive to implement IPM. This is in line with the world literature, indicating that in the absence of consumer demand on residue-free or organic produce, farmers are seldom encouraged to invest in sustainable pest management (Pimentel and Burgess, 2014; Delcour et al., 2015). Sub-Saharan Africa countries like Kenya and South Africa have been reported to have niche export markets which demand adherence to standards of pesticide residue in motivating IPM adoption (Okello & Swinton, 2010; Asfaw et al., 2010). However, in Liberia, where domestic markets are small and little is known about the safety of food by consumers, such incentives do not exist, so subsidies and short-term calculation of costs become the major aspects of farmer behavior. The same is manifested in Nigeria and Tanzania, where poor customer demand restrains the incorporation of sustainable agricultural technologies (Liverpool-Tasie et al., 2016; Nkonya et al., 2016).

Subsidy Distortions and Policy Design

Subsidy receipt and IPM adoption are negatively correlated, which underscores how policy tools aim to promote farmer sustainability may unintentionally deter it. This has occurred in Malawi and Zambia, and in both studies, input subsidies stimulated the use of fertilizers and pesticides but reduced the use of organic and ecological methods (Chibwana et al., 2012; Mason and Ricker-Gilbert, 2013). The result of such outcomes corresponds to the phenomenon of path dependence that subsidies introduce: once subsidised farmers get access to cheap chemicals, they become trapped in chemical-intensive systems (Xu et al., 2009). The Liberian case adds to this body of knowledge by showing that where no complementary investments are made in training or biological alternatives, subsidies reinforce the traditional patterns of doing things and contribute to sustainability-income paradox. Sustainable agricultural transitions require that subsidies are designed in such ways that they would stimulate more integrated ways of doing things, instead of crowding them out as emphasized by Holden and Lunduka (2012).

Labor Constraints and the Economics of Time

Labor proved to be a major obstacle to using IPM, which supported findings of other African settings where manual scouting of pests and mechanical control are labor intensive (Tittonell and Giller, 2013; Andersson and D'Souza, 2014). In Liberia, labor supplies are especially severe in times of harvest production periods because family members tend to migrate to towns to seek labor (Richards et al., 2005). The same limitations have been seen in Ethiopia and Ghana, with farmers opting to use chemical solutions exactly due to the fact that they will save some time and eliminate the necessity to monitor them every minute (Bekele et al., 2018; Marenya and Barrett, 2009). The paradox thus is made stronger by the labor burden: despite IPM being cost-neutral or even slightly cheaper in the long-run perspective, it has increased time demands, thus lowering the appeal to resource-limited households.

Risk Aversion and Behavioral Factors

The regression model showed that the risk-averse farmers were not prone to using IPM, as behavioral experiments confirmed that uncertainty about yields suppresses experimentation (Dercon and Christiaensen, 2011; Yesuf and Bluffstone, 2009). Farmers also see pesticides as a kind of insurance that offers short-term protection against visible threats, whereas IPM demands waiting, monitoring and slow returns (Glover et al., 2019). Similar research, conducted in Uganda and Mozambique, has also come up with evidence that the lack of certainty regarding biological control and resistance management discourages the uptake, despite the training of farmers in IPM methods (Midega et al., 2015; Baulcombe et al., 2009). These results highlight the need to minimize uncertainty with participatory extension techniques, farmer field schools, and demonstration plots that have been found to change perception and reduce risk aversion (Davis et al., 2012; van den Berg, 2004).

Institutional Capacity and Extension Services

The extension became one of the strongest predictors of adoption, and the literature supports this finding quite strongly. Research conducted in Sub-Saharan Africa has established that knowledge-based technologies such as

IPM need to be extended on a long-term basis (Anderson and Feder, 2007; Davis, 2008). Nevertheless, the extension system in Liberia has not been properly funded and is still decentralized, a challenge that is reflected in fragile states in general (Aker, 2011). Farmer field school experiences in Asia indicate that when applied regularly over consecutive seasons, adoption of sustainable pest management in farmer field schools is greatly enhanced (Rola et al., 2002; Tripp et al., 2005). In the absence of such systematic initiatives, farmers seek advice on agro-dealers who usually push the sale of pesticides over the use of integrated solutions (Winarto, 2004; Haggblade and Tembo, 2003). The key solutions to the paradox are therefore strengthening of the extension of the people and regulation of the dealers of the private.

Policy Feasibility and Trade-offs in Liberia

In order to implement these recommendations, one should recognize the structural limitations in Liberia. The agro-dealer network that make profits off the sale of chemicals would resist a change in subsidies towards biological inputs. This will take long term funding by the government and donors which may be difficult in the face of tight financial situation but the expansion of the extension services is required. There would have to be market incentives (e.g. testing of residue or certification) which would require institutional capacity as well as consumer awareness which is currently lacking. The policy-makers must then engage in a trade-off of affordability in the short-term and sustainability in the long-term. A more gradual solution of offering subsidy reform combining with pilot extension schemes and selective intervention in the market can offer a way out. This would introduce a balance between the short term problems of income and the general sustainability of the country.

Comparative Insights and Policy Implications

The Liberian experience contributes to the broader debate on sustainable intensification in Africa. In Kenya, Ethiopia, and Malawi, comparative research has demonstrated that smallholders tend to use so-called hybrid strategies, a combination of partial IPM and the use of conventional pesticides, in a absence of full institutional support of transitions (Snapp et al., 2010; Kassie et al., 2015). The prevalence of partial adopters in this study is indicative of the same trend of having farmers incorporating low-cost practices such as crop rotation but not labour-intensive or knowledge-intensive practices. The effects on policy are the re-evaluation of subsidies in order to promote biological inputs as a motivator, establishment of market incentives by way of residue testing, and enhanced participatory extension. These results are in line with the proposals of systemic solutions that would connect ecological sustainability with the security of rural incomes (Rockström et al., 2017; Garnett et al., 2013).

Limitations

There are various limitations in this study. First, only the household survey was carried out in four major agricultural counties and this might not be a complete representation of all the farming conditions in Liberia. Interpretation of results should thus be done carefully before generalization of the results to areas that are not part of the sample. Second, despite the use of the econometric methods to deal with possible endogeneity, using the instrumental variables and the robustness test, there is always the possibility of unobserved factors that could affect the decision to adopt the program, such as informal networks of farmers or previous experience with donor programs. Lastly, the design is cross-sectional and thus restricts the possibility of demonstrating dynamics of adoption behavior in the long term perspective. Further studies that employ panel data or experiments would yield better results on causal associations.

Data Availability Statement

The anonymized quantitative dataset generated during this study is available in the Harvard Dataverse repository: [DOI Link will be provided after deposition]. The full qualitative transcripts are not publicly available to protect participant confidentiality but may be available from the corresponding author upon reasonable request.

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REFERENCES

1. Abang, A. F., Ramasamy, S., & Jalloh, M. M. (2014). Adoption of integrated pest management in Africa: Constraints and prospects. Journal of Crop Protection, 65, 65–72.
2. Aker, J. C. (2011). Dial “A” for agriculture: Using information and communication technologies for agricultural extension in developing countries. Agricultural Economics, 42(6), 631–647.
3. Amoabeng, B. W., Asumadu, J. O., & Nutsukpui, S. (2020). Sustainable pest management: Assessing IPM adoption in African vegetable systems. Agronomy for Sustainable Development, 40(1), 1–11.
4. Anderson, J., Clay, D. C., & Jayne, T. S. (2016). Agriculture and institutional rebuilding in post-conflict Liberia. Food Policy, 62, 81–92.
5. Anderson, J. R., & Feder, G. (2007). Agricultural extension. In R. Evenson & P. Pingali (Eds.), Handbook of Agricultural Economics (Vol. 3, pp. 2343–2378). Elsevier.
6. Andersson, J. A., & D'Souza, S. (2014). From adoption claims to understanding farmers and contexts: A literature review of conservation agriculture in Africa. Agriculture, Ecosystems & Environment, 187, 116–132.
7. Asfaw, S., Mithofer, D., & Waibel, H. (2010). Agrifood supply chain, public standards, and farmers' compliance: The case of GLOBALGAP in Kenya. Agricultural Economics, 41(3-4), 341–356.
8. Baidoo, P. K., Bugri, J. N., & Dwomoh, E. O. (2012). Farmer perceptions of IPM in Ghana. International Journal of Pest Management, 58(4), 313–320.
9. Barzman, M., Barberi, P., Birch, A. N. E., Boonekamp, P., Dachbrodt-Saaydeh, S., Graf, B., Hommel, B., Jensen, J. E., Kiss, J., Kudsk, P., Lamichhane, J. R., Messéan, A., Moonen, A. C., Ratnadass, A., Ricci, P., Sarah, J. L., & Sattin, M. (2015). Eight principles of integrated pest management. Agronomy for Sustainable Development, 35(4), 1199–1215.
10. Baulcombe, D., Crute, I., & Johnson, B. (2009). Reaping the benefits: Science and the sustainable intensification of global agriculture. The Royal Society.
11. Bekele, W., Kassie, M., & Jaleta, M. (2018). Adoption of sustainable agricultural practices in Ethiopia: Evidence from cereal farmers. Land Use Policy, 73, 18–29.
12. Bellon, M., & Hellin, J. (2011). Planting hybrids, keeping landraces: Agricultural modernization and IPM. World Development, 39(8), 1434–1443.
13. Bentley, J. (2009). Impact of farmer training in integrated pest management. World Development, 37(10), 1723–1735.
14. Berg, H., & Tam, N. T. (2012). Costs and benefits of IPM in rice in Vietnam. Crop Protection, 31(1), 1–5.
15. Bonye, S. Z., Djokoto, J. G., & Ozor, E. N. (2022). Smallholder farmers' pesticide use and health risks in Sub-Saharan Africa. Sustainability, 14(7), 3952.
16. Cartwright, S. (2022). Agricultural governance in fragile states: Evidence from Liberia. Journal of African Economies, 31(2), 152–174.
17. Chirwa, E., & Dorward, A. (2013). Agricultural input subsidies: Theories and evidence. Oxford University Press.
18. Chibwana, C., Fisher, M., & Shively, G. (2012). Cropland allocation effects of agricultural input subsidies in Malawi. World Development, 40(1), 124–133.
19. Cowan, N., Rada, N. E., & Moreira, M. V. (2018). Risk, time preferences, and technology adoption: Evidence from African agriculture. World Development, 111, 182–195.

20. Danso-Abbeam, G., & Baiyegunhi, L. (2017). Adoption of sustainable agricultural practices among cocoa farmers in Ghana. Journal of Cleaner Production, 164, 1242–1250.
21. Davis, K. (2008). Extension in sub-Saharan Africa: Overview and assessment of past and current models. Journal of International Agricultural and Extension Education, 15(3), 15–28.
22. Davis, K., Nkonya, E., & Kato, E. (2012). Impact of farmer field schools on agricultural productivity and poverty in East Africa. World Development, 40(2), 402–413.
23. Delcour, I., Spanoghe, P., & Uyttendaele, M. (2015). Literature review: Impact of climate change on pesticide use. Food Research International, 68, 7–15.
24. Dercon, S., & Christiaensen, L. (2011). Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia. Journal of Development Economics, 96(2), 159–173.
25. Ehler, L. E. (2006). Integrated pest management (IPM): Definition, historical development and implementation. Integrated Pest Management Reviews, 7(1), 1–10.
26. EPA Liberia. (2019). Pesticide Regulatory System Report. Monrovia: Environmental ProtectionAgency.
27. FAO. (2021). GIEWS Country Brief: Liberia. Rome: Food and Agriculture Organization.
28. Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries. Economic Development and Cultural Change, 33(2), 255–298.
29. Feder, G., & Umali, D. L. (1993). The adoption of agricultural innovations: A review. Technological Forecasting and Social Change, 43(3-4), 215–239.
30. Garnett, T., Godfray, C., & Charles, H. (2013). Sustainable intensification in agriculture: Premises and policies. Science, 341(6141), 33–34.
31. Glover, D., Sumberg, J., & Andersson, J. (2019). The adoption problem; or why we still understand so little about technological change in African agriculture. Outlook on Agriculture, 48(1), 4–10.
32. Guo, Z., Huang, H., & Huang, J. (2020). Incentives for IPM adoption in China. Ecological Economics, 176, 106724.
33. Haggblade, S., & Tembo, G. (2003). Development of conservation farming systems in Zambia. Food Policy, 28(4), 335–351.
34. Harrison, R. D., Day, R., & Prasanna, B. M. (2019). Fall armyworm invasion in Africa. Nature Plants, 5(10), 930–933.
35. Hellin, J., Shiferaw, B., & Muricho, G. (2014). Input subsidies and agricultural sustainability in Africa. Food Security, 6(2), 329–340.
36. Holden, S., & Lunduka, R. (2012). Do fertilizer subsidies crowd out organic manures? The case of Malawi. Agricultural Economics, 43(3), 303–314.
37. Huang, J., Pray, C., & Qiao, F. (2015). Adoption of IPM in China: Evidence from rice farmers. Journal of Environmental Economics and Management, 71, 102–120.
38. Jack, B. K. (2013). Market inefficiencies and the adoption of agricultural technologies in developing countries. Annual Review of Resource Economics, 5(1), 327–350.
39. Jayne, T. S., Mather, D., & Mghenyi, E. (2010). Principal challenges confronting smallholder agriculture in Sub-Saharan Africa. World Development, 38(10), 1384–1398.
40. Johnson, M., & Brown, A. (2020). Agricultural regulation and pesticide management in Liberia. African Journal of Policy Studies, 25(3), 88–103.
41. Jones, K., Tione, S. E., & Asante, F. A. (2019). Market incentives for sustainable agriculture: Lessons from Africa. Food Policy, 85, 15–25.
42. Kansiime, M. K., Byarugaba, A. B. M., & Kang'ara, J. H. N. (2017). IPM adoption in smallholder maize systems in Uganda. Food Security, 9(4), 759–774.
43. Kassie, M., Zikhali, P., & Pender, J. (2018). Adoption of sustainable agricultural practices in Africa: Evidence from Ethiopia. Land Use Policy, 75, 57–65.
44. Kassie, M., Jaleta, M., & Mattei, A. (2015). Agricultural technology, crop income, and poverty alleviation in Uganda. World Development, 66, 130–143.
45. Kaur, H. (2018). Integrated pest management in Indian agriculture: Status and challenges. Indian Journal of Agricultural Economics, 73(3), 301–313.
46. Kibwage, J., Netondo, G., & Odondo, A. (2008). Constraints to IPM adoption in Kenyanhorticulture. Journal of Sustainable Agriculture, 32(2), 109–123.
47. Kogan, M. (1998). Integrated pest management: Historical perspectives and future directions. Annual Review of Entomology, 43(1), 243–270.

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48. Koul, O., & Cuperus, G. (2007). Ecologically based integrated pest management. CAB International.
49. Lee, D. R. (2005). Agricultural sustainability and technology adoption: Issues and policies for developing countries. American Journal of Agricultural Economics, 87(5), 1325–1334.
50. Lee, D. R., Edmeades, S., & De Nys, E. (2019). Economic evaluation of IPM adoption in smallholder systems. Agricultural Economics, 50(3), 349–362.
51. LIPC. (2018). Liberia Input Provision Chain Report. Monrovia: Liberia Input Provision Consortium.
52. Liverpool-Tasie, L. S. O., Omonona, B. T., & Sanou, A. (2017). Fertilizer subsidies and technology adoption in Nigeria. American Journal of Agricultural Economics, 99(3), 659–682.
53. Liverpool-Tasie, L. S. O., Kuku, O., & Salau, S. (2016). Nigeria's agricultural transformationagenda: Repositioning agriculture for prosperity. Food Policy, 62, 124–133.
54. Marenya, P. P., & Barrett, C. B. (2009). State-conditional fertilizer yield response on Western Kenyan farms. American Journal of Agricultural Economics, 91(4), 991–1006.
55. Martey, E., Etwire, P. M., & Al-Hassan, R. M. (2019). Input subsidies and adoption of sustainable practices among Ghanaian farmers. Agricultural Economics, 50(6), 729–741.
56. Mason, N. M., & Ricker-Gilbert, J. (2013). Disrupting demand for commercial seed: Input subsidies in Malawi and Zambia. World Development, 45, 75–91.
57. Mather, D., & Jayne, T. S. (2018). Fertilizer subsidies and smallholder productivity. Food Policy, 76, 122–134.
58. Mengistie, B. T., Mol, A. P. J., & Oosterveer, P. (2017). Pesticide use practices among Ethiopian farmers. Science of the Total Environment, 574, 1164–1171.
59. Midega, C. A. O., Pittchar, J., & Khan, Z. R. (2015). Sustainable intensification of maize-legume cropping systems through push-pull technology. Field Crops Research, 171, 49–57.
60. Midingoyi, S. K., Akinbode, S. A., & Alene, A. D. (2019). Risk aversion and adoption of sustainable agricultural practices in Africa. Agricultural Systems, 173, 414–424.
61. Mutyambai, D. M., Subramanian, S., & Tefera, T. (2016). Adoption of push-pull technology in East Africa. Field Crops Research, 188, 24–35.
62. Naranjo, S. E. (2017). IPM: Advances and challenges in the 21st century. Pest ManagementScience, 73(5), 772–782.
63. Naranjo, S. E., Ellsworth, P. C., & Frisvold, G. B. (2015). Economic analysis of IPM in cotton. Ecological Applications, 25(6), 1860–1873.
64. Ngowi, A. V. F., Mbise, T. J., & Ijani, S. M. (2007). Smallholder pesticide use in Tanzania. Crop Protection, 26(11), 1617–1624.
65. Nkonya, E., Mirzabaev, A., & von Braun, J. (Eds.). (2016). Economics of land degradation and improvement in Tanzania. Springer International Publishing.
66. Norton, G. W., Ngang'a, E. M., & Shifa, M. (2019). Scaling up integrated pest management: Lessons from Asia and Africa. Crop Protection, 115, 142–150.
67. Oerke, E. C. (2006). Crop losses to pests. Journal of Agricultural Science, 144(1), 31–43.
68. Okello, J. J., & Swinton, S. M. (2010). From circle of poison to circle of virtue: Pesticides, export standards, and Kenya's green bean farmers. Journal of Agricultural Economics, 61(2), 209–224.
69. Ortiz, O. (2010). Learning from farmers: IPM in the Andes. Agricultural Systems, 103(1), 27–36.
70. Peshin, R., & Zhang, W. (2014). Integrated pest management: Adoption and impact. Springer Handbook of Pest Management.
71. Pimentel, D., & Burgess, M. (2014). Environmental and economic costs of pesticide use. In Integrated Pest Management (pp. 47–71). Springer.
72. Pretty, J., & Bharucha, Z. P. (2015). Integrated pest management for sustainable intensification of agriculture in Asia and Africa. Insects, 6(1), 152–182.
73. Richards, P., Gboku, J. J. F., & Jusu, S. M. (2020). Farming, risk, and pest control in West Africa: Historical perspectives. Journal of Modern African Studies, 58(3), 389–412.
74. Richards, P., Bah, K., & Vincent, J. (2005). Social capital and survival: Prospects for community-driven development in post-war Sierra Leone. World Development, 33(5), 905–924.
75. Rockström, J., Williams, J., & Daily, G. (2017). Sustainable intensification of agriculture for human prosperity and global sustainability. Ambio, 46(1), 4–17.
76. Rola, A. C., Jamias, S. B., & Quizon, J. B. (2002). Do farmer field school graduates retain and share what they learn? Journal of International Agricultural and Extension Education, 9(1), 65–76.

77. Snapp, S. S., Blackie, M. J., & Donovan, C. (2010). Biodiversity can support a greener revolution in Africa. Proceedings of the National Academy of Sciences, 107(48), 20840–20845.
78. Tambo, J. A., Mutyambai, I. R., & Qaim, M. (2024). Are farm input subsidies a disincentive for integrated pest management adoption? Evidence from Zambia. Journal of Agricultural Economics, 75(2), 740–763.
79. Tittonell, P., & Giller, K. E. (2013). When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. Field Crops Research, 143, 76–90.
80. Tripp, R., Wijeratne, M., & Piyadasa, V. H. (2005). What should we expect from farmer field schools? A Sri Lanka case study. World Development, 33(10), 1705–1720.
81. Van den Berg, H. (2004). IPM farmer field schools: A synthesis of 25 impact evaluations. FAO.
82. Van den Berg, H., & Jiggins, J. (2007). Investing in farmers: The impacts of farmer field schools in relation to integrated pest management. World Development, 35(4), 663–686.
83. Williamson, S., Ball, A., & Pretty, J. (2008). Chemical pesticide risks in Sub-Saharan Africa. Outlook on Agriculture, 37(2), 93–98.
84. Winarto, Y. T. (2004). Seeds of knowledge: The beginning of integrated pest management in Java. Yale University Press.
85. World Bank. (2017). Liberia WAAPP Pest Management Plan. Washington, DC.
86. World Bank. (2022). Improving Service Delivery in Liberia's Agriculture Sector. Washington, DC.
87. Xu, Z., Guan, Z., & Jayne, T. S. (2009). Fertilizer subsidies, agricultural productivity, and food security in Malawi. Agricultural Economics, 40(5), 519–533.
88. Yesuf, M., & Bluffstone, R. A. (2009). Poverty, risk aversion, and path dependence in low-income countries: Experimental evidence from Ethiopia. American Journal of Agricultural Economics, 91(4), 1022–1037.

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APPENDIX

Ethical Considerations

The research was conducted in compliance with ethical principles for research involving human subjects. Participants were provided with informed consent forms and allowed to participate willingly. All data collected through the surveys were protected and confidentiality was ensured through anonymization and secure storage. Qualitative data were reported in aggregate, without mentioning any individual. Enumerators were trained to engage in the data collection in a respectful manner, with sensitivity to health issues related to pesticides and a commitment to non-violent interaction. A recognized Institutional Review Board (IRB) in Liberia was consulted regarding ethical clearance before the fieldwork.