Interplay of Part-time Occupation, Organic Fertilizer Application, and Farmer Behavior: A Survey

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Abstract

This survey paper provides a comprehensive analysis of the interplay between part-time farming, organic fertilizer use, and farmer behavior, employing Structural Equation Modeling (SEM) to elucidate their contributions to agricultural diversification, income strategies, and sustainable practices. The study underscores agricultural diversification's pivotal role in enhancing farm resilience and income stability, especially for smallholders. It highlights how diversification strategies reduce poverty and improve food security, as evidenced in regions like Ghana and Ethiopia. Part-time farming emerges as a strategic approach to diversify income and mitigate agricultural production risks, necessitating supportive policies for rural development and market access. The use of organic fertilizers is shown to enhance soil health and productivity, contributing to sustainable waste management and ecological sustainability. Integrated farming systems, such as the Integrated Organic Farming System (IOFS) model, are emphasized for their potential to improve crop yields and farmer incomes. Theoretical frameworks and SEM provide insights into decision-making processes and socio-economic incentives, with advancements like Adversarial Orthogonal Structural Equation Models (AdOSE) refining causal inference. The survey calls for policies that reduce transaction costs and facilitate market access to promote effective farm diversification. It suggests integrating diversification into national policies to enhance food security and sustainability. Future research should focus on long-term studies exploring yield and ecosystem service relationships, advocating for multidisciplinary collaborations and innovative funding mechanisms to advance agricultural sustainability and resilience amid climate and socio-economic challenges.

1 Introduction

1.1 Structure of the Survey

This survey systematically examines the intricate relationships between part-time farming, organic fertilizer usage, and farmer behavior through structural equation modeling (SEM). The introduction emphasizes the significance of these interconnections in promoting agricultural diversification, sustainable practices, and farm income strategies. The background section provides essential definitions and theoretical foundations, including an overview of SEM, to contextualize the analysis.

The core of the survey is organized into thematic sections. Initially, we investigate the prevalence and implications of part-time farming, focusing on its influence on farmer decision-making and the adoption of sustainable practices. We then assess the application of organic fertilizers, highlighting their agronomic efficiency, environmental benefits, and role in sustainable waste management. The section on farmer behavior theory further explores decision-making processes and the impact of socio-economic incentives on sustainable practices.

Subsequently, we introduce SEM as a crucial tool for understanding the complex interactions among study variables, discussing its applications, advantages, and limitations in agricultural research.

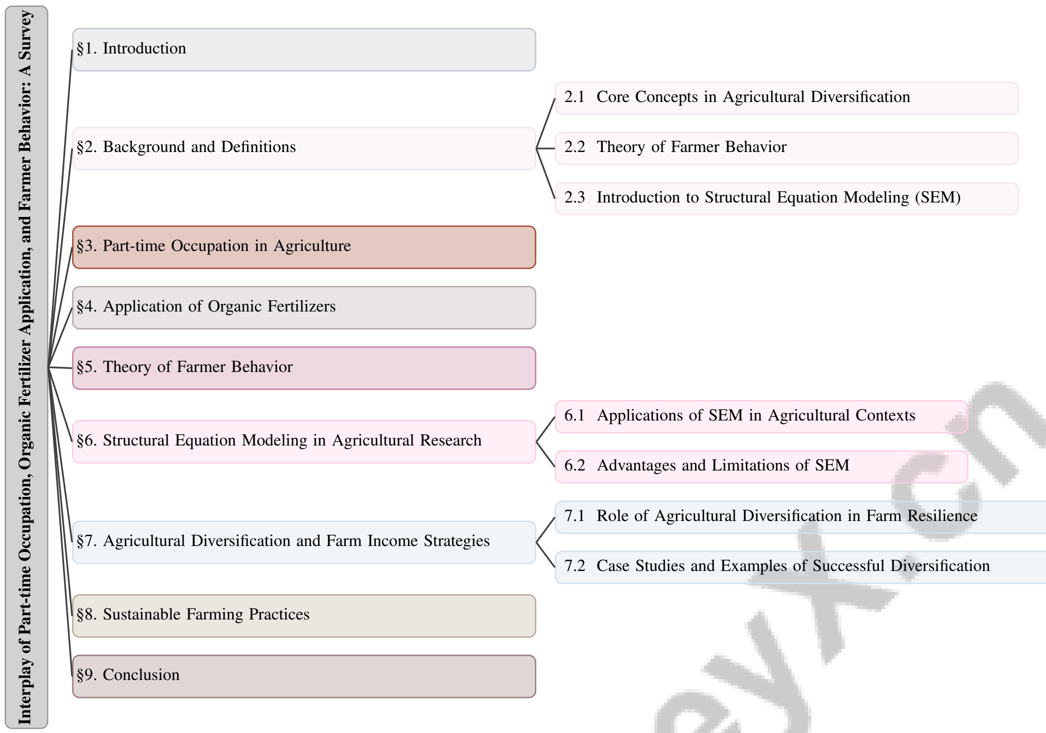

Figure 1: chapter structure

Following this, the importance of agricultural diversification and farm income strategies is emphasized, supported by case studies demonstrating successful diversification outcomes.

The survey concludes with a focus on sustainable farming practices, particularly integrated organic farming systems, and the influence of farmer behavior on their adoption. The conclusion synthesizes findings from various studies, underscoring the interconnections among key themes such as agricultural diversification, food security, and sustainability. It advocates for policy reform that incorporates agricultural diversification strategies, especially in regions like China and sub-Saharan Africa, where current policies often neglect these approaches. Furthermore, it posits that enhancing agricultural diversity can improve financial profitability, biodiversity, and ecosystem services, thereby guiding future research aimed at achieving sustainable agricultural practices and addressing poverty alleviation [1, 2, 3, 4, 5].The following sections are organized as shown in Figure 1.

2 Background and Definitions

2.1 Core Concepts in Agricultural Diversification

Agricultural diversification involves expanding the variety of crops and livestock to bolster sustainability and productivity, crucial for countering challenges like erratic climatic conditions and income instability [6, 7]. Key adaptation strategies, such as crop-livestock integration and improved varieties, mitigate environmental stresses [8]. Diversification enhances socioeconomic and ecological resilience by potentially reducing poverty and improving climate resilience, distinguishing diversified from non-diversified practices in maintaining productivity under climate change [3, 9].

In sustainable farming, diversification not only fosters economic resilience but also utilizes ecosystem services effectively, minimizing reliance on synthetic inputs [10]. The debate continues on whether diversification should be an economic objective or a policy outcome [11]. Regional studies, such as those on U.S. production agriculture, show varied strategies for revenue distribution across commodities [12]. Mixed evidence on the nexus between diversification and nutrition, especially in sub-Saharan Africa, underscores its complexity [2].

Understanding long-term impacts of diversification on socioeconomic and ecological benefits is crucial for assessing viability, providing insights into sustainability and productivity enhancements [4].

However, limited implementation within China's policies remains a significant barrier to sustainable farming and food security [1].

2.2 Theory of Farmer Behavior

Analyzing farmer behavior is vital for comprehending decision-making in agricultural practices and technology adoption. Influenced by socio-economic conditions, cultural norms, and individual preferences, farmer behavior can be examined using models like the Cragg two-step regression, which differentiates between the decision to diversify and the extent of diversification [7]. Research frameworks highlight education and experience as key in shaping adaptation decisions, impacting risk perception and adoption willingness [8]. Variability in responses to incentive programs, influenced by economic preferences and cultural characteristics, complicates decision-making [5].

Research themes include agricultural diversification policies' impact on dietary diversity and nutrition, linking farmer behavior to broader policy frameworks [2]. Integrating diversification into national policies, as emphasized by [1], can enhance sustainability and institutional support. A significant challenge is the lack of long-term data, hindering the assessment of temporal dynamics and benefits, contributing to farmers' reluctance to adopt new practices [4].

2.3 Introduction to Structural Equation Modeling (SEM)

Structural Equation Modeling (SEM) is a sophisticated statistical approach for examining complex relationships among observed and latent variables, crucial in agricultural research [13]. It surpasses traditional multivariate techniques by accommodating measurement errors and latent constructs, offering nuanced insights into variables like part-time farming, organic fertilizer use, and farmer behavior [14]. Advances such as Adversarial Orthogonal Structural Equation Models (AdOSE) enhance causal inference by minimizing dependencies between residuals and regressors [15]. Evaluating fit indices like RMSEA, CFI, and TLI for ordered categorical data ensures robust model assessments across diverse data types [16].

In agricultural research, SEM's modeling of latent variables and accounting for measurement errors are invaluable for understanding farmer behavior and sustainable practices. It enables analysis of long-term effects of chemical and organic fertilizers on soil and microbial properties [17]. Despite its strengths, SEM faces challenges like modeling complex hierarchical structures and requiring sophisticated software solutions [18]. SEM provides a robust framework for exploring interrelationships within agricultural systems, crucial for understanding how diversification enhances food security and sustainability [2, 13, 1]. Its evolution, driven by methodological innovations and computational tools, promises further utility in unraveling complex interactions in sustainable agriculture.

In recent years, the dynamics of part-time occupation in agriculture have garnered significant scholarly attention. This interest is largely due to the complex interplay of economic, social, and policy factors that shape the landscape of farming practices. Figure 2 illustrates the hierarchical structure of part-time occupation in agriculture, emphasizing the prevalence of part-time farming driven by these multifaceted influences. Moreover, the figure highlights the critical role that education and experience play in shaping farmer behavior and influencing socio-economic outcomes. By visualizing these relationships, we can better understand the underlying mechanisms that contribute to the growing trend of part-time farming.

3 Part-time Occupation in Agriculture

3.1 Prevalence of Part-time Farming

Part-time farming is increasingly prevalent due to economic pressures, labor market dynamics, and policy influences, serving as a strategy for income diversification and risk mitigation in agriculture [6]. This trend is particularly notable in regions where agricultural income alone is inadequate for household sustenance, prompting farmers to seek non-agricultural employment [7]. Market volatility and climate change further necessitate alternative income strategies for financial stability [8].

Demographic changes, such as an aging farmer population and youth migration to urban areas, exacerbate rural labor shortages, compelling farmers to balance agricultural and non-agricultural roles [3, 9]. Policy interventions, including rural development support, credit access, and diversification

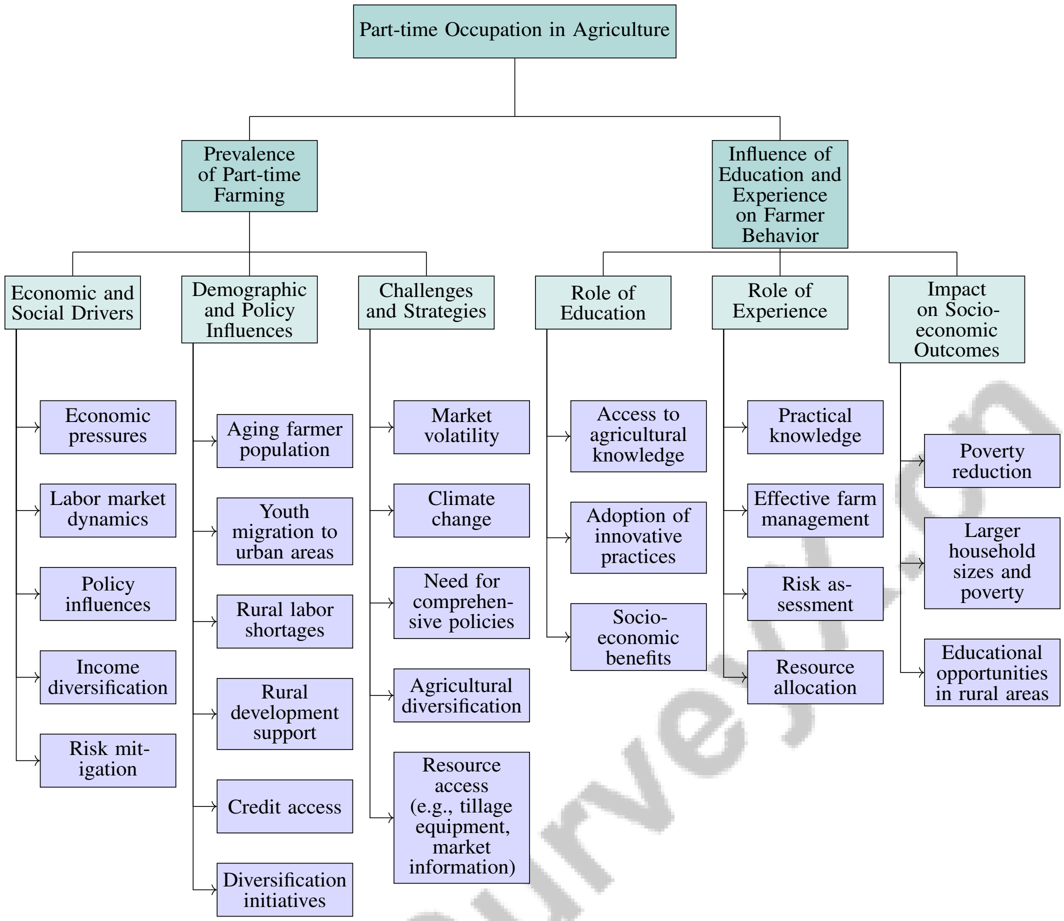

Figure 2: This figure illustrates the hierarchical structure of part-time occupation in agriculture, emphasizing the prevalence of part-time farming driven by economic, social, and policy factors, and the influence of education and experience on farmer behavior and socio-economic outcomes.

initiatives, influence part-time farming adoption, although effectiveness varies regionally due to differing institutional capacities and socio-economic contexts [11, 12].

As illustrated in Figure 3, the key factors influencing part-time farming are categorized into economic and policy influences, demographic and social changes, and environmental factors. This figure highlights the complexity of part-time farming adoption, emphasizing the interconnectedness of these influences.

The complexity of part-time farming necessitates comprehensive policies and support systems to address challenges faced by part-time farmers. Understanding these trends is crucial for developing strategies that enhance agricultural sustainability and rural livelihoods, especially in developing economies. Agricultural diversification, as evidenced in Ghana's integrated crop-livestock systems, can alleviate food insecurity and poverty, highlighting the importance of resources like tillage equipment and market information [7, 11, 2, 5, 10].

3.2 Influence of Education and Experience on Farmer Behavior

Education and experience are pivotal in shaping farmer behavior and decision-making. Higher education enhances farmers' ability to access, interpret, and apply agricultural knowledge, increasing the likelihood of adopting innovative and sustainable practices [3]. Experience, accumulated over years, equips farmers with practical knowledge crucial for effective farm management, including risk assessment and resource allocation. This experiential knowledge complements formal education,

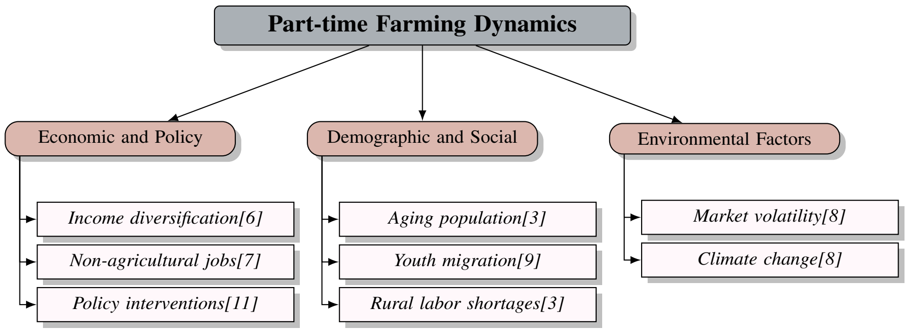

Figure 3: This figure illustrates the key factors influencing part-time farming, categorized into economic and policy influences, demographic and social changes, and environmental factors, highlighting the complexity of part-time farming adoption.

providing insights into local environmental conditions and market dynamics essential for informed decision-making [12, 4, 5, 1].

The synergy between education and experience influences socio-economic outcomes, such as poverty reduction. Larger household sizes often correlate with higher poverty rates, while increased educational attainment is associated with reduced poverty, underscoring education's socio-economic benefits [3]. This relationship emphasizes the need for investing in educational opportunities in rural areas to enhance agricultural productivity and alleviate poverty.

4 Application of Organic Fertilizers

4.1 Agronomic Efficiency and Soil Health

Organic fertilizers play a crucial role in enhancing soil health and boosting crop productivity, forming a cornerstone of sustainable agriculture. Derived primarily from animal waste, these fertilizers enrich soil fertility by providing essential nutrients and improving physical properties [19]. This not only results in higher crop yields but also supports a diverse microbial ecosystem vital for agro-ecosystem resilience. The Integrated Organic Farming System (IOFS) model exemplifies the effective integration of organic fertilizers with crops, livestock, and water harvesting, fostering a self-sustaining agricultural environment [6]. Organic inputs within this model are pivotal for nutrient cycling and soil structure enhancement, ensuring long-term productivity.

Organic fertilizers also mitigate the environmental impacts of conventional farming by reducing the need for synthetic fertilizers, thereby decreasing soil and water pollution. They enhance soil health by improving its properties and microbial diversity and significantly boost carbon sequestration, with studies showing increases of up to 2823

Thus, organic fertilizers are essential for improving agronomic efficiency and soil health, offering a sustainable approach to increasing crop productivity while maintaining environmental quality. Their use in integrated farming systems is a viable strategy for sustainable agricultural development, enhancing soil health, boosting productivity, and recycling on-farm resources, ultimately benefiting farmer livelihoods and reducing the environmental impact of conventional practices [6, 19, 5, 1].

4.2 Sustainable Waste Management and Recycling

Organic fertilizers are integral to sustainable waste management by converting agricultural and animal waste into valuable resources that enhance soil fertility and crop productivity. The IOFS model showcases this approach, highlighting significant economic and environmental benefits through the integration of organic waste recycling in farming practices [6]. This model alleviates the environmental burden of waste disposal and fosters a circular economy by transforming waste into agricultural inputs.

The IOFS model has shown net returns increasing by up to 355

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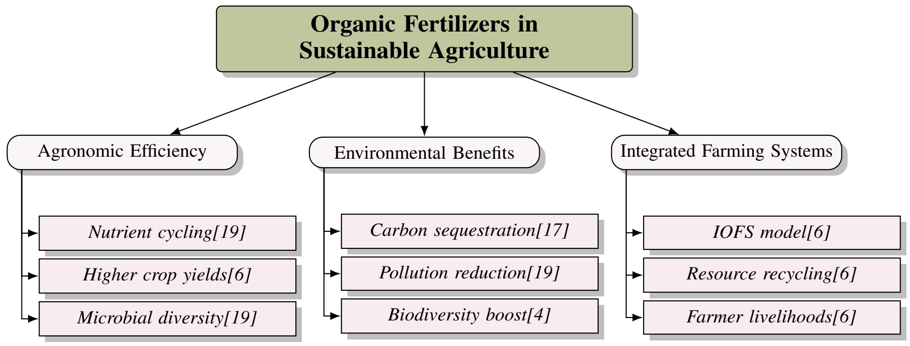


Figure 4: This figure illustrates the role of organic fertilizers in sustainable agriculture, highlighting their impact on agronomic efficiency, environmental benefits, and their integration into farming systems.

Additionally, organic fertilizers support broader environmental goals by minimizing pollution and promoting soil health. Recycling organic waste into fertilizers enhances agricultural sustainability by closing nutrient loops, reducing greenhouse gas emissions, and improving water quality. This process not only turns animal waste into valuable fertilizers but also reduces environmental pollution from landfilling and improper waste disposal. By preventing nutrient runoff, it supports beneficial microbial communities, enhances crop productivity, and contributes to a circular bio-economy, leading to resilient agro-ecosystems and improved farmer livelihoods [6, 19]. This sustainable waste management approach aligns with global efforts to reduce agricultural environmental impacts while ensuring food security and resilience.

5 Theory of Farmer Behavior

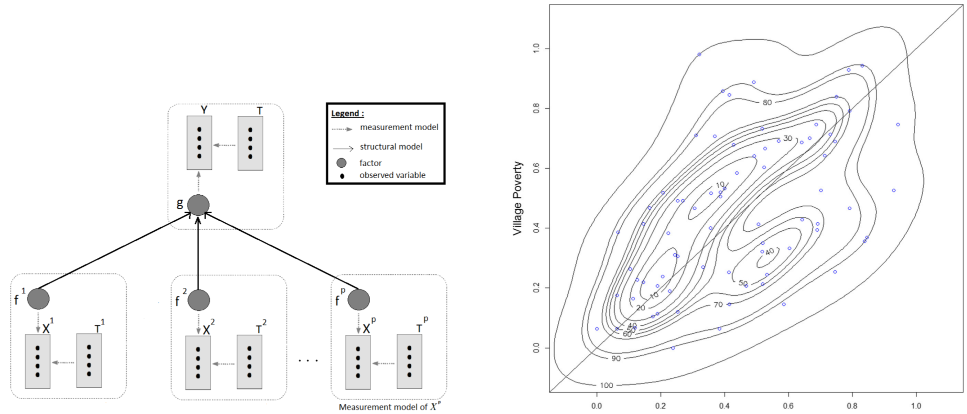
Understanding farmer behavior requires exploring theoretical frameworks that illuminate decision-making processes in agriculture. These frameworks reveal the socio-economic, environmental, and psychological factors influencing farmers' choices, providing a structured approach to analyzing their responses to changing conditions. The following subsection examines these frameworks, offering insights into the incentives driving sustainable practice adoption.

5.1 Theoretical Frameworks and Decision-Making Processes

Analyzing farmers' decision-making processes is crucial for promoting sustainable agriculture and resilience. Theoretical frameworks, such as the Sensitivity Analysis for Unmeasured Confounders (SAUC), offer robust methods for addressing biases in Linear Structural Equation Models (LSEMs), enhancing the accuracy of farmer decision-making studies [20]. Incorporating ordered categorical data in SEM further refines these analyses, improving model reliability and understanding of factors driving decisions on crop diversification and technology adoption [16].

The Integrated Organic Farming System (IOFS) exemplifies these frameworks' practical applications, emphasizing resource recycling and minimizing external dependencies to enhance farm efficiency and resilience [6].

As illustrated in Figure 5, integrating theoretical frameworks like SEM and poverty contour maps is essential for understanding farmer choices in complex environments. The SEM model tests hypotheses on interactions between observed and latent variables, capturing the multifaceted nature of decision-making. It includes a measurement model linking observed variables to latent constructs, offering insights into underlying factors influencing behavior. The contour map highlights geographic poverty disparities, providing context for economic constraints impacting decisions. These tools collectively offer a comprehensive framework for analyzing economic, social, and environmental factors shaping farmer behavior, informing policy and intervention strategies [21, 3].



(a) Structural Equation Modeling (SEM) Model[21]

(b) Contour Map of Village Poverty[3]

Figure 5: Examples of Theoretical Frameworks and Decision-Making Processes

5.2 Incentives and Adoption of Sustainable Practices

Incentives significantly influence the adoption of sustainable agricultural practices by affecting farmer behavior. Economic, policy-driven, and ecological incentives have been employed to encourage sustainability and resilience. Studies show that programs offering short-term economic benefits achieve higher adoption rates than those focusing solely on ecological services, highlighting the need to align incentives with farmers' immediate economic interests [5].

To illustrate this concept, Figure 6 presents a classification of the various incentives influencing the adoption of sustainable agricultural practices. This figure categorizes the incentives into three primary types: economic, policy-driven, and ecological, each accompanied by specific examples that demonstrate their respective roles in promoting sustainable practices.

Economic incentives, such as subsidies and tax breaks, effectively motivate farmers to adopt new technologies and practices perceived as risky or costly. They alleviate financial challenges, enabling investments in sustainable methods like organic farming and integrated pest management, crucial for overcoming barriers such as high initial costs and specialized knowledge requirements [1, 6, 4, 5, 10]. Economic incentives provide immediate financial returns, reducing perceived risks and encouraging broader participation.

Policy-driven incentives, including regulatory frameworks and certification schemes, create an enabling environment for sustainable practices. These incentives align with broader goals of food security and sustainability, impacting productivity, income, and environmental outcomes [2, 5, 1]. Certification schemes enhance market access and offer premium prices for sustainably produced goods, further incentivizing environmentally friendly practices.

Ecological incentives, though less immediately tangible, are vital for long-term sustainability. They emphasize intrinsic benefits like enhanced soil health, increased biodiversity, and improved ecosystem services, contributing to long-term profitability and resilience [1, 6, 4, 5, 10]. While not providing immediate financial returns, ecological incentives support agricultural systems' resilience and sustainability over time.

6 Structural Equation Modeling in Agricultural Research

6.1 Applications of SEM in Agricultural Contexts

Structural Equation Modeling (SEM) is an indispensable tool in agricultural research, adept at deciphering complex interrelations among variables within agricultural systems. Table 1 provides a comprehensive comparison of various Structural Equation Modeling methods, illustrating their adaptability and effectiveness in estimating latent variables and model parameters in agricultural research. The EM-SEM method exemplifies this by effectively estimating latent variables and model

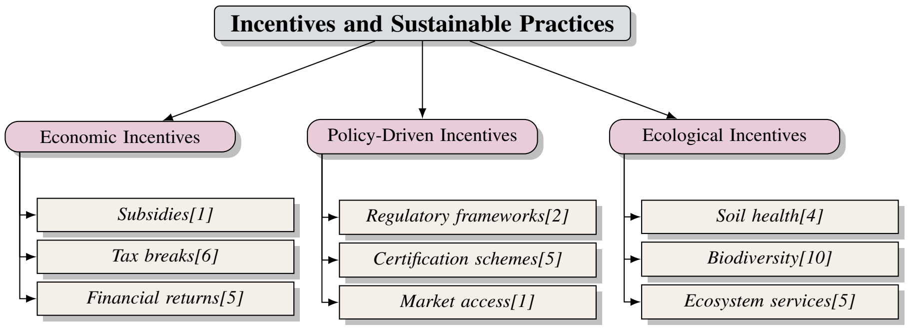


Figure 6: This figure illustrates the classification of incentives influencing the adoption of sustainable agricultural practices, highlighting economic, policy-driven, and ecological incentives as primary categories, with specific examples under each.

Method Name	Methodological Adaptability	Estimation Techniques	Latent Variable Analysis
EM-SEM[21]	Multigroup Analyses	EM Algorithm	Latent Factors Estimation
lava[18]	Multigroup Analyses	Robust Standard Errors	Latent Variable Models
MLE-AMASEM[22]	Complex Relationships Environments	Neural Network Techniques	Latent Variables Margins
PLS-SEM-R[13]	Complex Models	Maximum Likelihood Estimation	Latent Constructs

Table 1: Comparison of Structural Equation Modeling Methods in Agricultural Research: An Evaluation of Methodological Adaptability, Estimation Techniques, and Latent Variable Analysis. The table highlights the capabilities of different SEM methods, including EM-SEM, lava, MLE-AMASEM, and PLS-SEM-R, in addressing complex relationships and latent variable estimation within agricultural contexts.

parameters, proving its efficacy in both simulated and empirical data settings [21]. This is particularly crucial in agriculture, where latent factors like farmer attitudes or environmental influences play significant roles in observable outcomes.

SEM's adaptability extends to handling multigroup analyses and accommodating missing data, as demonstrated by evaluations of SEM packages with simulated data from various linear latent variable models [18]. This capability is vital in agricultural research, where data collection often encounters logistical hurdles, ensuring robust interpretation even with incomplete datasets. Advances in computational techniques, such as maximum likelihood estimation for Ancestral Marginal Acyclic Structural Equation Models (AMASEMs), further enhance SEM's applicability by utilizing neural networks to improve estimation accuracy [22]. This enables researchers to uncover intricate causal relationships in complex agricultural datasets.

Comparative analyses of parameter identification methods within SEM frameworks underscore the importance of selecting appropriate techniques to address the unique challenges of agricultural data [23]. Careful consideration of these methods is essential for ensuring valid results, particularly when modeling dynamic interactions between socio-economic and environmental factors. Despite its complexities, SEM remains a crucial tool in social sciences, including agricultural research [24]. Its application requires meticulous attention to avoid erroneous causal inferences, with ongoing methodological refinements enhancing its effectiveness in agricultural contexts [13].

6.2 Advantages and Limitations of SEM

Benchmark	Size	Domain	Task Format	Metric
FERT-TEA[17]	544,096	Agricultural Ecology	Microbial Composition Analysis	Alpha Diversity, Heavy Metal Concentration

Table 2: Overview of the FERT-TEA benchmark dataset utilized in agricultural ecology research, detailing its size, domain, task format, and evaluation metrics. This dataset is instrumental in analyzing microbial composition and assessing alpha diversity and heavy metal concentration within agricultural systems.

Structural Equation Modeling (SEM) offers a robust framework for analyzing complex relationships among variables in agricultural research. Its strength lies in modeling latent variables and accounting for measurement errors, enhancing causal inference precision in agricultural systems [25]. Techniques like Adversarial Orthogonal Structural Equation Models (AdOSE) address nonlinear and non-Gaussian data, overcoming common limitations in causal inference methods [15].

Table 2 presents a detailed description of the FERT-TEA benchmark dataset, which is crucial for understanding the application of Structural Equation Modeling in agricultural ecology research. SEM's versatility is further demonstrated across diverse datasets, including those with missing data or complex hierarchical structures. Estimation methods such as Diagonally Weighted Least Squares (DWLS) and Unweighted Least Squares (ULS) provide reliable fit indices, like RMSEA and CFI, compared to Maximum Likelihood (ML) methods, though researchers should apply conventional cutoff values cautiously [16]. Despite user-friendly interfaces in SEM packages, challenges persist for users unfamiliar with advanced statistical concepts or programming languages like R, necessitating additional support [13].

However, SEM is not without limitations. Its effectiveness hinges on the quality of prior information, such as partial ordering; inaccuracies can negatively impact estimation results [25]. Large sample sizes are typically required to ensure estimate stability and reliability, with small samples potentially undermining findings. The lack of a global goodness-of-fit measure in some SEM approaches, such as Partial Least Squares SEM (PLS-SEM), limits its use in confirmatory research where model validation is crucial [13].

Model mis-specification poses a significant challenge, potentially leading to erroneous causal conclusions. This is compounded by the complexity of latent variables, complicating model identifiability and representation of non-linear models [13]. Variability in results due to differing environmental conditions and methodological approaches, such as waste treatment methods in pathogen management studies, further complicates SEM applications in agricultural research.

Despite these challenges, SEM remains a vital analytical tool, deepening our understanding of the intricate interactions among diverse agricultural practices, economic factors, and environmental outcomes. Its significance is highlighted by its ability to integrate insights from decades of research on agricultural diversification, enhancing food security, biodiversity, and ecosystem services while informing sustainable agricultural policy development [1, 24, 2, 4, 5]. By recognizing and addressing its limitations, researchers can effectively leverage SEM to advance sustainable agricultural practices and bolster agricultural system resilience.

7 Agricultural Diversification and Farm Income Strategies

7.1 Role of Agricultural Diversification in Farm Resilience

Agricultural diversification is pivotal in enhancing farm resilience by expanding the range of crops and livestock, thereby mitigating risks from climate variability, market fluctuations, and ecological disturbances. This strategy reduces reliance on single commodities, stabilizing income and enhancing food security [7]. Diversified systems optimize resource use, such as land, water, and nutrients, leading to increased productivity and sustainability. For instance, crop-livestock integration enhances nutrient cycling and soil fertility, boosting yields while minimizing external input dependency [6]. This approach not only supports ecological balance but also provides multiple income streams, buffering farms against economic shocks [8].

Ecologically, diversification enhances resilience by promoting biodiversity and ecosystem services, which are crucial for withstanding pest and disease outbreaks. The presence of multiple species can disrupt pathogen transmission and reduce pest populations, maintaining agro-ecosystem health and long-term productivity [10]. Socio-economically, diversification offers significant advantages, as it enhances economic stability and adaptability to market changes. By producing a variety of products, farmers can access multiple markets, reducing the risk of price volatility impacting their overall income, a critical factor in regions with unpredictable agricultural markets [3].

7.2 Case Studies and Examples of Successful Diversification

Globally, successful agricultural diversification strategies have demonstrated the potential of diversified systems to boost resilience and productivity. In Africa, integrating crop-livestock systems has improved nutrient cycling and soil fertility while providing multiple income streams, enhancing economic stability against market fluctuations [8]. This diversification aids in managing risks associated with climatic variability and economic uncertainties [7]. In Asia, Integrated Organic Farming Systems (IOFS) have successfully promoted sustainable agriculture by incorporating crops, livestock, and water management practices, reducing reliance on external inputs and increasing productivity and profitability [6].

In the United States, diversification is employed to achieve more stable income streams by mitigating price volatility risks across various commodities [12]. This strategy underscores the importance of diversification in maintaining economic resilience and adapting to market changes. Research in sub-Saharan Africa has explored the link between diversification and nutritional outcomes, revealing mixed results regarding its impact on dietary diversity [2]. These findings suggest that while diversification enhances economic resilience, its nutritional effects may vary with regional contexts and specific strategies.

These case studies highlight the diverse applications of agricultural diversification in achieving resilience, productivity, and sustainability. Tailoring strategies to local conditions and market dynamics enables farmers to improve their systems, yielding economic and environmental benefits. Practices like intercropping and organic farming have shown significant financial returns and increased biodiversity, enhancing soil quality and carbon sequestration, with some studies reporting profitability increases of up to 2823

8 Sustainable Farming Practices

8.1 Integrated Organic Farming Systems (IOFS)

Integrated Organic Farming Systems (IOFS) represent a comprehensive approach that combines crops, livestock, and water management to create sustainable and self-reliant agricultural systems. By enhancing resource efficiency and reducing dependency on external inputs, IOFS significantly improve soil fertility, biodiversity, and ecological balance through practices like intercropping and organic farming. Over a 50-year analysis, these practices have been shown to enhance soil quality and carbon sequestration by up to 2823

The IOFS model notably enhances food security and nutritional diversity by enabling the cultivation of various crops, which increases dietary variety and provides resilience against crop failures [6]. Economically, IOFS optimize resource use and lower input costs, boosting profitability and resilience. Livestock integration promotes nutrient recycling, using animal waste as organic fertilizer, thus improving soil health and reducing reliance on synthetic fertilizers and pesticides. This closed-loop system not only cuts production costs but also diminishes environmental impact while fostering biodiversity through practices like rainwater harvesting and integrated livestock management [6, 4, 5].

Furthermore, IOFS emphasize natural resource conservation and ecosystem service preservation. The use of organic inputs and sustainable practices maintains soil health, enhances water quality, and boosts biodiversity. The ecological benefits associated with diversification, including increased biodiversity, improved soil quality, and enhanced carbon sequestration, contribute significantly to the long-term sustainability of agricultural systems and align with global sustainability and food security initiatives [4, 5, 1].

8.2 Farmer Behavior and Adoption of Sustainable Practices

Farmer behavior, shaped by socio-economic, cultural, and environmental factors, is critical in adopting sustainable farming practices. Understanding the motivations behind these practices is essential, as agricultural diversification is associated with increased profitability, biodiversity, and soil quality, enhancing environmental sustainability and system resilience [4, 5].

Farmers with higher education and experience tend to adopt sustainable practices more readily, as they can better access and interpret innovative agricultural information [19]. Education provides an understanding of the long-term benefits of sustainability, such as improved soil health and productivity, which can offset the initial costs and risks of transitioning. Experience offers practical insights into local conditions and market dynamics, aiding informed resource allocation and risk management.

Economic incentives play a significant role in shaping farmer behavior and promoting sustainable practices. A review of 577 studies indicates that financial incentives like subsidies or tax breaks effectively encourage sustainable practices by mitigating perceived risks and costs. These incentives align farmers' immediate economic interests with long-term sustainability goals, facilitating the transition to environmentally friendly systems [11, 5].

Cultural norms and community influences are also pivotal in the adoption of sustainable practices. Farmers in communities that prioritize environmental conservation are more likely to implement practices reflecting these values. Research highlights the importance of social norms and community incentives in adopting sustainable agricultural methods, leading to improved ecological and financial outcomes [4, 1, 5, 10]. Peer influence and social networks are crucial for disseminating information and encouraging adoption.

Future research should focus on optimizing waste treatment processes, exploring the economic viability of organic fertilizers, and integrating organic practices into mainstream agriculture to enhance sustainability [19]. Addressing these areas can help develop strategies that effectively support behavioral change and foster the widespread adoption of sustainable farming practices.

9 Conclusion

This survey highlights the intricate relationships among part-time employment, organic fertilizer use, and farmer behavior in promoting agricultural diversification and sustainability. Agricultural diversification emerges as a crucial strategy for enhancing the resilience and income stability of smallholder farms, significantly contributing to poverty alleviation and food security, particularly in regions like Ghana and Ethiopia. The development of policies tailored to local contexts is vital for effectively advancing diversified farming practices and improving nutritional outcomes.

Part-time farming is identified as a strategic approach to diversify income streams and mitigate agricultural production risks, aligning with broader socio-economic trends. There is a pressing need for comprehensive policies to address the challenges faced by part-time farmers, especially in terms of rural development and market access. The use of organic fertilizers is shown to improve soil health and crop productivity, playing a significant role in sustainable waste management and ecological sustainability. Their integration into farming systems, exemplified by models like the Integrated Organic Farming System (IOFS), offers a promising path for sustainable agricultural development, enhancing crop yields and farmer incomes.

Theoretical frameworks that explore decision-making and socio-economic incentives are essential for understanding farmer behavior and encouraging sustainable practices. Structural Equation Modeling (SEM) provides valuable insights into these complex interactions, with advancements such as Adversarial Orthogonal Structural Equation Models (AdOSE) improving causal inference. However, challenges like unmeasured confounding necessitate sensitivity analyses to ensure the robustness of causal inferences.

Policy implications emphasize the need to reduce transaction costs and enhance market access for smallholders to support effective farm diversification. The integration of agricultural diversification into national policies, as demonstrated by China's efforts, can substantially strengthen food security and sustainability, offering a model for global practices. Future research should focus on long-term studies examining the complex relationships between yield and ecosystem services, highlighting the importance of multidisciplinary collaborations and innovative funding mechanisms. Addressing these areas is crucial for advancing agricultural sustainability and resilience in the face of climate change and socio-economic challenges.

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