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The Policy-Practice Gap in Circular Agriculture: An Empirical Analysis of Adoption Determinants in Vietnam's Central Highlands

Thu Trang Bui [1], *Thi Mai Thanh Tran* [2*], *Minh Anh Do* [2], *Hoang Tan Dau* [2], *Duy Nguyen Vu* [3]

[1] *Institute of Vietnam and World Economy, Vietnam Academy of Social Sciences, Hanoi 10000, Vietnam*

[2] *University of Economics and Business, Vietnam National University, Hanoi 10000, Vietnam*

[3] *Academy of Finance, Hanoi 10000, Vietnam*

ABSTRACT

The transition to circular agriculture (CA) represents a critical pathway toward sustainable development, particularly in emerging economies where smallholder farmers remain central to agricultural production. However, the adoption of CA practices in these contexts continues to face substantial institutional and structural challenges. This study provides an empirical assessment of the determinants shaping CA adoption among farming households in Đắk Lắk province, a vital agricultural hub in Vietnam's Central Highlands. Using primary survey data collected from 274 households, the research applies exploratory factor analysis and multiple linear regression to evaluate the role of institutional, economic, and social factors in influencing adoption decisions. The findings reveal that favorable market conditions, farmers' education levels, support from local authorities, and the availability of infrastructure are significant positive drivers of CA uptake. In contrast, broader national government policies and interventions by private enterprises show no statistically significant impact on adoption behavior. This outcome highlights an important policy-practice gap, indicating that current top-down directives have limited effectiveness in promoting circular practices at the grassroots level. Instead, adoption appears to be a spontaneous, bottom-up process motivated by practical farm-level incentives and locally embedded institutional support. The study contributes to the growing literature on sustainable agricultural transitions by offering evidence from a key emerging

*CORRESPONDING AUTHOR:
Thi Mai Thanh Tran, University of Economics and Business, Vietnam National University, Hanoi 10000, Vietnam;
Email: maithanh@vnu.edu.vn

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economy context, emphasizing that future policy frameworks should prioritize strengthening local institutional capacity, improving market-driven incentives, and addressing on-the-ground constraints to foster meaningful and resilient pathways toward circular agriculture.

Keywords: Circular Agriculture; Sustainable Development; Adoption Determinants; Smallholder Farmers; Vietnam; Market Incentives; Policy Implementation

1. Introduction

The global agricultural sector is at a critical juncture, facing immense pressure to transition from the resource-intensive, linear "take-make-waste" model to more sustainable paradigms [1]. In this context, CA has emerged as a key strategy, defined as a sustainable approach focused on optimizing resource use, reducing waste, and enhancing profitability through practices of recycling and reuse [2]. This imperative is particularly urgent in Vietnam, where the agricultural sector, though central to national food security and export performance, is increasingly recognized as a major source of environmental degradation [3]. In particular, livestock farming generates an estimated 84.5 million tons of waste annually, of which only 20% is treated through biogas systems, composting, or other recycling methods [4]. The remaining 80% contributes significantly to pollution of air, water, and soil systems, particularly through the release of ammonia (NH_3) and hydrogen sulfide (H_2S) emissions exceeding legal thresholds by several fold [4].

In response, Vietnam has taken concrete steps to institutionalize circular economy (CE) principles through its national legal framework. This commitment is formalized in the Law on Environmental Protection 2020 and solidified by policies such as Decision 687/QĐ-TTg (2022) and, more recently, Decision 540/QĐ-TTg (2024), which sets sector-specific CE goals for agriculture to be achieved by 2030 [5]. For example, the roadmap targets the reuse of 80% of straw and stubble in rice production and 100% of shrimp and pangasius processing waste [6]. The Ministry of Natural Resources and Environment has further clarified that these principles aim to minimize input use, extend product lifecycles, and reduce emissions across sectors [4].

However, despite this strong policy endorsement, a significant gap between national strategy and on-the-ground implementation persists. The operationalization of these principles suffers from overlapping mandates and limited sector-specific action plans [7]. At the micro-level, the transition is hindered by a legal framework often described as fragmented and lacking specific technical guidelines [8]. Adoption among smallholder farmers is further constrained by high initial investment costs, a lack of clear subsidies, gaps in technology, and low awareness of CA's benefits [9, 10]. Consequently, traditional models like VAC (Garden-Pond-Livestock), while conceptually aligned with circularity, often lack integration with modern technologies, resulting in low productivity and limited market competitiveness [4].

These implementation challenges are particularly acute in the Central Highlands, a region well-positioned for sustainable agriculture but where CE adoption remains fragmented and small-scale [4, 11]. Đắk Lắk province, as an agricultural epicentre of the region, exemplifies these complexities. The province's agricultural structure is dominated by smallholder farming, and its economic importance is significant, with an agricultural GDP reaching 23.52 trillion VND in 2024 [6]. This is coupled with vulnerabilities characteristic of mountain agriculture, including difficult terrain and limited market accessibility [12, 13]. Furthermore, the province generates over 1.2 million tons of agricultural by-products annually, which are largely unutilized due to vague regulatory guidance, modest investment in green infrastructure, and local institutional inertia [6].

While these general barriers are recognized, there is a scarcity of empirical research that quantifies the relative importance of different determinants influencing adoption at the farm level, especially in strategic highland regions. A key puzzle this study addresses is the apparent disconnect between supportive national policies and the tangible, ground-level factors that shape farmers' decisions. Therefore, this study aims to empirically identify the determinants of CA adoption among smallholder farmers in Đắk Lắk province, providing a clear understanding of what truly motivates or hinders this transition.

Using survey data from 274 households and employing a multiple linear regression model, this paper assesses the impact of market conditions, infrastructure, governmental support, and farmer characteristics on CA uptake. The remainder of this paper is structured as follows. Section 2 reviews the relevant literature and theoretical frameworks. Section 3 details the research methodology, including data collection and analytical strategy. Section 4 presents the empirical results, which are then interpreted and contextualized in the Discussion in Section 5. Finally, Section 6 offers conclusions and policy implications derived from the study's findings.

2. Literature Review

A successful transition from a linear to CA necessitates a thorough understanding of the underlying factors that either facilitate or hinder CA adoption among farmers in Vietnam. Identifying these critical determinants is imperative for the design of coherent policy frameworks and context-specific business models that can effectively drive and institutionalize circular agricultural practices.

2.1. Circular Agriculture: An Essential Sustainability Paradigm

For many years, agriculture has largely followed a linear path where resources are taken, used to make products, and the resulting waste is discarded. This approach has led to significant challenges, including the degradation of soil and pressure on finite resources [1]. As a response, CA offers a different way forward. It is a model of farming designed to work in cycles, aiming to optimize the use of resources, minimize waste, and improve profitability through more sustainable methods [2, 14]. The goal is to move away from a system of disposal and toward one of regeneration and reuse.

At its core, circular agriculture involves several key principles that guide its practice. One fundamental principle is the efficient management of natural resources, which means using land, water, and energy thoughtfully to preserve biodiversity and maintain the long-term fertility of the soil [2]. A central tenet of this approach is to view agricultural residues not as waste, but as a valuable resource. Practices like recycling by-products and utilizing biomass are used to close nutrient loops and lessen the environmental footprint [2, 15]. The integration of modern technology, such as digital tools for monitoring soil and managing water, helps farmers optimize their processes and inputs [15]. Ultimately, making this system work requires effective collaboration between the different people involved in the agricultural value chain, from farmers and researchers to policymakers and consumers [14].

Adopting these circular principles can bring tangible benefits. For farming communities, this can translate into lower production costs, improved productivity, and new opportunities for employment [2]. At the same time, these practices contribute to a healthier environment by reducing ecological footprints and greenhouse gas emissions, and by improving the health of the soil over time [15, 16]. On a broader social level, this model of agriculture supports rural livelihoods, contributes to food security, and helps communities build resilience against the effects of climate change [17, 18]. By seeking to align economic activity with environmental care, circular agriculture provides a practical pathway toward a more sustainable future in food production.

2.2. Theoretical Frameworks for Innovation Adoption and Diffusion

To understand why farmers, choose to adopt or reject circular agriculture, it is helpful to draw upon established theories that explain how new practices are taken up within a community. This study is informed by two key theoretical perspectives: the Diffusion of Innovations Theory, which explains the process of adoption, and Institutional Theory, which highlights the influence of the broader environment on decision-making.

2.2.1. Diffusion of Innovations Theory

The Diffusion of Innovations (DOI) theory provides a valuable framework for understanding how a new idea or practice, such as circular agriculture, spreads through a social system over time. The theory suggests that the adoption of an innovation is not an instantaneous event, but a process influenced by several key factors. One of the most important is the perceived attributes of the innovation itself. For farmers, this includes its relative advantage (whether CA is seen as more profitable or efficient than current methods), its compatibility with existing farming practices and values, its complexity, its trialability, and the observability of its results on other farms [19].

Furthermore, DOI theory emphasizes the crucial role of communication channels and social networks in this process. The decision to adopt a new practice is often shaped by social factors, such as subjective norms and the influence of peers within the farming community [19]. For instance, group discussions and community demonstrations can significantly enhance adoption rates by providing social proof and practical knowledge [19]. In this context, individuals known as opinion leaders, who often hold central positions in social networks and possess more accurate knowledge, can play a pivotal role in accelerating the diffusion of circular practices by influencing the attitudes and decisions of their peers [20].

2.2.2. Institutional Theory

While DOI theory focuses on the characteristics of the innovation and the social system, Institutional Theory provides a complementary lens by explaining how the broader environment shapes the behavior of individuals and organizations. This theory posits that farmers' decisions are not made in a vacuum but are heavily influenced by the rules, norms, and beliefs that constitute their institutional context. These influences often manifest as pressures that encourage conformity to established or emerging standards.

These pressures can be categorized into three main types. First, coercive pressure arises from formal regulations and policies, such as government environmental standards or financial incentives that compel or reward the adoption of specific practices. This pressure has been identified as a key driver in the development of the circular economy and a critical factor for new enterprises in the sector [21, 22]. Second, normative pressure stems from professional and social expectations about what is considered appropriate behavior. In agriculture, this can be shaped by training from extension services, standards set by farming cooperatives, or the shared values within a community, which guide the adoption of new technologies and practices [23, 24]. Finally, mimetic pressure describes the tendency for farmers to imitate the practices of other farms that are perceived as successful or legitimate, a pattern observed in the diffusion of circular economy practices in various regions [21]. Together, these institutional forces create a powerful context that can either enable or constrain the transition toward circular agriculture [21, 22].

In synthesis, these two theories provide a comprehensive dual-lens framework for this study. While DOI Theory helps explain the 'pull' factors at the micro-level – how farmers are drawn to an innovation based on its perceived benefits and social influence – Institutional Theory explains the 'push' factors at the macro-level – how the broader regulatory and normative environment pressures or enables this adoption. This study uses this integrated framework to understand why, in the context of Đắk Lắk, certain factors appear more influential than others.

2.3. Determinants of Circular Agriculture Adoption

The transition from conventional to circular agriculture is a complex process influenced by a wide array of factors. Research has identified several key determinants that shape farmers' decisions to adopt these sustainable practices. Understanding these factors is essential for designing effective policies and support systems. This review categorizes these determinants into institutional and policy, economic and market, technological and infrastructural, and social and individual factors.

2.3.1. Institutional and Policy Factors

The institutional and policy environment plays a foundational role in either facilitating or hindering the adoption of circular agriculture. The presence of supportive regulatory frameworks, including relevant policies and subsidies, is a critical factor in shaping farmers' willingness to adopt new practices [9, 25]. Effective institutional support is essential for helping farmers overcome the initial barriers to entry [26, 27]. However, for policies to be effective, they must be tailored to the specific regional and contextual needs of farming communities, as a one-size-fits-all approach is often inadequate [27, 28].

2.3.2. Economic and Market Factors

Economic considerations are often the most direct drivers of a farmer's decision-making process. The financial implications of transitioning to circular systems, including production, investment, and operational costs, are significant hurdles that must be addressed [9, 29]. A lack of clear financial incentives or subsidies can act as a major barrier to adoption [25, 27]. Conversely, strong market demand for sustainably produced goods can provide a powerful incentive for farmers to change their practices [25]. Ultimately, the potential for improved economic resilience and long-term profitability serves as a key motivator for embracing circular models [19].

2.3.3. Technological and Infrastructural Factors

The practical implementation of circular agriculture often depends on access to appropriate technology and enabling infrastructure. The availability of innovative farming techniques and technologies, such as those related to renewable energy, is a crucial determinant of adoption [26, 27, 30]. Limited access to such technologies can negatively impact farmers' attitudes and their perceived ability to implement new methods [19]. Furthermore, basic infrastructure, such as efficient transportation systems, is vital for connecting farmers to markets and support services, particularly in mountainous regions where poor infrastructure can severely limit the feasibility of adopting new practices [12, 22].

2.3.4. Social and Individual Factors

Beyond external structures, the characteristics of farmers and their social environments significantly influence adoption. Social norms and peer influence within a community often play a dominant role in encouraging behavioral change [19, 31]. A farmer's individual background, including their level of education, awareness of environmental issues, and previous experience with innovation, is also a significant factor [9, 26, 32]. Consequently, a lack of knowledge or familiarity with circular principles can be a substantial barrier [9, 33]. Finally, psychological factors such as a farmer's personal attitudes, motivations, and sense of control over their ability to implement changes are important predictors of their intention to adopt sustainable practices [19, 28, 34].

2.4. Circular Agriculture in the Vietnamese Context and the Research Gap

In Vietnam, circular agriculture is an emerging and important approach to addressing the environmental and economic pressures resulting from decades of intensive farming. The nation's agriculture has historically relied on a high volume of agrochemicals, leading to consequences such as soil degradation and water pollution [3]. In response, circular models are being explored, often focusing on the integration of different farming systems and the utilization of the country's abundant agricultural by-products, such as rice straw and husks [35, 36]. These practices offer a pathway toward a more sustainable agricultural sector.

Despite this potential, the widespread adoption of circular agriculture in Vietnam is met with considerable challenges. Farmers often face significant financial barriers, including the high initial costs of transitioning and a lack of specific subsidies for circular practices [9, 10]. These economic hurdles are compounded by technological limitations and a general lack of awareness and technical knowledge among farming communities [3, 10]. Furthermore, the national policy landscape, while supportive in principle, remains fragmented, with regulations scattered across various legal documents, which can hinder clear and effective implementation on the ground [8].

These challenges are often more pronounced in the country's mountainous regions, such as the Central Highlands. These areas present unique difficulties for farmers, including difficult terrain, limited accessibility, and underdeveloped infrastructure, all of which can complicate farming operations and limit access to markets [12, 13, 37]. While previous studies have examined circular agriculture in various contexts within Vietnam, there remains a notable gap in the literature. Few studies have systematically and quantitatively investigated the specific determinants that influence the adoption of circular agriculture practices among smallholder farmers in the distinct ecological and socio-economic context of Vietnam's mountainous regions. This study aims to address that gap by providing an empirical analysis of the factors driving or impeding the transition to circular agriculture in this vital area.

3. Data Description and Research Method

3.1. Research Design and Data Collection

This study employed a cross-sectional research design using a quantitative survey to investigate the factors influencing the adoption of CA practices among farming households. The study was conducted in Đắk Lắk province, a region selected for its critical role as a socio-economic and agricultural hub in Vietnam's Central Highlands. The province is characterized by vast, fertile land suitable for high-value crops but simultaneously faces significant sustainability challenges, including resource depletion, environmental degradation, and the impacts of climate change, making it a highly relevant context for this research.

To capture a representative sample, data were collected from several communes chosen for their high concentration of agricultural production, including Ea Kao, Hoa Thuan (Buon Ma Thuot city), Ea Kênh (Krong Pắk district), and Ea Kpam (Cư M'gar district). Data was gathered using a structured questionnaire administered through face-to-face interviews conducted by trained enumerators. The questionnaire was designed to capture information on household demographics, farm characteristics, and perceptions and practices related to circular agriculture. Out of 300 questionnaires initially distributed, 274 were completed and deemed valid for analysis, resulting in a response rate of 91.3%.

The final sample consisted of 274 farming households. Demographically, the respondents were predominantly male (66.4%), with an average age of 53 years. Most participants had completed either lower secondary (44.5%) or upper secondary education (32.8%). In terms of agricultural activities, many households (91.2%) were engaged primarily in crop cultivation, operating on an average farm size of 36.6 sào (approximately 500m^2). Detailed characteristics of the survey sample are presented in **Table 1,** and **Figures A1, A2,** and **A3.**

Table 1. Basic characteristics of the survey sample.

Indicator		Frequency	Percentage (%)
Gender	Female	92	33.6
	Male	182	66.4
	Total	274	100
Education level	Illiterate	3	1.1
	Primary school	26	9.5
	Lower secondary school	122	44.5
	Upper secondary school	90	32.8
	Vocational/College	18	6.6
	University or above	15	5.5
	Total	274	100
Type of farming	Crop cultivation	250	91.2
	Forestry	1	0.4
	Livestock	20	7.3
	Aquaculture	3	1.1
	Total	274	100
	Minimum Value	**Maximum Value**	**Mean**
Age	27	75	53
Farm size (Sào)	0.5	70	36.597
Cost (Million VND)	0	1380	120.475
Profit (Million VND)	−20	3000	423.213

Source: Authors' calculation.

3.2. Measurement of Variables

The key constructs in the research model were operationalized using multi-item scales, with responses measured on a five-point Likert scale ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). This approach allows for a nuanced capture of farmers' perceptions and behaviors.

The dependent variable for this study is *Circular Agricultural Practices (SXTH).* This is a latent construct that measures the extent to which farmers actively engage in circular activities. It was measured using survey items that assessed specific behaviors, such as reducing chemical inputs, reusing organic materials and farm waste, and regularly maintaining equipment. The dependent variable (SXTH), an index created by averaging the scores of its constituent Likert-scale items, was treated as a continuous variable for the regression analysis, a common and accepted practice in social science research when the scale comprises multiple items.

The model included five key independent variables, each designed to capture a specific dimension of influence on CA adoption: *Government Policies (CSCP)*, which assesses farmers' awareness of national-level support; *Support from Local Authorities (CQDP),* measuring perceived engagement from local government; *Support from Enterprises (HTDN),* gauging the level of private sector assistance; *Infrastructure (CSHT),* reflecting the perceived quality of essential public works; and *Market Conditions (TT),* capturing farmers' views on market demand and incentives for sustainable products.

Finally, to control for demographic characteristics that may influence adoption behavior, the model incorporated two control variables: the *Age (TUOI)* and *Education Level (HOCVAN)* of the household head.

The specific items used to measure each of these constructs are detailed in the **Appendix** (see **Table A1**).

3.3. Analytical Strategy

The data analysis was conducted using IBM SPSS Statistics 23.0 and followed a multi-stage process to ensure the reliability and validity of the results.

First, the internal consistency of the measurement scales for each construct was assessed using Cronbach's Alpha. A coefficient of 0.6 or higher was considered acceptable for exploratory research. Following this, Exploratory Factor Analysis (EFA) with Principal Axis Factoring was employed to examine the construct validity of the measurement items. The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity were used to confirm the suitability of the data for factor analysis. Items with factor loadings below 0.5 were removed to ensure that the final factors were robust and clearly defined.

Second, to test the hypotheses, a Multiple Linear Regression model was used. This method was chosen as it is a robust method for examining the linear relationships between multiple independent variables and a continuous dependent variable, aligning perfectly with the study's objective of identifying the relative importance of key determinants. The model estimated the impact of the independent variables on the adoption of circular agricultural practices, specified as follows:

$$SXTH = \beta_0 + \beta_1.CSCP + \beta_2.CSHT + \beta_3.TT$$
$$+\beta_4.CQP + \beta_5.HTDN + \beta_6.TUOI + \beta_7.HOCVAN$$

Finally, a series of diagnostic tests was performed to validate the assumptions of the regression model. Multicollinearity was checked using the Variance Inflation Factor (VIF), with a threshold of VIF < 10 indicating no significant issue. The presence of autocorrelation was assessed using the Durbin-Watson statistic, with values between 1 and 3 considered acceptable. These steps ensure that the estimated coefficients are reliable, and the conclusions drawn from the model are statistically sound.

4. Results

4.1. Cronbach's Alpha Analysis Results

To assess the internal consistency and reliability of the measurement scales used in this study, a Cronbach's Alpha analysis was performed. Following established guidelines for exploratory research, constructs with a Cronbach's Alpha coefficient of 0.6 or higher are considered reliable. Additionally, to refine the scales, individual items with a corrected item-total correlation below

0.3 were removed.

This iterative process led to the removal of two items from the 'support from Local Authorities' (CQĐP) construct and one item from the 'support from Enterprises' (HTDN) construct. The final scales were then reanalyzed for reliability.

The results, presented in **Table 2**, show that all final constructs demonstrated strong internal consistency. The Cronbach's Alpha coefficients for the retained scales ranged from 0.659 to 0.919, all comfortably exceeding the recommended threshold of 0.6. This confirms that the measurement scales used for subsequent analysis are reliable and effectively capture the intended underlying concepts.

Table 2. Summary of Scale Reliability Testing Using Cronbach's Alpha.

No.	Variable Group	No. of Items	Cronbach Alpha
1	Circular Production (SXTH)	6	0.659
2	Government Policy (CSCP)	5	0.898
3	Support From Local Authorities (CQĐP)	5/3	0.798
4	Support From Enterprises (HTDN)	3/2	0.741
5	Infrastructure (CSHT)	3	0.919
6	Market Conditions (TT)	4	0.802

Source: Authors' calculation.

4.2. Exploratory Factor Analysis (EFA) Results

Following the reliability analysis, Exploratory Factor Analysis (EFA) was conducted to assess the construct validity of the measurement scales (see **Tables A2, A3, A4,** and **A5** for factor loadings and reliability scores). The primary objectives were to identify the underlying factor structure of the survey items and to confirm that the items for each theoretical construct loaded together as intended. The Principal Axis Factoring method with Varimax rotation was employed for this purpose.

Prior to factor extraction, the suitability of the data for EFA was confirmed. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.809 for the independent variables and .750 for the dependent variable, both of which are well above the recommended threshold of 0.6. Bartlett's Test of Sphericity was also statistically significant for both the independent variables ($\chi^2(136) = 2829.9$, $p < 0.001$) and the dependent variable ($\chi^2(15) = 295.6$, $p < 0.001$). These results indicate that the correlations between the items were sufficiently large for EFA.

The analysis of the independent variables extracted five distinct factors with eigenvalues greater than 1.0, which collectively explained 75.57% of the total variance. For the dependent variable, a single factor was extracted, explaining 41.71% of its variance. All retained items exhibited strong and clear factor loadings on their respective constructs (all > 0.5), confirming an interpretable factor structure. The final results of the EFA, along with the reliability scores for the resulting constructs, are summarized in **Table 3**.

4.3. Regression Results

Prior to the regression analysis, a Pearson correlation analysis was conducted to examine the relationships between the variables. The results are presented in **Table 4**. The dependent variable, Circular Agricultural Practices (SXTH), shows a significant and positive correlation with Market Conditions (TT, $r = 0.406$, $p < 0.05$), Infrastructure (CSHT, $r = 0.299$, $p < 0.05$), Education Level (HOCVAN, $r = 0.251$, $p < 0.05$), and Support from Local Authorities (CQĐP, $r = 0.240$, $p < 0.05$). These initial findings are consistent with the subsequent regression results. Furthermore, the correlations among the independent variables are generally low to moderate, indicating that multicollinearity is not a significant issue, which corroborates the VIF values reported in the regression analysis.

To test the proposed hypotheses, a multiple linear regression analysis was conducted. The model aimed to identify the key determinants influencing the adoption of circular agricultural practices (SXTH) among farming households in Đắk Lắk. The results of this analysis are presented in **Table 5**.

Table 3. Summary of Exploratory Factor Analysis and Reliability Results.

Constructs and Items	Factor Loadings	Cronbach's Alpha (α)	% of Variance Explained
Government Policies (CSCP)		**0.898**	**27.32%**
CSCP4: Banks offer loans to support CA.	0.910		
CSCP3: The government has tax incentives for CA.	0.894		
CSCP5: I am aware of support packages for CA.	0.860		
CSCP2: The government has many policies encouraging CA.	0.735		
CSCP1: I am aware of legal documents on CA.	0.705		
Infrastructure (CSHT)		**0.919**	**23.99%**
CSHT1: Roads in my area are increasingly solidified.	0.905		
CSHT2: Electricity and water systems are convenient.	0.887		
CSHT3: It is easy to purchase agricultural inputs.	0.885		
Market Conditions (TT)		**0.802**	**11.52%**
TT2: Clean agricultural products are easier to market.	0.861		
TT4: Consumers demand eco-friendly processes.	0.729		
TT1: Clean products can be sold at higher prices.	0.711		
TT5: Enterprises value clean agricultural production.	0.700		
Support from Local Authorities (CQĐP)		**0.798**	**6.84%**
CQĐP5: Local authorities focus on green agriculture.	0.873		
CQĐP4: Local authorities pay attention to environment.	0.857		
CQĐP6: Local authorities see agriculture as strategic.	0.839		
Support from Enterprises (HTDN)		**0.741**	**5.91%**
HTDN1: I receive capital investment from enterprises.	0.834		
HTDN3: My output products are guaranteed by enterprises.	0.743		
Circular Agricultural Practices (SXTH)		**0.659**	**41.71%**
SXTH5: I reuse materials in the production process.	0.716		
SXTH2: I minimize the use of harmful chemicals.	0.698		
SXTH9: I actively seek out new techniques.	0.686		
SXTH4: Equipment is regularly maintained.	0.619		
SXTH6: I recycle waste and agricultural residues.	0.563		
SXTH8: I give by-products to other households.	0.503		

Source: Authors' calculation.

Table 4. Pearson Correlation Matrix.

Variable	SXTH	CSCP	CQĐP	HTDN	CSHT	TT	TUOI	HOCVAN
SXTH	1							
CSCP	0.024	1						
CQĐP	0.240*	0.250*	1					
HTDN	−0.031	0.559*	0.168*	1				
CSHT	0.299*	−0.057	0.093	−0.127*	1			
TT	0.406*	0.087	0.276*	−0.023	0.516*	1		
TUOI	−0.002	0.014	0.008	−0.021	−0.134*	−0.079	1	
HOCVAN	0.251*	0.069	−0.002	−0.059	0.161*	0.104	−0.407*	1

*Note: * Correlation is significant at the 0.05 level (2-tailed).*
Source: Authors' calculation.

Table 5. Results of the Multiple Linear Regression Analysis.

Variable	B	β	t	Sig.	VIF
Market Conditions (TT)	0.369	0.369	7.179	< 0.001***	1.004
Education Level (HOCVAN)	0.246	0.242	4.229	< 0.001***	1.245
Support from Local Authorities (CQĐP)	0.225	0.225	4.390	< 0.001***	1.000
Infrastructure (CSHT)	0.222	0.222	4.269	< 0.001***	1.030
Age (TUOI)	0.010	0.107	1.894	0.059*	1.218

Table 5. *Cont.*

Variable	B	β	t	Sig.	VIF
Support from Enterprises (HTDN)	0.017	0.017	0.320	0.749	1.015
Government Policies (CSCP)	−0.010	−0.010	−0.188	0.851	1.011
(Constant)	−1.387		−3.400	0.001	

*Notes: Dependent Variable: Circular Agricultural Practices (SXTH). N = 273. B = Unstandardized Coefficient; β = Standardized Coefficient. Significance levels: * $p < 0.10$, *** $p < 0.01$. Model summary: $R^2 = 0.301$, Adjusted $R^2 = 0.283$, F-statistic = 16.368***, Durbin-Watson = 1.769.*
Source: Authors' calculation.

The overall regression model was found to be statistically significant, F (7, 265) = 16.368, $p < 0.001$, indicating that the model is a good fit for the data. The adjusted R^2 value was 0.283, which suggests that the independent and control variables collectively explain 28.3% of the variance in the adoption of circular agricultural practices. Diagnostic tests confirmed the validity of the model's assumptions. All Variance Inflation Factor (VIF) values were below 2.0, well under the common threshold of 10, indicating that multicollinearity was not an issue. Furthermore, the Durbin-Watson statistic of 1.769 suggests the absence of significant autocorrelation among the residuals.

Regarding the individual predictors, Market Conditions emerged as the most powerful determinant of CA adoption (β = 0.369, $p < 0.001$). This was followed by Education Level (β = 0.242, $p < 0.001$), Support from Local Authorities (β = 0.225, $p < 0.001$), and Infrastructure (β = 0.222, $p < 0.001$), all of which exerted a significant positive influence. The Age of the farmer also showed a marginally significant positive effect (β = 0.107, p = 0.059). In contrast, Government Policies (CSCP) and Support from Enterprises (HTDN) were not found to have a statistically significant impact on the adoption of circular practices in this study.

5. Discussion

The empirical investigation in Đắk Lắk Province provides critical insights into the adoption of CA at the household level. Before discussing the determinants, it is pertinent to address the model's explanatory power. The adjusted R^2 of 0.283, while moderate, is a reasonable and meaningful outcome for cross-sectional research in the social sciences, which often contends with the inherent complexity and heterogeneity of human decision-making. The findings suggest that the transition toward CA is in its nascent stages, characterized by spontaneous, bottom-up practices rather than a systematic, policy-driven movement. This is underscored by the survey data indicating that while many farmers engage in some circular activities, their awareness of CA as a formal concept remains very low (only 4.8%). This context makes identifying the true drivers and barriers to adoption essential for shaping future interventions. The analysis reveals that adoption is significantly influenced by a core set of pragmatic factors: market conditions, farmer education, local institutional support, and infrastructure.

Role of market forces and human capital

Market Conditions (β = 0.369) emerged as the most influential determinant of CA adoption. This finding strongly suggests that farmers in Đắk Lắk, like those in many other regions, operate as rational economic actors; they are most motivated to adopt new practices when they perceive clear and immediate financial benefits. This aligns with the Diffusion of Innovations (DOI) theory, where the "relative advantage" of an innovation is a primary driver of its uptake [19]. The result corroborates a broad consensus in the literature that emphasizes market demand and financial incentives as powerful motivators for sustainable practices [9, 25, 27]. However, the market drivers in Đắk Lắk appear largely responsive and informal. This contrasts with experiences in other Southeast Asian highlands, such as Chiang Mai, Thailand, where proactive, community-driven models like local organic markets and farmer cooperatives – often facilitated by strong community membership and knowledge sharing – have created a more stable and structured incentive system, pulling farmers toward sustainable production rather than leaving them to react to volatile price signals alone [38].

The second most significant factor was the Education Level of the household head (β = 0.242). This highlights the critical role of human capital in the transition to more knowledge-intensive farming systems, a point of particular relevance in highland areas where agroecological challenges are common [39]. Higher education levels equip farmers not only with the cognitive abilities to understand complex ecological principles but also to better assess long-term benefits and manage the risks associated with innovation. This finding is highly consistent with a large body of research that identifies education as a key enabler of sustainable farming adoption [26, 32] and speaks directly to the challenge of knowledge gaps identified as a major barrier in studies from the USA to Albania [9, 33]. From a DOI theory perspective, higher education reduces the perceived "complexity" of the innovation, making adoption more likely.

Additionally, the farmer's age showed a marginally significant positive effect (β = 0.107, $p = 0.059$) on CA adoption. While the literature often presents mixed findings on the role of age, our result suggests that, contrary to the common assumption that older farmers are more resistant to change, their accumulated experience may be a valuable asset. It is plausible that older farmers possess more extensive tacit knowledge of resource-conserving methods that resonate with circular principles, even if they are unfamiliar with the formal terminology. This aligns with a body of research which identifies a farmer's "previous experience with innovation" as a significant determinant of adopting sustainable practices [9, 26, 32]. This suggests that rather than being a barrier, the experience of older farmers represents an underappreciated resource that policy and extension programs could leverage.

On-the-ground enablers: local support and infrastructure

The analysis also confirmed the significant positive influence of Support from Local Authorities (β = 0.225) and Infrastructure (β = 0.222). These two factors represent the tangible, on-the-ground support system for farmers. In the context of Vietnam, local authorities are the primary interface for policy implementation. Their active engagement, through guidance and encouragement, provides a sense of legitimacy and reflects the powerful "normative pressures" described in Institutional Theory [23]. This tangible, local-level support often proves more influential than abstract national directives, a finding echoed in studies emphasizing the need for tailored, context-specific institutional support [24, 27].

Similarly, adequate infrastructure is not merely a convenience but a fundamental prerequisite for participation in a circular economy, especially in mountainous regions like Đắk Lắk, which face characteristic vulnerabilities such as difficult terrain and limited market accessibility [12]. These issues align with broader challenges in highland agriculture, including environmental degradation and difficult water management, which can be mitigated by better infrastructure [40, 41]. The importance of functional roads, reliable electricity, and water directly reinforces findings from the Himalayas that stress the foundational role of rural infrastructure in determining the future of mountain farming livelihoods [12]. It also aligns with broader institutional analyses which argue that enabling infrastructure is a critical prerequisite for the success of any circular economy transition, especially in the agricultural sector [22]. Without this basic infrastructure, even the most willing farmers are isolated and unable to adopt new practices.

The policy-practice gap: explaining insignificant factors

Perhaps one of the most telling findings is the statistical insignificance of both national Government Policies (CSCP) and Support from Enterprises (HTDN). This does not mean that national policies or the private sector are unimportant; rather, it points to a significant policy-implementation gap and a nascent private-sector engagement model. The lack of influence from national policies, while striking, provides empirical weight to critiques of Vietnam's legal framework for the circular economy as being fragmented and lacking the specific, actionable guidelines needed by farmers [7, 8]. This finding highlights a critical disconnect where top-down "coercive pressures" from the state are failing to translate into meaningful action at the farm level, a problem compounded by low farmer awareness and a lack of clear incentives [9, 10]. Experiences from other regions suggest that effective policy support requires tangible, accessible interventions, such as waste disposal facilities and robust extension services, to bridge this gap [42].

Similarly, the non-significant effect of enterprise support suggests that linkages between private firms and smallholders in the realm of CA are still weak or unstructured. This reflects a broader challenge in developing sustainable value chains, where creating effective public-private partnerships tailored to the local context is a critical but often missing step for scaling up innovations in emerging economies.

Implications for policy and practice

Empirical evidence indicates that policies aimed at promoting circular agriculture in Vietnam's Central Highlands should shift from broad national directives towards a more enabling, bottom-up approach that addresses the practical factors influencing farmers' decisions. This analysis points to several specific policy implications.

First, as market conditions are the most significant driver, policy should focus on creating tangible economic benefits for sustainable production. Rather than relying on abstract national goals, local authorities can play a crucial role in fostering the development of "green" value chains. This could involve providing targeted incentives for enterprises and cooperatives to expand market access for circular products, supporting the establishment of specialized agricultural cooperatives and associations to improve farmers' bargaining power, and promoting certification systems that can command price premiums. Such market-oriented measures align with the "relative advantage" principle, a confirmed powerful motivator for farmer adoption.

Second, the strong influence of education highlights the importance of investing in human capital. This support should extend beyond formal education to include practical, hands-on training programs for farmers on specific circular agriculture techniques, production organization, and market navigation. Furthermore, enhancing the capacity of grassroots agricultural staff at the commune and village level is essential for creating a reliable local support system that can effectively disseminate knowledge and build trust within the farming community.

Third, bridging the identified policy-practice gap requires empowering local institutions to act as facilitators and coordinators. The finding that local support is significant while national policies are not suggests that a decentralized approach to implementation may be more effective. Local governments should be equipped with the financial resources and technical capacity to develop context-specific mechanisms that encourage the formation of new agricultural enterprises and specialized cooperatives. By strengthening local institutional capabilities and related infrastructure, policymakers can foster an environment where the current spontaneous adoption of circular practices can develop into a more systematic and sustainable agricultural transition.

6. Conclusions

This study investigated the factors determining the adoption of CA practices among smallholder farmers in Đắk Lắk province, Vietnam. The findings reveal that this transition is in an early, spontaneous phase, driven by practical, farm-level considerations rather than top-down policy directives. Our analysis identified four significant and positive drivers of CA adoption: market conditions, farmer education level, support from local authorities, and infrastructure. Conversely, national-level government policies and support from private enterprises did not show a statistically significant impact. The core contribution of this research is the empirical identification of a critical policy-practice gap, demonstrating that CA adoption in this context is currently a bottom-up process.

The primary practical implication for policymakers is clear: to accelerate the transition to a circular model, efforts should shift focus from promulgating broad national strategies to empowering local institutions and fostering tangible, market-based incentives. Closing the gap between national policy and the on-the-ground realities faced by farmers is essential for building a more sustainable and resilient agricultural sector in Vietnam.

This study has several limitations that offer avenues for future research. First, its cross-sectional design identifies associations but limits the ability to draw firm conclusions about causality. Second, the measurement scale for the dependent variable (Circular Agricultural Practices) yielded a moderate reliability score; future studies should aim to develop and validate a more robust scale. Third, the study relies on self-reported data, which may be subject to social desirability bias. Finally, as the research was conducted in a single province, the findings may not be generalizable to all highland regions.

Future research should build on these limitations. Longitudinal studies are needed to track the evolution of these determinants over time as policies and market conditions change. Qualitative methods, such as in-depth case studies, would be invaluable for exploring the nuances of the policy-practice gap and the specific mechanisms through which local institutions facilitate adoption. Finally, comparative studies across different mountainous regions could help distinguish context-specific factors from more universal drivers of CA adoption.

Author Contributions

Conceptualization, T.T.B. and T.M.T.T.; methodology, T.T.B., T.M.T.T., H.T.D.; software, T.T.B., H.T.D., M.A.D.; validation, T.T.B. and D.N.V.; formal analysis, T.T.B., T.M.T.T.; investigation, T.T.B., T.M.T.T.; resources, T.T.B., T.M.T.T.; data curation, T.T.B. and D.N.V.; writing—original draft preparation, T.M.T.T., H.T.D., M.A.D., D.N.V., T.T.B.; writing—review and editing, T.M.T.T., H.T.D., M.A.D., D.N.V., T.T.B.; visualization, H.T.D., M.A.D. ; supervision, T.T.B.; project administration, T.T.B. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki. As per the institutional guidelines of VNU University of Economics and Business for non-interventional social science research, a formal ethics committee review was not required for this study. Nevertheless, all ethical procedures were strictly followed. Informed consent was obtained from all subjects involved in the study. Participants were assured that their participation was voluntary, and that all data would be coded, anonymized, and treated with strict confidentiality to protect their privacy.

Informed Consent Statement

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

Data Availability Statement

The data supporting the reported results in this study are available upon request from the corresponding author. The datasets analysed or generated during the study are not publicly available due to privacy and ethical restrictions. However, data can be made available for academic research purposes upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

Appendix A

Table A1. Description of Measurement Items.

No.	Code	Items
I		**GOVERNMENT POLICY (CSCP)**
1	CSCP1	I am aware that circular agriculture regulations are expressed in legal documents.
2	CSCP2	I feel that the government has many policies encouraging circular agriculture.
3	CSCP3	I know the government has tax incentive policies to implement circular agriculture.
4	CSCP4	I know banks offer loans to support circular agriculture.

Table A1. *Cont.*

No.	Code	Items
I		**GOVERNMENT POLICY (CSCP)**
5	CSCP5	I am aware of current support packages for circular agriculture from banks, associations, investment funds, enterprises...
II		**SUPPORT FROM LOCAL AUTHORITIES (CQDP)**
1	CQĐP1	The district People's Committee where I live has a department managing agricultural production activities.
2	CQĐP2	In my locality, there is coordination among the government, agricultural cooperatives, social organizations, and farmers in organizing circular agriculture activities.
3	CQĐP3	I have been introduced, guided, and facilitated by local authorities to implement circular agriculture models.
4	CQĐP4	Local authorities in my area pay special attention to environmental protection in agricultural production.
5	CQĐP5	Local authorities in my area focus on building green and sustainable agriculture.
6	CQĐP6	Local authorities identify agriculture, farmers, and rural areas as strategic issues in sustainable development.
7	CQĐP7	I observe that the government cooperates and supports both enterprises and farmers in circular agriculture.
III		**SUPPORT FROM ENTERPRISES (HTDN)**
1	HTDN1	I receive capital investment from enterprises.
2	HTDN2	I receive technical support and training in agricultural production from enterprises.
3	HTDN3	My output products are guaranteed by enterprises.
4	HTDN4	I cooperate with technical providers to reduce environmental impact from production and consumption.
IV		**INFRASTRUCTURE (CSHT)**
1	CSHT1	Roads in my area are increasingly solidified.
2	CSHT2	The electricity and water systems are convenient for my agricultural production.
3	CSHT3	It is easy for me to purchase agricultural inputs.
V		**MARKET CONDITIONS (TT)**
1	TT1	I find that clean agricultural products can be sold at higher prices than traditional ones.
2	TT2	I find that clean agricultural products are easier to market.
3	TT3	I know that there are many enterprises/corporations pioneering in building and positioning clean agricultural products in the market.
4	TT4	Consumers demand environmentally friendly production processes.
VI		**CIRCULAR PRODUCTION PRACTICES (SXTH)**
1	SXTH1	I strive to reduce the consumption of raw materials and energy in production.
2	SXTH2	I try to minimize the use of chemicals harmful to the environment and health in production.
3	SXTH3	Packaging such as plastic bags, foam boxes, and paper is reused multiple times.
4	SXTH4	Equipment is regularly maintained, cleaned, and serviced.
5	SXTH5	I always reuse materials that can be recycled in the production process.
6	SXTH6	I recycle waste and agricultural residues after using agricultural products.
7	SXTH7	I sell scrap and used materials to others.
8	SXTH8	I give agricultural by-products to other households for farming or breeding.
9	SXTH9	I actively seek out new techniques and eco-friendly products for use in production.

Table A1. *Cont.*

No.	Code	Items
VII		**CIRCULAR AGRICULTURE PERCEPTION (NNTH)**
1	NNTH	Have you ever heard of circular agriculture? (Your awareness of circular agriculture)

Source: Authors' calculation.

Table A2. Total Variance Explained by Independent Variables.

Total Variance Explained									
Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	4.644	27.317	27.317	4.644	27.317	27.317	3.772	22.187	22.187
2	4.078	23.988	51.304	4.078	23.988	51.304	2.682	15.775	37.962
3	1.957	11.515	62.819	1.957	11.515	62.819	2.499	14.700	52.662
4	1.162	6.838	69.657	1.162	6.838	69.657	2.400	14.117	66.779
5	1.005	5.914	75.571	1.005	5.914	75.571	1.495	8.792	75.571
6	0.665	3.914	79.485						
7	0.626	3.685	83.170						
8	0.514	3.022	86.191						
9	0.423	2.486	88.677						
10	0.383	2.252	90.929						
11	0.318	1.869	92.798						
12	0.293	1.726	94.524						
13	0.264	1.556	96.079						
14	0.226	1.332	97.411						
15	0.191	1.122	98.533						
16	0.140	0.824	99.357						
17	0.109	0.643	100.000						

Source: Authors' calculation.

Table A3. Total Variance Explained by Dependent Variables.

Total Variance Explained						
Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	2.502	41.707	41.707	2.502	41.707	41.707
2	0.974	16.238	57.945			
3	0.874	14.569	72.514			
4	0.672	11.204	83.717			
5	0.558	9.307	93.024			
6	.419	6.976	100.000			

Source: Authors' calculation.

Table A4. KMO and Bartlett's Test for Independent Variables.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.809
Bartlett's Test of Sphericity	Approx. Chi-Square	2829.915
	df	136
	Sig.	0.000

Source: Authors' calculation.

Table A5. KMO and Bartlett's Test for Dependent Variables.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.750
Bartlett's Test of Sphericity	Approx. Chi-Square	295.606
	df	15
	Sig.	0.000

Source: Authors' calculation.

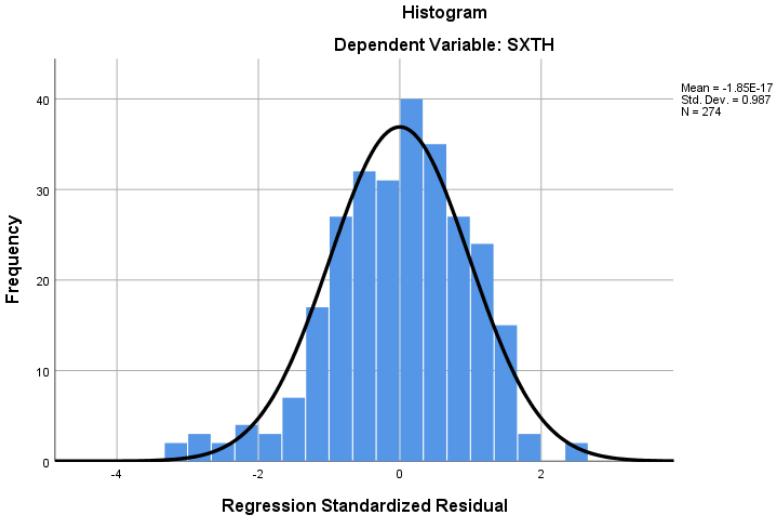

Figure A1. Histogram of Standardized Residuals.

Source: Authors' calculation.

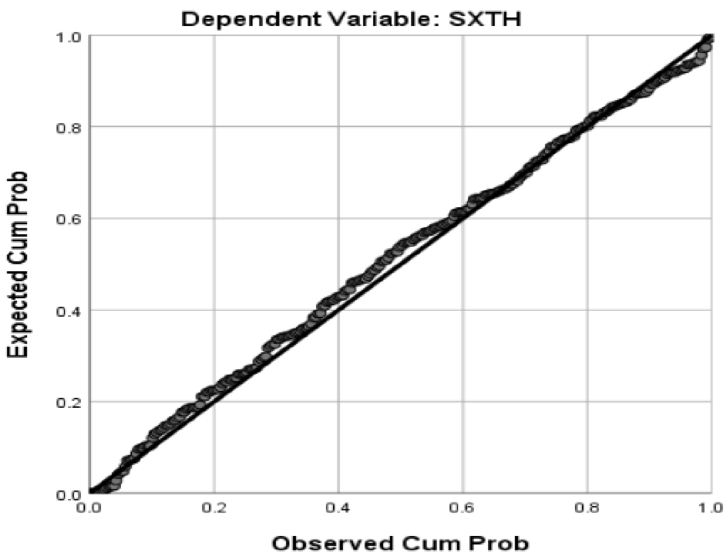

Figure A2. Normal P-P Plot of Regression Standardized Residual.

Source: Authors' calculation.

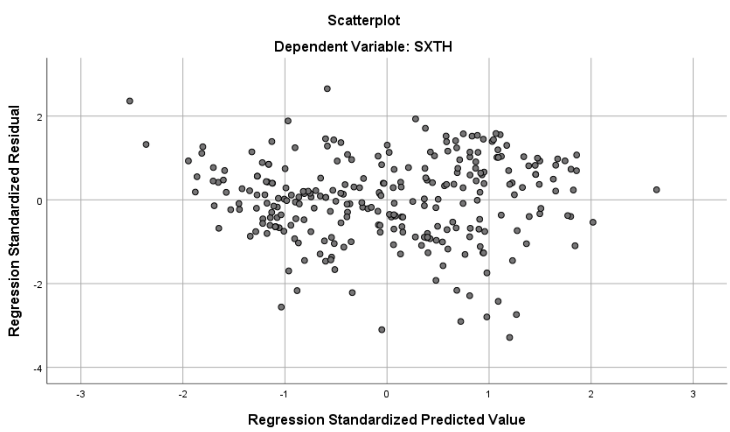

Figure A3. Scatterplot of Standardized Predicted Values vs. Standardized Residuals.

Source: Authors' calculation.

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