DEVELOPING CIRCULAR ECONOMY MODEL IN PIG FARMING IN SON DUONG COMMUNE, TUYEN QUANG PROVINCE

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ABSTRACT

Developing a circular economy in agriculture is a sustainable direction, contributing to improving production efficiency, reducing waste and protecting the rural environment. This study focuses on analyzing the current situation, potential and proposing solutions to develop a circular economy model in pig farming in Son Duong commune, Tuyen Quang province. Using research methods such as household surveys, in-depth interviews and SWOT analysis, the study shows that most farming households have initially reused waste as fertilizer, but the circular economy model is still fragmented, small-scale, and lacking linkages. From there, the article proposes a number of solutions to develop a sustainable circular economy model for the locality. Some proposed solutions include techniques, production organization, support policies and raising awareness of people in production areas.

1. Introduction

In the context of the global resource crisis, environmental pollution and climate change, the transition from a linear to a circular economy has become an inevitable trend towards green growth and sustainable development. According to Ellen MacArthur Foundation (2019), the circular economy is an economic system in which the use of resources is optimized, products, materials are reused, recycled and recovered to minimize waste into the environment. This model is being applied by many countries in the field of agriculture, especially animal husbandry, in order to save costs, use renewable energy and reduce greenhouse gas emissions.

In Vietnam, the policy of socio-economic development is affirmed in the National Strategy on Green Growth for the period 2021-2030, vision 2050 and the National Strategy on Circular Economy to 2030 (Ministry of Natural Resources and Environment, 2023). The Ministry of Agriculture and Rural Development (2022) also emphasizes that building a model of agricultural market economy is a key task to improve the efficiency of resource use, protect the environment and increase the added value of agricultural products. In particular, pig breeding is considered one of the potential fields of application of the circular economy, due to the abundant by-products and organic waste that can be reused as fertilizer, biogas or bioenergy products. Tuyen Quang province is a locality with a tradition of agricultural development, in which Son

Duong is a key area for pig breeding. However, according to local surveys, animal husbandry activities here are mainly small, scattered, low technical level and lack a synchronous waste treatment system, causing local environmental pollution in many communes (Tuyen Quang Department of Agriculture and Rural Development, 2024). Although some households have built biogas or composting plants, the application of circular economy in animal husbandry is still spontaneous and has not become a popular production model.

In that context, the study and proposal of solutions to develop the circular economy model in pig breeding at the farmer household level has profound practical significance. Not only help improve the efficiency of resource use and reduce environmental pollution, but also contributes to the implementation of the objectives of the Vietnam Sustainable Agricultural Development Strategy to 2030. According to Nguyen Van Binh (2023), the transformation of the livestock model towards a circular economy can help increase 15–20% economic efficiency and reduce up to 30% of solid waste into the environment. This confirms the urgency of the implementation of the model in rural and mountainous areas such as Son Duong where investment resources are limited but there is great potential to apply the circular economy in animal husbandry.

Stemming from that practice, the study "Development of circular economy model in pig breeding by farmers in Son Duong commune, Tuyen Quang province" was conducted in order to:

(1) Assess the current situation and application of the circular economy in pig breeding by farmers;

(2) Analyze the advantages, disadvantages, opportunities and challenges of developing a circular economy model in pig breeding.

(3) Propose a group of synchronous solutions to improve and replicate the market economy model, contributing to promoting the development of green and sustainable agriculture in the locality.

2. Theoretical, practical and reseach methods

2.1. Theoretical basis of circular economy in animal husbandry

Circular economy is understood as an economic development model in which resources, materials and products are maintained for as long as possible in the use cycle, while reducing waste and greenhouse gas emissions to the environment (Ellen MacArthur Foundation, 2019). Circular economy is considered an inevitable solution to help balance between economic growth and environmental protection, towards sustainable development (Nguyen Van Binh, 2023). In the field of agriculture, the circular economy not only helps reuse by-products, reduce resource waste, but also creates added value through the formation of closed value chains between cultivation – animal husbandry – processing – consumption (Ministry of Agriculture and Rural Development, 2022). Especially in pig breeding, the application of the market economy is clearly shown in the following models:

+ Using livestock waste to produce microbial organic fertilizers, biogas or Biochar;

+ Reuse post-treatment wastewater to irrigate crops;

+ Combining VACB model (Vuon – Ao – Chuong – Biogas) helps to form a closed biological cycle, reduce environmental pollution and save production costs.

According to the Ministry of Natural Resources and Environment (2023), agricultural market economy is not only a technical solution but also a strategic direction to help localities adapt to climate change and transition to green agriculture. In the context of Son Duong Commune – Tuyen Quang Province, where pig farming at household scale is rapidly developing, the application of a circular economy model presents an opportunity to simultaneously enhance economic efficiency and mitigate negative impacts on the rural ecological environment.

In Vietnam, several circular economy models in livestock production have been implemented in provinces such as Hoa Binh, Bac Giang, Ha Nam and Tuyen Quang, yielding positive results with economic efficiency increasing by 15–25% and waste volume reduced by 30–40% (Nguyen Van Binh, 2023; Department of Agriculture & Rural Development of Tuyen Quang, 2024). However, most of these models remain spontaneous, small-scale, lacking value-chain linkages and a clear incentive mechanism. Therefore, the research, assessment and proposal of solutions to promote CE-based pig farming at household level is essential, contributing to the concretization of the Government's policies on circular agriculture and green agriculture development (Decision No. 687/QD-TTg dated June 7, 2022).

2.2. Research Methodology

** Data collection methods*

+ Survey by questionnaire: Conduct a survey of 50 pig farmers in Son Duong commune on the scale, form of breeding, waste treatment, level of application and awareness of market economy.

+ In-depth interviews: Conducted with 5 typical households and 3 local officials to exploit information on policies, techniques and difficulties in the implementation of circular economy.

+ Collecting secondary data from Department of Agriculture and Environment Tuyen Quang, People's Committee of Son Duong Commune and local statistical reports (2020–2024).

** Methods of data processing and analysis*

+ Statistical descriptive analysis to reflect the current situation of pig breeding and the level of application of circular economy.

+ SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) to identify advantages, disadvantages, opportunities and challenges in the development of the circular economy model.

+ Comparative analysis and synthesis are used to evaluate the effectiveness, feasibility and propose solutions to complete the model.

3. Research results and discussion

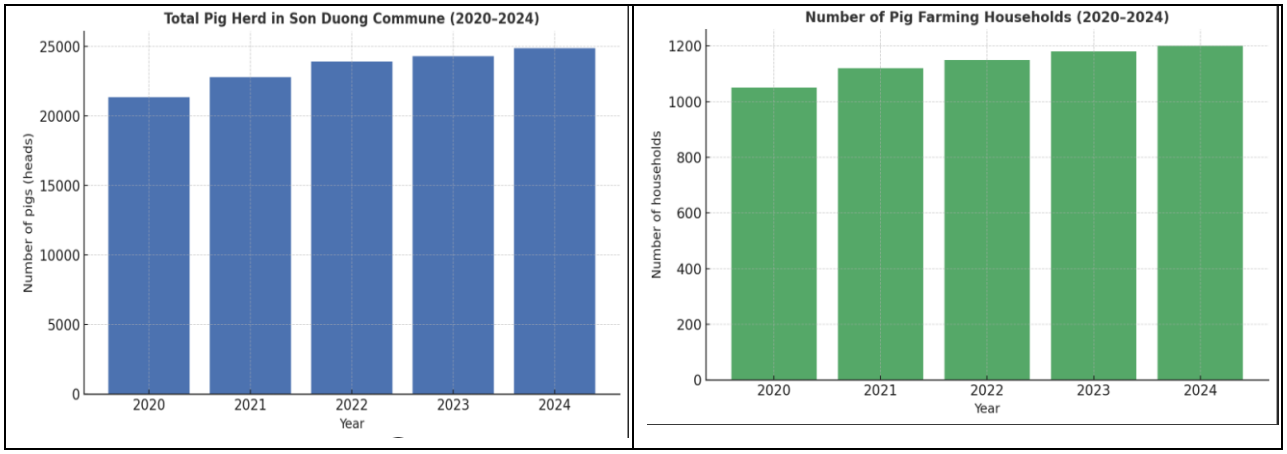
3.1. The current situation of circular economy application in pig breeding of farmer households in Son Duong commune

From 2020 to 2024, the total pig herd in the area increased from 21,350 to 24,851 heads, equivalent to a growth of 16.4%, with an average annual growth rate of 3.8%. This demonstrates

a significant recovery following the severe impacts of African swine fever during 2018–2019. From 2021 onward, as the disease was effectively controlled and breed sources stabilized, pig numbers continuously increased, reflecting the improved stability of production structure and resilience of local farmers.

The increase in meat production from 2,450 tons (2020) to 2,850 tons (2024) also confirms the trend of recovery and expansion of production scale, contributing to meeting the local food demand and supplying the local market. The production value in 2024 reached VND 159.2 billion, with the average revenue per household increasing by about 15–18% compared to 2020.

Figure 1. Scale and speed of development of pig herds and pig raising households in the period 2020-2024 in the study area



(Source: Survey results in 2025)

The number of pig-raising households increased from 1,050 households in 2020 to 1,200 households in 2024, an increase of 150 households, equivalent to an average annual growth rate of 3.4%. However, the average herd size per household remained stable at around 20–21 heads, showing no significant change compared to 2020. This indicates that most households still maintain small-scale production, primarily serving self-consumption and local retail markets, with large-scale industrial farms yet to be established. Approximately 70% of households raise fewer than 30 pigs per cycle, 18% raise between 30-100 pigs, and only 10% operate large farms (>100 pigs). This pattern reflects the characteristics of smallholder economies in midland and mountainous regions, predominantly small to medium scale and largely self-sufficient. These conditions limit the adoption of advanced technical measures, particularly circular economy models, due to low capital investment capacity and a lack of technical knowledge.

Although the scale of production is small, from 2022-2024, the trend of conversion to bio-intensive and conventional farming models will increase sharply. About 40-45% of households have applied at least one recirculating measure, such as building biogas cellars, composting microorganisms, reusing wastewater, or combining planting trees and raising fish in the same VACB ecosystem In particular, 52% of households recycle pig manure, 41.5% have biogas cellars, and 28% of households reuse barn washing water. The group of households applying 3 or more circular economy measures accounted for 48%, with a 12% decrease in food costs, 18% decrease in fertilizer costs, and 10–15% increase in income compared to the group

that has not yet applied. This proves that circular economy not only improves environmental efficiency but also brings practical economic value to farmers.

Table 1: The level of application of circular economy model of pig farmers in the study area

Measures of circular economy	Applicable household rate (%)
Treatment of compost into organic fertilizer	52,0
Using biogas cellars	41,5
Reuse of barn cleaner	28,0
Utilize by-products as aquaculture feed	24,5
Combining pig farming with tree planting	39,0

(Source: Survey results in 2025)

The data indicate that pig production in Son Duong has experienced stable growth, characterized by small-scale operations but with considerable potential, especially in adopting circular economy models. This represents an inevitable development pathway for ensuring sustainable rural growth, simultaneously improving economic efficiency and protecting the rural environment.

3.2. SWOT analysis for the circular economy model in pig breeding of farmer households in Son Duong commune

To evaluate the potential and feasibility of developing circular economy models in household-based pig farming in Son Duong Commune, the research team employed SWOT analysis to identify the key Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T) in the adoption and scaling-up process. This method was constructed based on a 2025 survey of pig-raising households, in-depth interviews with local agricultural officers, and the integration of previously published data.

Table 2. SWOT analysis for circular economic model in pig breeding in Son Duong commune

Factors	Detailed contents
Strengths (S)	+ Local people have a long tradition in pig breeding, accumulating a lot of practical experience and disease prevention. + Rich agricultural by-products such as corn, cassava, rice bran, rice straw are convenient to reuse in feed production and composting. + The percentage of households with biogas tanks reached 41.5%, of which 52% recycled into organic manure, 39% of households combined animal husbandry – cultivation – fish farming according to the VACB model. + Abundant rural labor, low labor costs, easy access to technology suitable to the size of the household.
Weaknesses (W)	+ The production scale is small, with an average of 20–21 heads/household, lack of concentration and association. + Lack of initial investment capital for the construction of biogas plants, wastewater treatment systems and organic composting technology. + Awareness and skills of circular economy are still limited: about 40–45% of

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Factors	Detailed contents
	households do not understand the process or apply the wrong technique. + Lack of large-scale demonstration models of cooperatives or large farms as scaling points.
Opportunities (O)	+ The State and local authorities are implementing the National Strategy on circular economy to 2030 (Ministry of Natural Resources and Environment, 2023), creating a favorable legal corridor for circular agriculture development. + The market demand for clean, organic food, biosecurity is increasing, expanding opportunities for circular consumption of livestock products. + Ability to access green credit, OCOP program, Environment Fund and international support projects on sustainable agriculture. + The system of research and training facilities at Tan Trao University is ready to support the transfer of technology to farmers.
Threats (T)	+ Fluctuations in feed prices and input costs reduce profits, affecting the ability to maintain the model. + Risk of recurrence of African swine fever and other animal diseases affecting biosecurity. + The market for organic fertilizer, biogas and by-products is not stable, the commercial value is still low. + Lack of specific support mechanisms in terms of capital, techniques, certifications and brands for farmers applying circular economy.

(Source: Survey results in 2025)

The analysis results indicate that Son Duong possesses several internal advantages for developing circular economy practices, particularly traditional livestock-raising experience, an abundant supply of agricultural by-products, and a readily available local labor force. These form essential foundations enabling farmers to adapt effectively to environmentally friendly, circular production models.

However, small production scale, limited capital and technical capacity remain major barriers, resulting in circular economy adoption being largely confined to basic waste utilization practices such as composting manure and producing biogas, rather than establishing a fully closed-loop production cycle. In addition, the lack of linkage among households, cooperatives and downstream enterprises restricts opportunities for scaling up and enhancing the economic value of circular economy-based livestock systems.

At the external level, national and provincial policies promoting circular economy development, together with the growing trend of green consumption, create significant opportunities for Son Duong to develop a circular livestock value chain. Nevertheless, challenges such as disease risks, high input costs and unstable market outlets need to be addressed through strengthening the "four-party linkage" model (Government – Research Institutions – Enterprises – Farmers) in order to ensure the sustainability of circular economy initiatives.

3.3. Solutions to develop the circular economic model in pig breeding of farmers in Son Duong commune

3.3.1. Strategic Orientation

From the assessment of the situation and the above analysis, it is possible to identify 4 key strategic groups to help localities exploit strengths, overcome limitations and adapt to environmental challenges.

Table 3. Strategic orientation for the development of the model of circular economic model in pig breeding in Son Duong commune

Strategy Group	Specific Orientation
S–O (Leverage strengths to exploit opportunities)	Promote the advantages of experience and available raw materials to expand the household scale circular economy model; promote cooperation with cooperatives and enterprises to consume clean products.
W–O (Overcome weaknesses to take advantage of opportunities)	Providing preferential loans, training on waste treatment and composting techniques; building community circular economy demonstration models.
S–T (Promote strengths to limit challenges)	Strengthen the application of biosecurity measures, develop production – recycling – consumption chains in order to stabilize output and reduce price dependence.
W–T (Minimizing weaknesses, coping with challenges)	Establishing a circular livestock cooperative as a chain-linked nucleus; proposing the government to support the certification mechanism "Son Duong clean pork" to improve the brand value.

(Source: Survey results in 2025)

Circular economy in pig breeding in Son Duong has a solid development base, but needs synchronous support in capital, technology and market. In the period 2025–2030, the implementation of S–O and W–O strategies is considered the most feasible direction, helping to transform household farming from a traditional form to a closed, sustainable and environmentally friendly circular model, in line with the "green agriculture" orientation of Tuyen Quang province.

3.3.2. Solutions to develop the circular economic model in pig breeding in Son Duong commune

The research results show that the development of the circular economy model in pig breeding in Son Duong commune is highly feasible but needs synchronous support in terms of techniques, organization, policies and raising public awareness. Four major solution groups are proposed to foster the formation and scaling-up of circular economy models in the coming years:

** Group of technical solutions*

Technical advancement plays a decisive role in ensuring the effectiveness and long-term sustainability of circular economy models. Pig-raising households should receive support to

adopt technologies appropriate for household-scale production, specifically:

+ Construct and upgrade small- and medium-scale biogas digesters to ensure effective livestock waste treatment while generating renewable bioenergy for heating and cooking.

+ Application of Biochar, EMIC technology or microbiological preparations in the treatment of waste, reducing odors, increasing the nutritional value of organic manure.

+ Guide the techniques of composting microorganisms, reusing wastewater after treatment to irrigate plants, creating a closed cycle of "animal husbandry – cultivation – recycling".

+ Develop VACB model (Vuon – Ao – Chuong – Biogas) in accordance with local conditions, reduce greenhouse gas emissions (CH_4 and NH_3).

** Group of solutions on production organization and association*

+ Establishing a cooperative group or cooperative (cooperative) for circular animal husbandry, creating a linkage between households to share experience, equipment and investment resources.

+ Build a value chain "production – recycling – consumption", in which the cooperative mediates the collection of organic fertilizers and by-products to produce microbial fertilizers or commercial biogas.

+ Cooperate with enterprises in consuming clean, organic products and by-products from circular economy.

+ Implement the "4 houses" model: State – Scientists – Enterprises – Farmers, in order to create a synchronous technical, output and policy support mechanism.

** Group of solutions on mechanisms, policies and finance*

+ Integrate circular economy into green agriculture, OCOP and new rural development programs in the period 2025-2030.

+ Providing green credit and preferential loan packages for households and cooperatives applying circular economy, especially investing in biogas plants, composting systems and wastewater treatment equipment.

+ Promulgating tax support policies, certifying clean – organic – circular products, helping to improve commercial value.

+ Encourage enterprises to invest in waste treatment technology and bioenergy recycling, in order to form a closed value chain between animal husbandry – processing – consumption.

+ The commune governments need to coordinate with the Department of Agriculture and Rural Development and financial institutions in guiding procedures, connecting capital and transferring technology to farmers.

** Group of solutions on propaganda, training and public awareness raising*

+ Organize periodic circular economy technical training, guide households on how to design models of biological breeding, waste treatment and utilization of by-products.

+ Propagating through farmers' associations, youth unions, and agricultural extension on the benefits of circular economy for the environment and the economy of households.

+ Develop demonstration models and community learning points in some villages or

areas with high livestock density.

+ Encourage young people and women to participate in the green livestock model, thereby spreading sustainable production thinking.

+ Putting information technology content into short-term training programs and local media, in combination with universities and research institutes.

Table 4. Summary of solutions to develop the model of circular economy in pig breeding in Son Duong commune

Group of solutions	Focus content	Expected outcomes
Technical Insurance	Application of biogas, microbiological preparations, composting technology, VACB model	Reduce pollution by 30–40%, save costs by 10–15%
Production Organization	Formation of a circular livestock cooperative, a value chain linking "4 houses"	Increase scale and efficiency, reduce production risk
Financial Policy	Green credit support mechanism, OCOP, clean product certification	Attract investment, stabilize market outlets, and enhance product value.

(Source: Survey results in 2025)

4. Conclusions and recommendations

4.1. Conclusion

The study titled “Developing Circular Economy Models in Household-Based Pig Farming in Son Duong Commune, Tuyen Quang Province” assessed the current situation, conducted a SWOT analysis and proposed key solution groups to promote sustainable circular economy development. The research confirms that circular economy models in household pig production in Son Duong are highly feasible and generate significant economic, environmental and social benefits. During the period 2020–2024, the total pig herd increased steadily at 3.8% per year, with pork production reaching 2,850 tons. Approximately 45–50% of households have adopted circular economy practices such as biogas digesters, composting organic manure and implementing the VACB model.

Circular economy adoption has contributed to a 10–15% reduction in production costs, a 30–40% decrease in environmental pollution and improved household income. However, small-scale production, limited capital and insufficient technical capacity remain major constraints. To achieve sustainable circular economy development, comprehensive support in technology, finance and policies is required. In particular, the establishment of circular livestock cooperatives, strengthened “four-party linkage” (Government – Research Institutions – Enterprises – Farmers) and promotion of certification and branding for clean products should be prioritized. With its existing advantages, Son Duong has strong potential to become a model

locality for circular livestock production at the commune level in Tuyen Quang Province during 2025–2030.

4.2. Recommendations

To promote the development of the circular economy model in pig farming in Son Duong commune in particular and in similar localities in general, the research team proposes several specific recommendations as follows:

(1) For local authorities and Tuyen Quang Department of Agriculture and Environment:

+ Promulgate a separate action plan on agricultural market economy, integrated into the new advanced rural development program for the period 2025-2030.

+ Support preferential loans, green credit and technical guidance on biological waste treatment for livestock households and cooperatives.

+ Develop community-scale circular economy demonstration models in villages with high livestock density.

(2) For livestock households and cooperatives:

+ Actively associate in groups or cooperatives, share experiences and waste treatment equipment, and participate in the OCOP program to improve product value.

+ Strengthen the application of improved biogas, microbial organic composting technology, and closed VACB model to reduce costs and emissions.

+ Towards VietGAP certification and green livestock products, as the foundation for building the brand "Son Duong clean pork".

(3) For research institutions, universities and enterprises

+ Tan Trao University and research institutes need to continue supporting technical transfer, advising on circular economy planning, and evaluating the effectiveness of the actual model.

+ Enterprises processing food and organic fertilizers need to link the procurement of by-products and products from circular economy, forming a closed value chain from production to consumption.

(4) For green agricultural development programs and projects:

+ Integrate the circular economy model into the agricultural development project to respond to climate change and the new OCOP program.

+ Call for technical and financial support from international organizations (UNDP, FAO, JICA) to implement the pilot project on "Livestock circulation for emission reduction".

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