Research Overview of Rural Logistics Distribution System for Agricultural Products

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Abstract
The logistics distribution of agricultural products in rural areas plays a key role in ensuring economic continuity and community welfare. This system connects agricultural producers with local and global markets, ensuring that products remain fresh and of high quality. However, rural logistics faces unique challenges, such as limited infrastructure, long distances, and inadequate technology. Efficiency in this system not only increases farmers' income but also price stability and product availability in the market. This study explores various elements that affect the logistics distribution system in rural areas, including road infrastructure, storage facilities, transportation technology, and distribution mechanisms. This study uses a systematic literature review approach to analyze data related to this topic. The analyzed articles are limited to articles published in the period between 2013 and 2024. The focus areas of global and Indonesian show a difference in research focus, with global scholars placing more emphasis on technological innovation and management practices, while research in Indonesia is more focused on supply chain analysis and distribution strategies. The main challenges of rural logistics in Indonesia include poor road infrastructure, inadequate storage, and price inequality due to intermediaries. Recommended solutions include infrastructure upgrades, the adoption of modern technology, and innovative distribution models such as farmer cooperatives and digital platforms. Further research is needed to identify solutions that can be implemented in different local contexts. This research is expected to make a significant contribution to the development of a more efficient and effective rural logistics distribution system in Indonesia.
Keywords: rural logistics; distribution system; agricultural products; research overview

1. Introduction

The logistics distribution of agricultural products in rural areas is a vital component in ensuring economic survival and the welfare of rural communities. This distribution system plays a key role in connecting agricultural producers with markets, both local and global, and ensuring that agricultural products can be sold in fresh and quality conditions (S. Hadi et al., 2023). However, rural logistics is often faced with a variety of unique challenges, including

limited infrastructure, long distances between production centers and markets, and a lack of adequate technology to support distribution efficiency and effectiveness.

An efficient rural logistics distribution system not only increases farmers' income but also contributes to price stability and availability of agricultural products in the market(Song et al., 2019). In this context, it is important to understand the various elements that affect the logistics distribution system in rural areas(Mulyana, 2014). It includes an analysis of road infrastructure, storage facilities, transportation technology, and distribution mechanisms used. Road infrastructure, for example, largely determines the speed and cost of delivery. In many rural areas, poor road conditions can hinder transportation access, increase logistics costs, and damage the quality of agricultural products during travel.

Comparing Indonesia to other ASEAN nations, the country's LPI has generally been worse due to subpar infrastructure. As compared to other ASEAN nations like Singapore, Thailand, Malaysia, and Vietnam, Indonesia continues to do unsuccessfully in logistics. Keeping the balance of economic activities between areas is a challenge for the logistics sector due to the size of Indonesia's territory, which is made up of numerous islands divided by sea. There are numerous infrastructural constraints in certain Indonesian villages since they belong to a highly backward village group (T. S. Sinaga et al., 2022). To support the smooth running of rural logistics activities, the main requirement is the availability of adequate supporting infrastructure. Rural areas in Indonesia are not fully accessible from telecommunication and electricity networks and poor road conditions are the main factors affecting the performance of rural logistics in Indonesia. These things are the main challenges of the implementation of rural logistics in distributing agricultural products to cities.

Storage facilities are also a critical aspect of the agricultural product distribution system. Inadequate storage may lead to product losses due to spoilage or deterioration in quality(T. Sinaga, 2019). The use of modern storage technologies such as refrigerated warehouses and state-of-the-art packaging facilities can help reduce these losses and ensure that agricultural products remain in the best condition until they reach the market. In addition, proper transportation technology, including the use of vehicles specifically designed to transport fresh produce, can improve distribution efficiency and reduce delivery times.

The distribution mechanism also requires special attention. In many rural areas, distribution is often done by intermediaries which can lead to price disparities and reduce the profits that farmers earn (T. S. Sinaga et al., 2022). Innovations in distribution models, such as the establishment of farmer cooperatives and the use of digital platforms for direct sales, can help address this problem by giving farmers direct access to a wider and more profitable market(Hansen, 2019).

Research in this area has shown that the adoption of information and communication technology (ICT) can play an important role in improving the efficiency of rural logistics distribution systems(Ji & Huang, 2009; Xiao, 2022). The use of mobile apps, supply chain management systems, and e-commerce platforms can help farmers to track shipments, manage inventory, and access new markets(Song, 2019). In addition, the government and non-governmental institutions also have an important role in supporting infrastructure development and providing training and technical assistance to farmers.

Overall, research on logistics distribution systems for agricultural products in rural areas highlights the importance of a holistic approach involving infrastructure improvement,

technology adoption, and distribution model innovation. Thus, the development of an efficient and effective distribution system can be a key driver in improving farmers' welfare, reducing product losses, and ensuring the availability of high-quality agricultural products in the market (Tian et al., 2023). Further research is needed to identify solutions that can be implemented in various local contexts and to ensure that the benefits of an enhanced logistics distribution system can be felt by all stakeholders in the agricultural supply chain.

Based on the background and literature review that has been presented, this study aims to explore and analyze the rural logistics distribution system for agricultural products. To achieve this goal, three main research questions have been formulated. First, this study will identify the main topics discussed in the literature related to rural logistics distribution systems for agricultural products (RQ1). Second, the study will investigate the technologies and innovations that have been implemented in various countries, including Indonesia, to improve the agricultural logistics distribution system (RQ2). Finally, the study will formulate recommendations for future publication based on an analysis of identified research gaps and opportunities (RQ3). By answering these questions, this research is expected to make a significant contribution to the understanding and development of rural logistics distribution systems for agricultural products, as well as provide direction for further research in this field.

2. Literature Review

2.1 Rural Logistics

Rural Logistics refers to a series of processes that involve planning, implementing, and controlling the flow of agricultural products from the point of origin (field or livestock) to the final consumer(T. Sinaga, 2019). This definition includes all activities related to the transportation, storage, handling, and management of agricultural product inventories such as fruits, vegetables, grains, and animal products. The main goal of agricultural logistics is to ensure that products reach consumers in good condition, on time, and at an efficient cost. The scope of agricultural logistics is very broad and involves various important components. It includes post-harvest processes such as sorting and packing, transportation, storage in suitable conditions, distribution to local or international markets, as well as supply chain management which includes demand planning and inventory control(T. S. Sinaga, 2022). In addition, agricultural logistics also includes the use of technology to improve process efficiency and effectiveness, such as information technology-based supply chain management systems, the Internet of Things (IoT) for tracking, and big data for predictive analytics.

The importance of logistics in the context of agriculture cannot be underestimated. Efficient logistics help reduce post-harvest losses, which can account for 30-40% of total production in some developing countries (T. S. Sinaga & Bahagia, 2019). In addition, good logistics ensure that agricultural products can reach the market quickly, maintaining their freshness and quality, which in turn increases farmers' income and consumer satisfaction. By improving logistics efficiency, production and distribution costs can be reduced, making agricultural products more competitive in the market. Furthermore, well-organized logistics can support food security by ensuring an even and timely distribution of surplus production to areas in deficit.

2.2 Main Components of Rural Logistics

Rural logistics is a vital element in delivering products and services from remote villages to markets. Its effectiveness is key in encouraging rural communities access to a wider market, increasing their incomes, and fueling economic growth in rural areas(T. S. Sinaga, 2022). To achieve smooth operations and provide maximum benefits, rural logistics requires synergy from five main components.

Table 1. Key Component of Rural Logistics

Main Components	Description
Infrastructure	An adequate and well-maintained road network is the main foundation for the smooth movement of goods. Sturdy and secure bridges are also important for connecting remote areas and allowing access between islands or areas separated by rivers. Adequate storage warehouses designed to protect goods from damage and pests are important elements in maintaining product quality. Transportation facilities such as trucks, buses, and trains complete the infrastructure to transport goods and services from villages to markets.
Technology	An effective information system allows for tracking the movement of goods, monitoring inventory, and optimizing delivery routes. Communication technologies such as mobile phones and the internet open up better communication access between business actors in rural areas and markets. Storage technologies such as cooling and freezing help extend the shelf life of goods and minimize damage.
Human Capacity	Skilled labor is needed to operate the infrastructure, technology, and transportation systems used in rural logistics. Entrepreneurship is the key to developing a logistics business in rural areas and providing services needed by local business actors.
Institutional	Strong government institutions play a role in supporting the development of rural logistics and providing services needed by local business actors. Farmer organizations can assist farmers in accessing markets and getting better prices for their products.
Collaborate	Cooperation between business actors in rural areas allows for resource optimization and increased logistics efficiency. Cooperation with the public sector helps improve infrastructure, technology, and human capacity in rural logistics. Cooperation with international institutions opens access to funding and expertise for the development of rural logistics.

These five key components are intertwined and must work together effectively to ensure the smooth operation of rural logistics. Its success will benefit rural communities, encourage access to a wider market, increase income, and spark economic growth in rural areas. With

synergy and joint commitment, rural logistics can be a driving force for economic progress and community welfare in remote parts of the country.

3. Material and Method

The research uses a systematic literature review to collect and analyze relevant data. This literature research uses specific keywords to obtain articles that are close to the focus of the rural logistics research area. The keywords used include: "rural logistics", "distribution systems", and "agricultural product". Articles are collected using Publish and Perish software which is then analyzed from the original aspect of the journal. The results of this SLR analysis are then synthesized and presented as narratives or tables. A systematic literature review is a comprehensive and methodical approach to reviewing and synthesizing existing research on a topic, providing a solid foundation for advancing knowledge and informing decision-making in various fields(Petticrew & Roberts, 2008). This image outlines the key steps involved in conducting a systematic literature review (SLR). A systematic literature review is a rigorous and structured approach to reviewing and analyzing existing research literature on a specific topic or research question.

There are three stages in this process, including: 1) Planning, research literature, selection, evaluation of literature, data analysis, and identifying research findings. This stage involves defining the research question, developing a search strategy, selecting relevant studies based on predefined criteria, critically evaluating the studies, extracting, and analyzing data, and identifying key findings from the reviewed literature; 2) Synthesis of findings. This stage involves synthesizing and combining the findings from the individual studies included in the review. This may involve qualitative or quantitative methods, such as meta-analysis, to integrate and summarize the overall findings; 3) Discussion. The final stage involves discussing the implications of the synthesized findings, drawing conclusions, identifying limitations, and suggesting recommendations for future research or practice. After reviewing many scientific articles, the next step is to divide the focus of research areas carried out by Indonesian researchers with global researchers. The expected result is a clear research mapping in the rural logistics area so that further research can continue the research gap that will contribute to the development of rural logistics.

4. Results

Figure 1 is interesting because it provides insight into how big data and IoT are being used in various sectors related to agriculture, logistics, sustainability, policy analysis, and more, highlighting areas where these technologies are gaining traction or still have room for growth. This can be relevant for individuals or organizations involved in these sectors who are interested in understanding the latest trends and applications of big data and IoT technologies.

As such, this graph not only shows the level of technology adoption in different sectors but can also be used as a guide to identify opportunities and challenges in the future application of big data and IoT. This is important for strategic decision-making and policy development that supports innovation and efficiency in various areas.

Table 3. Results of Rural Logistics Research by Global Researchers

Focus Area Research	Source
Case studies of agricultural product logistics in specific regions	(Cai, 2016a; Fliehr, 2013; Fu et al., 2020; Gillette et al., 2024; X. Hu, 2021; Y. Hu, 2023; J. Li, 2023; M. Liu, 2015; Z. Qi et al., 2023; H. Shu et al., 2023a; Wendong, 2019; M. Zhao et al., 2019)
Location optimization for agricultural logistics facilities	(Do Amaral et al., 2012; Gao et al., 2019; Jabarzadeh et al., 2020; D. Li et al., 2020; Shi, 2013; T. Sinaga, 2019; Yamchi et al., 2020; Yu, 2016)
Consumer behavior and e-commerce	(B. Liu, 2023; Mir, 2014; Romero-Lopez et al., 2020)
Policy analysis	(Bate et al., 2019; Bian & Xu, 2023; Dai, 2023; D. He & Guan, 2023; Singh & Ru, 2023)
Efficiency measurement	(Qiao, 2022)
Optimization for agricultural product	(Mirabelli & Solina, 2022; D. Wu, 2022; Yamchi et al., 2020)
Food traceability in agricultural supply chains	(Maheshwari, 2022a)
Sustainability	(Brzozowska et al., 2016a; Su et al., 2023; C. Wang, 2014)
The impact of rural logistics	(Brzozowska et al., 2016b; Cai, 2016b; N. Li, 2023; Peng et al., 2014; Xu, 2013; Yan, 2020)
Cold chain logistics	(H. Li, 2014; X. Qi, 2024; J. Wu, 2024; X. Zhang, 2019; L. Zhao, 2022)
E-commerce logistics	(Fan & Sun, 2018; Z. He, 2021; K. Liu, 2021; Meng, 2020; H. Shu et al., 2023b; Sun, 2017; Tu et al., 2018; F. Wang, 2023; H. Wang, 2024; Zeng et al., 2022; X. Zhang, 2021; Y. Zhang, 2018)
Agricultural product logistics networks	(Jia, 2022; J. Shu, 2023; X. Wang, 2022; D. Wu, 2022; Xiang, 2022; Yang, 2022; Yaşlak, 2023)
Blockchain technology	(Maheshwari, 2022b; W. Wang, 2024; Ye, 2022; S. Zhang et al., 2020)
Logistics Distribution	(Chu, 2019; Gu, 2022; Ji & Huang, 2009; C. Li, 2023; Mustakim et al., 2022; Song, 2019; Zhou, 2011)
Big data and data mining	(Lei, 2023)
Use of the Internet of Things (IoT)	(Zhengjun, 2019)

Figure 2 shows various aspects of logistics that are the focus of researchers' research in Indonesia. The category with the longest bar is 'Food Security and Logistics Optimization' with a value of 6 articles, indicating that this topic is probably the most significant or most

common among those listed. Other categories have varying values, with some categories such as 'E-Commerce' and 'Green Logistics' having 2 articles each, and 'Collaborative Management' and 'Logistics Infrastructure Planning' having 4 articles published each.

These charts provide a visual representation of the various components related to logistics management and the emphasis or importance of each in each context. It can be used for analysis in business optimization, supply chain management studies, or presentations related to logistics efficiency strategies.

Figure 1. Focus Area of Rural Logistics Research (Global Scholars)

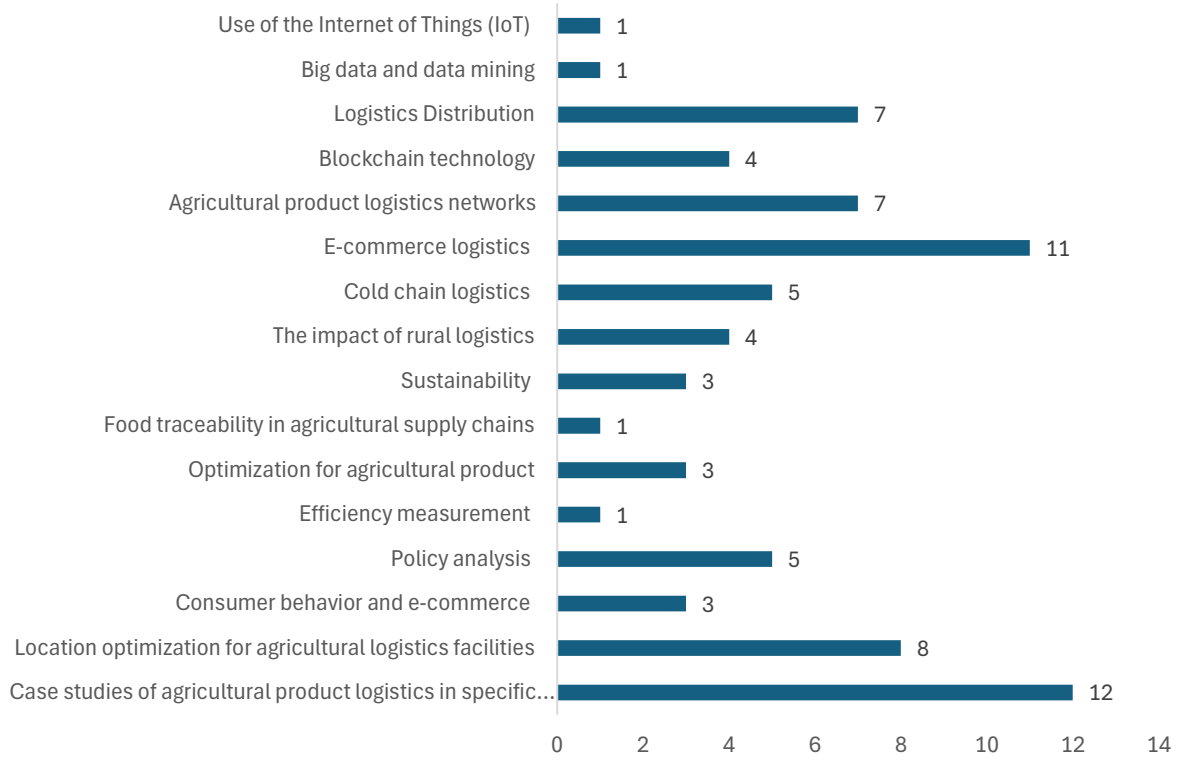

Figure 2. Focus Area of Rural Logistics Research (Indonesian Scholars)

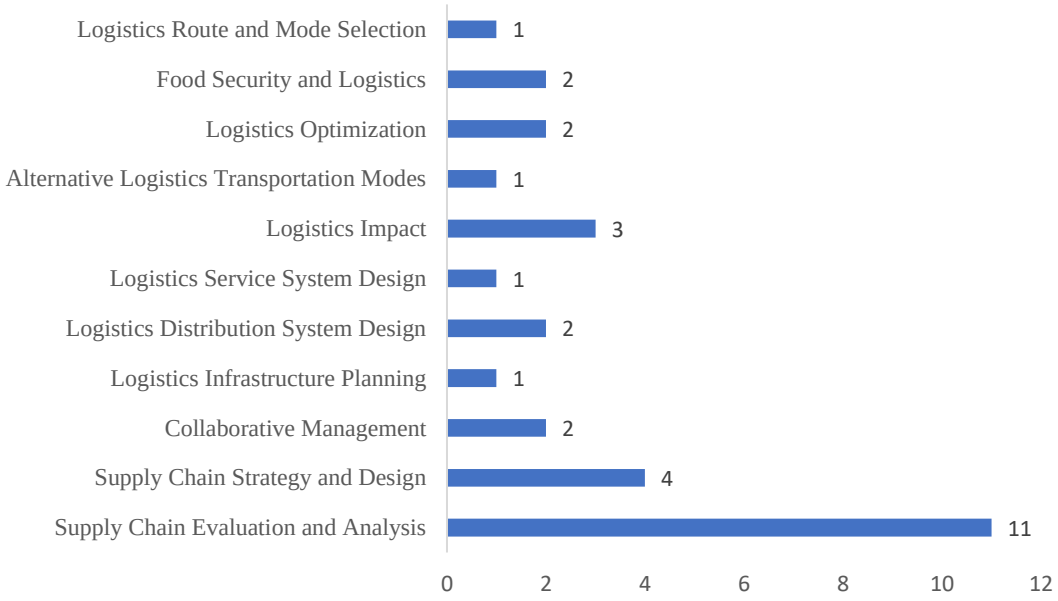

Table 3. Results of Rural Logistics Research by Indonesian Researchers

Focus Area Research	Source
Logistics Route and Mode Selection	(T. Sinaga, 2019; Widodo et al., 2021)
Food Security and Logistics	(Limenta & Chandra, 2017; Neilson & Arifin, 2013; Neilson & Wright, 2017; Rusmawati & Hartono, 2021; Setiartiti, 2021; Sujarwo, 2016)
Logistics Optimization	(E. Gunawan et al., 2019; Subiyanto, 2020)
Alternative Logistics Transport in Modes	(Matous et al., 2015)
Logistics Impact	(Amin et al., 2021; A. Hadi, 2018; Muslimin et al., 2015; Rahayu et al., 2021; Suwanda & Surjasa, 2018)
Logistics Service System Design	(Fizzanty, 2018; Shalannanda et al., 2020; Suryaningrat, 2016)
Logistics Distribution System Design	(Asmara & Ichtiarto, 2021; S. Hadi, Bahri, et al., 2023; T. S. Sinaga, 2022)
Logistics Infrastructure Planning	(A. Gunawan, 2020; Mulyana, 2014; Ralahalu & Jinca, 2013; Sandee, 2016)
Collaborative Management	(Hanafiah & Widjaja, 2017; Natawidjaja et al., 2014; Widadie et al., 2022; WULANDARI et al., 2020)
Green Logistics	(Engelage et al., 2017; S. Hadi, Miru, et al., 2023)
E-Commerce	(Bahtiar, 2020; Suroso et al., 2020)

To produce a clear picture of what areas have been focused on in the rural logistics sector, the author deliberately presents both images so that future researchers can easily identify what research topics have been carried out by global scholars and Indonesian scholars. The results presented in this article are expected to be a reference for further research on rural logistics in Indonesia. The study on the rural logistics sector is still very broad and is needed for the development and improvement of rural logistics performance in Indonesia. This study on the rural logistics sub-sector can produce solutions to improve Indonesia's logistics performance index (LPI) to be better in the future.

5. Discussion

Global Research Trends in Rural Logistics

Based on the results shown in Figure 1, global research in the field of agricultural product logistics shows several key trends that reflect technological developments and practical needs in logistics management. The most researched topic is decision-making tools for the logistics management of agricultural products. This shows the importance of developing a decision support system that can assist logistics managers in making more precise and efficient decisions. These decision-making tools can cover a variety of aspects, from route planning, and inventory management, to selecting the optimal transportation method. Cold chain logistics for fresh agricultural products took second place, emphasizing the need for special handling to maintain product quality. Research in this area focuses on the development of storage and transportation technologies that can maintain the required temperature throughout the supply chain.

In addition, e-commerce in agricultural product logistics is emerging as a significant area of research. The development of e-commerce has changed the distribution and sales patterns of agricultural products, providing an opportunity for farmers to reach a wider market without going through traditional intermediaries. Research in this area includes the development of digital platforms that facilitate direct transactions between farmers and consumers, as well as the optimization of distribution systems to accommodate the increasing demand from online channels. The use of the Internet of Things (IoT) in the logistics of agricultural products has also received attention, signaling the increasing adoption of digital technology in the sector. IoT allows for better monitoring and management of product conditions throughout the supply chain, such as temperature, humidity, and location, helping to ensure that product quality is maintained until it reaches consumers.

Supply chain optimization and sustainability in agricultural product logistics are also the focus of the research, with five studies. This shows that operational efficiency and the environmental impact of logistics activities are important concerns for researchers. Supply chain optimization aims to minimize costs and delivery times, while sustainability focuses on reducing carbon footprint and using more environmentally friendly resources.

Focus of Rural Logistics Research in Indonesia

In Figure 2, rural logistics research in Indonesia focuses more on supply chain analysis and evaluation, with Supply Chain Evaluation and Analysis dominating the research focus. This shows that a deep understanding of supply chain performance is a top priority for researchers in Indonesia. These evaluations and analyses include measuring efficiency,

identifying bottlenecks, and developing strategies to improve supply chain performance. Supply Chain Strategy and Design takes second place, reflecting the need to design an effective and efficient supply chain strategy. Research in this area involves the development of models and frameworks to support the planning and implementation of strategies that can improve the overall performance of rural distribution systems.

Several other categories such as Food Security and Logistics, Logistics Optimization, Distribution System Design, and Collaborative Management also received attention, albeit in a smaller number of studies. This shows that there are efforts to address specific issues such as food safety, logistics system optimization, efficient distribution system design, as well as collaborative management between various actors in the supply chain. Other categories such as Logistics Route and Mode Selection, Logistics Infrastructure, Service System Design, and Infrastructure Planning have a more limited number of studies. This suggests that this area is still under-researched and needs more attention in the future. For example, the selection of optimal routes and modes of transportation is essential to reduce delivery costs and times, especially in rural areas with limited infrastructure.

Future Research

Rural logistics research at the global level and in Indonesia has a different but complementary focus. At the global level, technological innovation and management practices are the focus, while in Indonesia, supply chain analysis evaluation and distribution strategy development are priorities. To address the challenges faced in rural logistics in Indonesia, collaboration between the government, the private sector, and academia is needed to develop comprehensive and sustainable solutions. Investments in infrastructure, adoption of digital technologies, and managerial capacity building at the local level are important steps that need to be taken. From the results obtained, some research areas in rural logistics require further research which can be seen in Figure 3.

Selecting the optimal route and mode of transportation is very important to reduce shipping costs and time. Further research can focus on developing algorithms and models for route optimization as well as evaluation of the most efficient modes of transportation in rural areas. Further research is needed to explore the need for proper logistics infrastructure, such as storage facilities, transportation networks, and other supporting technologies that can improve distribution efficiency.

The design of logistics service systems requires more research to develop better and more efficient services for farmers and business actors in rural areas. This could include developing a service platform that integrates various aspects of logistics, from ordering to delivery. Infrastructure logistics planning needs more studies to ensure that infrastructure development is carried out considering the specific needs of rural areas, including needs analysis and long-term planning.

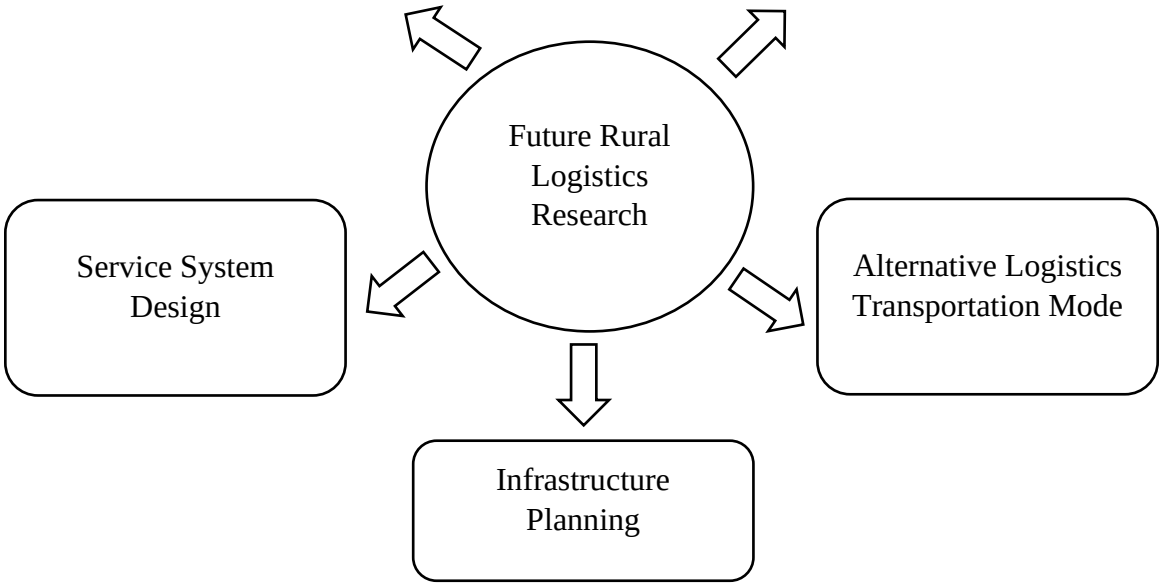

Figure 3. Scope Area for Future Research

The category of alternative logistics transportation mode has not been the focus of research. Researching alternative modes of transportation such as electric vehicles, drones, or small trains can offer innovative solutions to address logistical challenges in hard-to-reach rural areas. Further research is also needed to explore other innovative solutions that can be applied in various rural contexts in Indonesia. Thus, efforts to improve rural logistics performance can significantly contribute to improving Indonesia's overall logistics performance index.

6. Conclusion, Implication, and Recommendation

This study concludes that agricultural product logistics in Indonesia is a dynamic and growing field, presenting various challenges and opportunities for improving logistics operations in rural areas. The adoption of the latest technologies such as the Internet of Things (IoT), big data, artificial intelligence (AI), and blockchain has great potential to improve the efficiency, transparency, and overall effectiveness of agricultural product logistics. These technologies enable better tracking, optimization, automation, and data-driven decision-making throughout the supply chain. Researchers are actively exploring ways to utilize this technology, drive efficiency improvements, and ensure sustainability throughout the agricultural supply chain in Indonesia. This research effort aims to identify and implement technological and operational solutions to overcome the obstacles faced in rural logistics.

The implications of these findings are widespread. First, the government and industry stakeholders must focus on developing technological infrastructure in rural areas. Investing in advanced technology can provide long-term benefits in the form of improved logistics efficiency and reduced product losses. Second, training and education for farmers and industry players on the use of this technology is essential to ensure effective adoption.

The recommendations resulting from this study include several key steps. First, collaboration between the government, the private sector, and educational institutions is needed to create a comprehensive training program on modern logistics technology. Second, policies that support the development and application of technology in the agricultural sector should be

prioritized, including incentives for technology investment and further research. Third, the establishment of a rural logistics innovation center can be a platform to test and develop technological solutions that are suitable for local conditions.

Overall, although agricultural logistics in rural Indonesia is a complex and dynamic field, the integration of disruptive technologies accompanied by focused research efforts can pave the way for the development of a stronger, transparent, and sustainable distribution system for agricultural commodities from the field to the market and consumers. A technology-driven and research-backed approach is considered crucial to improving logistics performance in the sector, and the implications and recommendations outlined can guide achieving those goals.

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