

Multimodal Freight Transport and Urban Rural Connectivity in Emerging Economic Regions of Indonesia

Nurullah Budisiswanto¹

¹University Swadaya Gunung Jati Cirebon, Indonesia

Email: budisiswanto@ugj.ac.id

Abstract. *This study examines how multimodal freight transport can improve urban and rural connectivity and promote balanced regional development in the Ciayumajakuning region of West Java, Indonesia, comprising Cirebon, Indramayu, Majalengka, and Kuningan. Although the region has strong industrial and agricultural potential, fragmented logistics systems and poor transport integration continue to constrain economic growth. A qualitative descriptive approach was employed, combining spatial and temporal analysis using secondary data from regional planning documents, national logistics statistics, GIS mapping, and stakeholder interviews. The study evaluated transport development from 2010 to 2025, compared district performance, and identified infrastructure gaps affecting regional economic integration. The findings indicate that road infrastructure has received the largest investment, improving connectivity in urban areas such as Cirebon. However, rural districts, particularly Indramayu and Kuningan, continue to experience inadequate transport infrastructure and weak integration between road, rail, and maritime networks. Limited port capacity, insufficient rail connections, and heavy dependence on road transport increase logistics costs and reduce efficiency. The results demonstrate that stronger multimodal connectivity enhances market access, reduces transportation costs, and accelerates freight movement between urban and rural areas. The study recommends developing integrated logistics hubs, expanding rail and port infrastructure, strengthening public private partnerships, and improving coordination between national and regional transport policies. These strategies can support more inclusive regional development and provide a practical model for sustainable logistics integration in emerging economic regions of Indonesia.*

Keywords: Multimodal Transport; Urban–Rural Connectivity; Regional Development; Logistics Infrastructure; Ciayumajakuning, Indonesia

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INTRODUCTION

An efficient and integrated freight transport system is a fundamental component of regional economic development. Transport infrastructure facilitates the movement of commodities, connects production centres with markets, reduces spatial barriers, and supports interactions between urban and rural economies. In rapidly developing regions, the quality of freight connectivity is particularly important because economic expansion often generates increasingly complex movements of agricultural products, industrial goods, and commercial inputs. Consequently, inadequate transportation integration can restrict market accessibility, increase distribution costs, and intensify development disparities between urban centres and their

surrounding rural areas (Cervero, 2013; Pucher et al., 2007; Rode et al., 2017; Vinod Kumar & Dahiya, 2016).

This issue is particularly relevant to the Ciayumajakuning region of West Java, which comprises Cirebon, Indramayu, Majalengka, and Kuningan. The region occupies a strategic position within the broader transportation and economic network of Java and is characterised by diverse economic activities, including agriculture, manufacturing, trade, and logistics-related services. Its proximity to major road, railway, and maritime corridors provides considerable potential for the development of an integrated regional logistics system. Moreover, the interaction between Cirebon as an urban and commercial centre and the surrounding districts reflects an emerging pattern of metropolitan and hinterland integration (Januar, 2023; Ruswandi, 2013). Nevertheless, the economic potential of the region has not been fully supported by an equally integrated freight transportation network.

Freight movement in Ciayumajakuning remains predominantly dependent on road transportation, while the operational integration of road, railway, and maritime infrastructure is still limited. Transport facilities frequently function as separate systems rather than as components of a coordinated logistics network. Weak intermodal connections, insufficient freight terminals, limited port capacity, and inadequate access from rural production areas to major transport corridors may increase travel time and logistics costs. These conditions can particularly disadvantage agricultural producers, small and medium-sized enterprises, and manufacturing activities located outside the principal urban centres. Previous studies have demonstrated that fragmented logistics systems can reduce the competitiveness of regional industries and restrict the participation of rural producers in broader supply chains (Berti & Mulligan, 2016; Mittal et al., 2018; Monios & Bergqvist, 2017; Reardon et al., 2012).

Multimodal freight transport offers a potential approach to addressing these limitations by coordinating two or more transport modes within a unified movement and logistics system. Effective multimodal integration can facilitate the transfer of goods between road, rail, and maritime networks, thereby reducing unnecessary delays, improving transport reliability, and optimising the use of existing infrastructure. It can also decrease excessive reliance on road freight and improve connections between rural production areas, urban distribution centres, ports, and national markets. However, the effectiveness of multimodal transportation depends not only on physical infrastructure but also on institutional coordination, integrated planning, operational interoperability, investment capacity, and supportive regulatory frameworks (Chen et al., 2019; Karam et al., 2023; Pencheva et al., 2022; Taran et al., 2024; Wibowo & Chairuddin, 2017).

Existing studies have discussed multimodal transportation, logistics efficiency, and infrastructure connectivity in Indonesia, particularly at the national level or across Java Island (Nugraha & Santoso, 2025; Sandee, 2016; Syaban et al., 2023). Nevertheless, limited attention has been given to the spatial and temporal development of multimodal freight infrastructure at the subregional level. In particular, there remains insufficient empirical understanding of how transport infrastructure development has evolved across the four districts and cities of Ciayumajakuning, how access differs between urban and rural areas, and how infrastructure, institutional, and economic factors influence multimodal integration. A district-level analysis is therefore necessary because aggregate assessments may conceal significant disparities in infrastructure provision, logistics accessibility, and regional development outcomes.

Accordingly, this study examines the development and current condition of multimodal freight transport in the Ciayumajakuning region from 2010 to 2025. It analyses the spatial distribution and temporal development of road, railway, and maritime infrastructure; compares transport accessibility and logistics conditions across Cirebon, Indramayu, Majalengka, and Kuningan; and identifies the infrastructure, institutional, and economic constraints affecting multimodal integration. The study also evaluates the implications of multimodal freight

connectivity for urban–rural relationships and regional economic development. By providing a spatially grounded and region-specific assessment, this research is expected to contribute to the formulation of more coordinated, inclusive, and sustainable freight transport policies for emerging economic regions in Indonesia.

METHODS

Research Design and Study Area

This study employed a qualitative descriptive design supported by spatial-temporal, comparative, and descriptive statistical analyses. The design was selected to examine the development, distribution, and integration of multimodal freight transport infrastructure and its implications for urban–rural connectivity. The analysis focused on the Ciayumajakuning region of West Java, Indonesia, comprising Cirebon, Indramayu, Majalengka, and Kuningan. These areas were examined as an interconnected economic region characterised by urban commercial centres, industrial activities, agricultural production areas, and major road, railway, and maritime transport networks.

The study covered the period from 2010 to 2025. This period was selected to capture changes in regional transport infrastructure, investment priorities, freight movement, and accessibility over approximately 15 years. The analysis considered road, railway, and maritime transport because these modes constitute the principal components of the regional freight system. Air freight was not included because the study primarily examined the movement of regional agricultural, industrial, and commercial goods through land and maritime networks.

Data Sources and Collection

The study used both secondary data and qualitative information obtained from relevant stakeholders. Secondary data were collected from national and regional statistical publications, transportation planning documents, regional development plans, logistics reports, and infrastructure-development documents issued between 2010 and 2025. The principal sources included publications from Statistics Indonesia and its regional offices, national and regional transport authorities, local development-planning agencies, and other institutions responsible for road, railway, port, and logistics infrastructure.

The documentary data covered the availability and development of transport infrastructure, infrastructure investment, freight movement, logistics costs, travel time, transport accessibility, and relevant regional economic activities. Documents were reviewed and organised according to year, administrative area, transport mode, and type of infrastructure to facilitate temporal and interregional comparisons.

Spatial data were obtained from available Geographic Information System datasets. The spatial layers included major roads, toll roads, railway lines, ports, transport terminals, urban centres, rural production areas, industrial locations, and other relevant economic activity centres. These datasets were used to map the distribution of transport infrastructure and identify the spatial relationships between freight networks, production areas, and regional markets.

Qualitative information was also obtained through semi-structured interviews and stakeholder discussions. Participants represented relevant groups involved in regional transportation and logistics, including local government officials, logistics operators, and transport planners. Participants were selected purposively based on their professional responsibilities, experience, and knowledge of transportation development in Ciayumajakuning. The interviews explored infrastructure conditions, intermodal connectivity, institutional coordination, investment priorities, operational constraints, urban–rural accessibility, and opportunities for developing a more integrated regional logistics system.

The authors should insert the total number of participants, the interview period, the duration of each interview, and the procedures used to obtain informed consent in the final manuscript.

Data Analysis

Data analysis was conducted in four stages. First, a temporal analysis was performed to identify changes in transport infrastructure and logistics development between 2010 and 2025. This analysis examined the expansion or improvement of road, railway, port, and supporting logistics infrastructure, as well as changes in investment patterns and freight activity over time.

Second, spatial analysis was conducted using GIS mapping and spatial overlay techniques. Transport-network layers were combined with data on industrial areas, agricultural production centres, urban settlements, and other economic activity locations. This procedure was used to assess the spatial distribution of transport infrastructure, identify areas with limited accessibility, and examine the extent to which road, railway, and maritime networks were physically connected.

Third, a comparative analysis was undertaken across Cirebon, Indramayu, Majalengka, and Kuningan. The comparison focused on infrastructure availability, access to major transport corridors, multimodal connectivity, logistics efficiency, and the relationship between transport accessibility and regional economic activities. This analysis was intended to identify geographical disparities, infrastructure gaps, and districts requiring specific policy intervention.

Fourth, simple descriptive statistical summaries were used where numerical data were available. The indicators included logistics costs, travel time, freight volume, infrastructure investment, and other transport-performance measures reported in the secondary sources. These statistics were used to describe patterns and differences rather than to test causal relationships or statistical hypotheses.

The interview data were reviewed and grouped into recurring themes concerning infrastructure limitations, modal integration, institutional coordination, financial constraints, and urban–rural connectivity. The qualitative findings were then compared with the documentary, statistical, and spatial results. Information from different sources was cross-checked to identify consistent findings, explain geographical differences, and strengthen the interpretation of transport-development patterns in the Ciayumajakuning region.

RESULTS AND DISCUSSION

Overview of Multimodal Transport System in Ciayumajakuning

Ciayumajakuning area that include Cirebon, Indramayu, Majalengka, and Kuningan is known as growing economy zone in West Java, Indonesia. This area have good location and have many transport like road, train, and port, so have big potential for logistics and industry center. But even have this facility, multimodal transport in this area still not connected well. Different transport mostly work alone and not much coordination, so make logistics not efficient, cost become higher, and service not always reliable.

Space and time analysis of infrastructure from 2010 until 2025 show some important finding. First, road network in Ciayumajakuning already quite good and become main way for goods movement in region. But, traffic jam especially in city like Cirebon make it not efficient. Even there is new investment to make main road bigger, especially road connect Majalengka and industry area in north corridor, still many village area not connected well, so hard to reach market and economy chance.

Second, this region have wide railway infrastructure, but use for goods transport still not optimal. Connection to big economy city like Jakarta and Bandung already exist but not use much because rail system is old, intermodal terminal not enough, and logistics planning not well coordinated. The Trans-Java Railway Project that still develop expected to improve regional

connection, but the benefit only can fully get if also supported by effort to modernize and connect freight rail into wider logistics system.

Third, Cirebon Port act as main sea gateway for region, and play important role to support trade between island and along coast. But, its operation capacity limited because docking facility not enough and connection with land transport also weak. No smooth link between port and road-rail network make cargo movement from port to inland become slow, so supply chain delay and logistics cost become higher.

Several previous studies support the notion that the Ciayumajakuning area (covering Cirebon, Indramayu, Majalengka, and Kuningan) has significant economic potential and regional interaction as a growing economic zone. For example, research on movement patterns in the Greater Cirebon Metropolitan Area indicates strong economic agglomeration and interactions between the core city and its hinterlands, reflecting the dynamic growth of the Ciayumajakuning region (Januar, 2023). Additionally, studies in the West Java Regional Spatial Planning highlight Ciayumajakuning as a priority development area with key commodities that should be focused on to enhance regional competitiveness (Ruswandi, 2013; Iswandi et al., 2026). Other research has concluded that implementing multimodal transportation in Java, including the integration of land, sea, and rail modes, can improve logistics efficiency and reduce operational costs, which is highly relevant to the transportation integration needs in Ciayumajakuning (Nugraha & Santoso, 2025).

This finding show that there is urgent need for more integrated multimodal logistics strategy that use strength from each transport mode together. To fix infrastructure gap, improve connection between modes, and make institution work together will be key to unlock full economic potential of the region. With right policy action and strategic investment, Ciayumajakuning can become example of good regional logistics integration and give big contribution to Indonesia wider economic development goal.

Spatial-Temporal Analysis of Transport Development

Space and time analysis of Ciayumajakuning transport infrastructure show big progress, especially in road network expansion in last ten year. Investment in main road and toll road help improve movement between city and industrial area (Temjanovski et al., 2016; Andani et al., 2019; Nguyen et al., 2017). But this progress not same in all place, and show gap in transport access across region. Urban area, especially Cirebon city, get most benefit with fast infrastructure growth that improve access to regional and national economic route. In contrast, rural area like Indramayu and Kuningan still face lack of infrastructure, with limited access to transport that efficient and reliable. This growth that focus on city make imbalance between region and limit economic potential in outer area.

One big problem is lack of multimodal integration. Even Ciayumajakuning have strategic location near national road and rail corridor, this region still not have enough integrated logistics hub to support smooth transfer between transport mode. Some intermodal terminal exist, but their operation still separate, not well coordinated, and often not have enough infrastructure to support efficient goods move across modes (Karam et al., 2023; Pencheva et al., 2022; Šakalys & Batarlienė, 2017). This cause logistics not efficient, distribution cost become higher, and make local industry less competitive, especially for area outside main city zone.

Time trend in infrastructure investment also show imbalance. From 2010 to 2025, most funding go to road expansion project, while rail and port get only small improvement. Government Tol Laut program try to improve sea connection across island, but its effect in Ciayumajakuning still limited. Problem like port bottleneck and freight rail not used much still make multimodal transport not work well (Abu-Aisha et al., 2024; Ambra et al., 2019; Dua & Sinha, 2019; Islam, 2014). If development not done together for all mode land, rail, and sea, region

can become separated transport system that reduce long term logistics efficiency and regional connection.

Several previous studies reinforce the importance of analyzing transport infrastructure development and multimodal integration in regions similar to Ciayumajakuning. Research on multimodal transportation implementation on Java Island highlights that multimodal systems are essential to enhancing logistics efficiency and lowering distribution costs, but infrastructure investment and stakeholder coordination remain critical challenges for achieving these benefits (Syaban et al., 2023). Other studies examining multimodal freight terminal needs in Indonesia argue that establishing integrated intermodal facilities especially freight rail terminals is key to connecting transport modes and supporting future logistics demands, aligning with national logistics system goal (Syaban et al., 2023; Afiatno et al., 2025; Halim, 2023; Judijanto et al., 2024; Sandee, 2016; Kurniawan, 2024; Cupiadi & Siswanti, 2025) Putri et al., 2024). In addition, research on multimodal transport systems in Indonesia shows that a well-designed multimodal network can significantly improve logistics performance by optimizing the use of different transport modes, provided that planning and investment are coordinated across levels of government and sectors. These findings corroborate the observed infrastructure imbalances in Ciayumajakuning and emphasize the need for strategic multimodal integration to fully capture the region's economic potential (Wibowo & Chairuddin, 2017).

These finding show urgent need for more balance and coordinated infrastructure investment strategy. Giving priority to multimodal integration by build logistics hub, digital coordination system, and stronger cooperation between agencies will be very important to change Ciayumajakuning into region that strong, resilient, and include all economy growth.

Implications for Urban-Rural Connectivity

The finding of this study show strong and direct relation between multimodal transport development and better connection between city and village in Ciayumajakuning region. Better integration across transport mode can change spatial economy by reduce gap between main urban area and outer rural area. One big impact is better market access. With better connection, rural producer especially in area like Kuningan and Indramayu can send goods more easy to city market. This not only reduce transaction cost but also make rural product more competitive in wider regional and national supply chain.

Moreover, multimodal system that work well can increase logistics efficiency a lot. For industry that need big volume and fast delivery like agriculture and manufacturing, connect road, rail, and sea transport in smooth way can reduce time travel and cost. This make logistics system more strong and able to support economy activity in many sector. Because of this, regional development become more clear. Multimodal connection act like trigger for grow industrial cluster, better trade flow, and more active business environment. This development help create inclusive and sustainable economic growth across Ciayumajakuning region. However, to get this benefit still depend on solve some ongoing problem. Even there is many investment in transport infrastructure, still have big gap especially in connection between rail and port system. This limitation make multimodal logistics not work well, especially to support direct link between rural production area and urban market.

Coordination between institutions still be big problem. Good multimodal transport need all government, private companies, and local people work together smooth. In Ciayumajakuning, many job overlap and governance split make things slow, waste time, and planning no together. If institutions no match, trying connect transport types maybe just stay separate and not work well. Also, money problem is big trouble. Making new multimodal logistics need lot money. But in place like Ciayumajakuning, government and private people not put much money. This no money make infrastructure no modern and slow to use new logistics technology together. To really use big change from multimodal transport, must fix all system problem with policy work

together, rule change, and smart money planning. Doing this can make Ciayumajakuning become example for connect region and fair economic grow in Indonesia.

Several earlier studies corroborate the strong link between multimodal transport systems and improved connectivity and economic outcomes across regions. Research on multimodal transportation implementation in Java highlights that integrating land, sea, and rail modes can enhance logistics efficiency, accelerate goods distribution, and reduce operational costs, contributing to regional economic growth by improving access to remote or underconnected areas. This supports the idea that multimodal integration can reduce urban–rural disparities and strengthen rural producers’ access to larger markets (Zhao et al., 2025). Empirical studies in Indonesia also demonstrate that multimodal transport systems significantly improve logistics cost efficiency and connectivity, especially when stakeholders coordinate infrastructure and operations across different modes (Kurniawan, 2024). Additionally, policy-oriented research on national logistics systems emphasizes that integrating multimodal transportation into planning is crucial for lowering systemic logistic costs and enhancing competitiveness, providing a basis for the broader economic benefits observed in your study (Kurniawan, 2022).

Policy Recommendations

From this study, some policy idea given to fix logistics problem and make multimodal transport work good in Ciayumajakuning. The idea try make connection better, stop waste time, and help all region grow together with one logistics plan.

First, make integrated logistics hub need do first. Hub is place where road, rail, and sea meet easy. Connecting transport this way can make less wait time, stop traffic jam at important point, and make freight move faster. This very important for spread-out place like Ciayumajakuning, because transport connect no smooth now and block supply chain.

Second, make public-private partnership strong very important. Big money need for infrastructure, government money alone no enough. Make private company join with good PPP can bring more money, smart know-how, and make project faster. Give clear reward like tax cut, land use allow, and share risk to make investors like multimodal logistics. Working together this way is key to make transport strong and can make money.

Third, fix infrastructure important fast, especially rail and port. Road get better, but rail and sea no get enough money, so multimodal logistics still slow. Upgrade railway that link industrial area to port, and make port modern to carry more cargo, very needed for supply chain go smooth. This not only make connection better, also help environment because less road freight.

Lastly, need policy work together more to make national and regional transport plan same. Now, planning split in government, so infrastructure project no match and rules not same. If national, regional, and private logistics work together, money for infrastructure go smart, help everyone, and match long-term goal. This very important to fix gap in access and make city and village grow same.

Several studies in transportation and logistics policy provide evidence that the types of policy ideas proposed in this research are effective for strengthening multimodal systems and reducing transport gaps. For example, research on strategic multimodal freight transport planning highlights that integrated planning models can optimize infrastructure investment and reduce total distribution costs, even under limited budgets, by coordinating road, rail, and other transport modes rather than developing them in isolation. Such integrated strategic planning directly supports the need for connected logistics hubs and coordinated investment in Ciayumajakuning’s multimodal network. Other studies on multimodal logistics institutions in Indonesia emphasize the importance of strong governance and policy coordination across agencies to harmonize infrastructure development and operational management, aligning well with recommendations to enhance institutional cooperation and planning alignment (Budiswanto, 2023). Moreover, reviews of transportation mode integration show how

collaborative systems and digital platforms can help bridge regional disparities and improve overall logistics efficiency a finding that supports the call for digital coordination systems and stakeholder partnerships in the region (Munawar, 2023; Moazzeni & Sgarbossa, 2026; Qamar & Khan, 2024; Barykin et al., 2021).

Establishing integrated logistics hubs, strengthening public-private partnerships, upgrading rail and port infrastructure, and aligning national and regional transport plans are critical steps to improve connectivity, reduce inefficiencies, and support inclusive economic growth. Evidence from previous studies reinforces that integrated planning, strong governance, and collaborative digital systems significantly enhance multimodal transport performance, reduce distribution costs, and bridge urban-rural disparities. By implementing these policies, Ciayumajakuning can transform into a resilient and efficient logistics hub, unlocking the full economic potential of both urban and rural areas in the region.

CONCLUSION

In the end, make multimodal transport in Ciayumajakuning can change much and make city and village connect better and economy grow faster. Ciayumajakuning in West Java still new economic place, and can get big help if all transport like road, rail, and sea join together in one system. But just build infrastructure not enough; need fix problem with institutions not work together, make connection gap smaller, and put money fair to all transport type. Follow policy ideas in this study with data is very important for long time success. Good example is Cirebon, coast city in Ciayumajakuning. On north coast road (Pantura), Cirebon have toll road, working port, and railway line. This make Cirebon good for logistics hub, connect inland places like Kuningan, Majalengka, Indramayu to national and world market. Local government with private people try make this better with dry port and better port-to-rail connection. Even with all effort, transport in Cirebon still no work together good. Roads, ports, and rail have limit, and schedule not match, so freight move slow. Local Transportation office say cargo through Cirebon Port grow 25% in five year, show need better logistics. But rail only move 15% of cargo, show problem in transport mix and need multimodal work stronger. This show bigger problem for all Ciayumajakuning. Road get much better, toll road expand, but rail and port still behind. So infrastructure no match and multimodal transport no work full. Also, city and village not same access. Cirebon and other city well connected, but rural place like Indramayu and Kuningan still hard reach, so they not join supply chain and economy like city.

SUGGESTION

Looking at last ten year, show need better plan for balanced and future growth. Money go much to roads, but sea and rail still no get same attention. If this not fix, Ciayumajakuning logistics stay split, make less competitive and hard for all region grow together. So, next step not just build roads and ports, also fix institutions, make government office work together, and put money smart. If do all this, Ciayumajakuning can use location and transport well, become big regional hub, help everyone have chance, link city and village, and help Indonesia grow. Study show important make city and village connect with multimodal transport. Better connection can cut logistics cost, make rural people sell easier, and help region grow with more trade, investment, and industry. This very needed for new economic place like Ciayumajakuning, because transport problem now stop region connect well. To fix problem in making multimodal transport work and make region connect better and economy grow, this study give some policy idea. Idea try make logistics work together, bring more money, and make all important people work with each other in national and regional level. First, build multimodal logistics hub must do first. Hub is important place where road, rail, and sea meet easy in one system. Put logistics together in hub make cargo move faster, stop traffic jam, and make freight go smooth. For place like Ciayumajakuning with spread-out factories and more trade, hub can change supply chain and make transport same everywhere. Second, make Public Private Partnership (PPP) strong very needed to bring money and know-how for transport. Big money needed for multimodal, government alone not enough.

If make rule clear, give reward for investors, and make buying process open, private company want join. Good PPP can build dry port, intermodal terminal, digital logistics, and keep transport run efficient long time. Third, must make rail and port upgrade top priority. Road get much money in last years, but rail and port still behind, so multimodal transport no work best. Better rail connection, especially from inland factories to coast, can make less road use, help environment, and make region supply chain stronger. Also, make port bigger and connect with other transport easier so cargo move smooth and reach market in country and abroad. Lastly, policy need work together better to make transport plan same in all government level. Now, transport rule split, so money and project not match and some work double. Make policy link national plan and region plan will help logistics system run one way. All ministry, local government, and private company must work together, so multimodal system not just work right, but help people and region fair. All these ideas try make multimodal transport strong, fast, and help all people, so economy grow and city-village connect better in new economic region like Ciayumajakuning.

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