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The Role of Information Technology in the Development of an Integrated Land Multimodal Transportation System

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Abstract: Transportation in Indonesia faces challenges of congestion, high costs, and uneven infrastructure. Information technology is essential for developing an integrated multimodal land transportation system to improve efficiency, transparency, and data management. A systematic literature review (2010-2025) shows that IoT, GPS, ITS, real-time tracking, EDI, Big Data, and AI improve operational performance. Case studies reveal the great potential of IT, despite infrastructure, human resources, and interoperability constraints. Regulations support digitization, but more coordination and investment is needed. Recommendations include infrastructure improvement, human resource development, standardization, and collaboration among stakeholders for an efficient and sustainable transportation system. Optimal implementation of information technology will be key to the success of national transportation transformation.

Keyword: Technology, Logistics, Transportation, Land Multimodal, Transportation System

INTRODUCTION

Transportation is critical to Indonesia's economy and social connectivity. For stable economic growth, smooth logistics distribution, and increased population mobility, efficient movement of goods and people is required. However, Indonesia's transportation system, which consists of many islands, faces many problems. These problems include severe traffic congestion in cities (Appliansyach et al. 2024). Public transportation in Indonesia is still poor. While there are various types of public transportation, such as buses, trains, and city shuttles, many of them are not well integrated, making it difficult for people to use them effectively. In addition, public vehicles often do not operate on schedule, and their physical condition does not meet comfort and safety standards. (Appliansyach et al. 2024) The lack of integration between different modes of transportation is also a major problem. In Indonesia, the logistics sector accounts for 23.5% of GDP. This is much larger than the figure in neighboring countries such as Malaysia, which only accounts for about 13% of GDP. (Haris et al. 2022).

This comparison shows significant inefficiencies in Indonesia's supply chain and transportation system. These high logistics costs are not just a macroeconomic issue, but a reflection of various inefficiencies at the operational level, such as overlapping procedures,

lack of transparency, and inadequate infrastructure. These inefficiencies can be fundamentally addressed through the utilization of information technology (IT). IT can optimize shipping routes, reduce waiting time at terminals, and simplify repetitive administrative procedures, thereby directly reducing operational costs and increasing national economic competition. Therefore, IT is no longer just a supporting tool, but has evolved into a strategic solution to improve efficiency and transparency in the supply chain.

In the face of these challenges, the concept of an integrated land multimodal transportation system is highly relevant. This system involves the use of more than one mode of transportation (e.g. trucks, trains) working together under one management system to efficiently move goods or passengers from the point of origin to the point of destination. However, the successful implementation of integrated multimodal systems relies heavily on information technology capabilities (Kerja 2020). IT has transformative potential as a capitalist to address existing problems and realize a smarter, more efficient, and integrated transportation system. By leveraging IT, the transportation system can achieve improved operational efficiency, transparency, quality of service, and ultimately, drive inclusive and sustainable economic growth in Indonesia. Information Technology (IT) has undergone a significant evolution, from a mere support tool to a strategic core in various sectors, including transportation and logistics. A comprehensive understanding of IT is essential to appreciate its role in the development of an integrated land multimodal transportation system. Basically, Information Technology (IT) can be defined as a collection of tools that make it easier for people or institutions to manage information and complete work related to data management. Lucas (2000) expands the definition of IT as all forms of technology that enable the electronic transmission of information. Over time, the scope of IT has expanded. Williams (2005) defines IT as anything that supports the recording, storage, processing, retrieval, transmission, and reception of information. A more comprehensive definition comes from the Information Technology Association of America (ITAA) (Syafnidawaty 2021), which defines IT as the study of the design, development, implementation, and management of computer-based information systems, especially software and hardware applications. The rapid development of IT. especially in the field of computer-based information, has changed the way organizations operate and interact.

An integrated multimodal transportation system requires more than just individual tools; it requires a system that is designed, developed, implemented, and managed holistically. This includes complex data integration, seamless communication between modes, and real-time decision-making capabilities. Thus, the evolution of the definition of IT reflects its increasing complexity and strategic role. In integrated multimodal transportation, IT serves as the core architecture that enables interconnection, coordination, and optimization across modes and functions. The successful integration of transportation systems relies heavily on sophisticated and well-managed IT capabilities, not just the adoption of individual technologies.

In general, the main elements of information technology consist of software, hardware, data, communication networks, people, and processes. This is especially true in the rapidly evolving field of computer-based IT, which has changed the way organizations function and interact with each other. In the world of business and logistics, information technology has transformed from a mere support tool to a key driver for innovation and efficiency. Information technology enables automation of manual tasks, inventory management directly through the system, warehouse management, planning the best delivery routes with Transportation Management Systems, and real-time fleet monitoring. These capabilities are crucial in managing the complexity of the supply chain in the modern era. Multimodal transportation is one of the basic concepts in the contemporary logistics industry that aims to improve the speed and efficiency of shipping people and goods.

Multimodal transportation is the process of transporting goods from one place to another through various means, such as air, sea, and land (truck or train). The fact that one company handles all shipments under one contract is one of the main features of multimodal transportation. This makes logistics easier for companies and ensures that goods are moved across regions and distances efficiently. For travelers, multimodal public transportation refers to a series of trips that use two or more public transportation options to arrive at a destination.

Characteristics and Benefits

Businesses and the logistics sector can benefit greatly from multimodal transportation in several ways:

a. Increased Efficiency: Multimodal systems can achieve greater efficiency by combining the flexibility of some modes, such as trucks for local deliveries, with the speed of other modes, such as trains for long-distance transportation. For example, using trains instead of trucks for long distances can save logistics costs (Wibowo and Chairuddin 2017).
b. Cost Savings: Companies can minimize overall shipping costs by optimizing the use of various means of transportation.
c. Simplified Management: Multimodal transportation simplifies the shipping process for companies by requiring only one transportation carrier to handle the paperwork and coordination efforts, with one contract covering the entire journey.
d. Ownership and choice: Multimodal transportation includes a variety of modes, such as public transit, rail, air travel, bicycle, and pedestrian, thus meeting the needs of all people by providing more connections and choices. The goal of multimodal transportation is to ensure that all modes of transportation, cars, commuter trains, public transport, bicycles, and pedestrians are safe links and make it easy for commuters to use different modes.

In multimodal freight transportation, the concepts of "one contract, one responsible company" and "a series of trips using two or more modes of public transportation to reach a destination" for passengers implicitly suggest the existence of an excellent information system. Without this information system, the efficiency and management ability of a single line will be severely limited due to the complexity of coordination between various modes. To organize a comprehensive passenger journey, it is necessary to collect detailed information on status, tracking, fares, and schedules. The most important factor is the effectiveness and efficiency of information exchange between transportation operators. Information technology, which is often referred to as the "nervous system" of the multimodal transportation network, is the main support for this effect. Therefore, the efficiency and effectiveness of management in multimodal transportation (both for goods and people) is fundamentally based on the ability of information technology to integrate data, processes, and communications between different operators and modes. Without robust information systems to support the "one contract" or "series of trips", the multimodal concept will undoubtedly become a significant bottleneck in its coordination and operation, indicating that IT is a valuable tool that is not only useful for successful multimodal integration.

Key Components of Multimodal Integrity

Buchari (2008) asserts that the idea of multimodal public transportation needs to fulfill six important components:

1. Connecting Modes: consists of access modes and exit modes. Access is the mode of transportation used from the place of residence to the public stop, bus stop, or terminal, such as walking, cycling, motorcycle, or taxi. Exit modes are used to move from the stop to the final destination (Kerja 2020).

2. Main Modes: Compared to other modes, generally used for the most leisure trips and longest travel times. One component of the study and development of these main modes is to synchronize schedules between modes and public transport vehicles (Kerja 2020).
3. Multimodal Network: The availability of an intermodal network is a basic component. Interconnections between different types of modes and recognition with respect to tiers or hierarchies within the network are what make these networks possible. The highest networks have limited access and high-speed modes, while the lowest networks have high levels of access, lower speeds, and more complex network densities (Kerja 2020).
4. Transfer Point: This section is very important to ensure that personal information is transferred to public areas. Good parking facilities are essential to encourage private vehicle users to increase their mobility and extend their trips using public transport (Kerja 2020).
5. Intermodal Transfer Point: These facilities are very important as they serve as connection points between two different types of networks, such as river and road or rail networks (Kerja 2020).
6. Regulation: Regulations should be multimodal as a means of controlling transit performance in general. This includes correlation with other modes through transfer points and intermodal transfer points, as well as regulations relating to main, feeder, pre and post modes (Kerja 2020).

Transportation to function as a cohesive unit is known as transportation system integration. The main objective is to achieve efficient and effective transportation. Integration is often considered as the most logical solution to overcome increasingly complex urban transportation problems (Ramadhan and Buchori 2018). People can manage travel costs and time more precisely, efficiently, and effectively with integration (Jufridar and Saifuddin 2023). The main goal of public transportation system integration is to make traveling from one place to another easier with rider-friendly intermodal facilities. Ultimately, this will benefit society. Improving accessibility is the main goal of public transportation system integration, as accessibility is an important thing that is experienced directly by individuals and users when traveling (Ramadhan and Buchori 2018).

Types of Integration

Integration of public transportation systems encompasses a variety of interrelated dimensions, including:

1. Physical Integration: This refers to the physical connectivity between modes, such as terminal design that allows buses, trains, or other modes to move easily (Ramadhan and Buchori 2018).
2. Network Integration: To ensure there are no gaps in the transportation network, the routes and coverage of intermodal services must be synchronized.
3. Schedule Integration: Arrange the departure and arrival times of various modes of transportation to minimize waiting time and facilitate the transfer process.
4. Fare and Ticket Integration: Customers can pay once for the entire trip due to its integrated payment system.
5. Information Integration: Provides users with comprehensive travel information on routes, schedules, costs, and conditions of all types of directly connected transportation.
6. Land Use Integration: Urban planning that supports the development of transportation nodes as activity centers, integrating transportation with housing, employment, and other amenities.

7. Social Integration: ensuring that transportation systems provide equitable services to all segments of society, including vulnerable groups.
8. Environmental Integration: Encouraging environmentally friendly transportation methods and minimizing the negative impact of transportation on nature (Ramadhan and Buchori 2018).

The existence of "information fusion" as one type of integration in transportation systems highlights that information technology is not just a tool, but also an important part of the integration itself. This suggests that if there are problems in the IT aspect, then efforts to integrate the physical, network, or timetable are directly hampered, resulting in negative impacts that reduce efficiency and user experience. Physical, network, and schedule components are tangible elements that can be observed and felt. However, for these components to function in an integrated and efficient manner, they require continuous coordination and communication. For example, the integration of schedules between transportation modes requires real-time data accurate, and integrated fares require a centralized and easily accessible payment system and user data. Information fusion is the "binder" that allows all other types of integration (physical, network, schedule, fare) to work optimally. If information integration does not work well, then integration efforts in other aspects will become fragmented and less efficient. This suggests that investment and attention to information systems and technology should be a top priority in any transportation integration project, as failure to do so will have a detrimental impact on the overall system, reducing the "user convenience" and "accessibility" that are the primary goals (Ramadhan and Buchori 2018).

To improve efficiency, sustainability, and competitiveness in Indonesia's transportation industry, the land multimodal transportation system, system integration, and information technology must work well together.

- Information Technology as a Driver: Information technology acts as a key enabler that delivers infrastructure and applications. It enables real-time data collection, processing, analysis, and dissemination. These capabilities are essential for modal coordination and smart transportation decision-making.
- Multimodal Transportation as an Operational Model: The multimodal transport operational model leverages the strengths of each mode to optimize the movement of goods and people. However, to ensure smooth intermodal transitions, this model inherently requires a high level of coordination and management.
- System Integrity as a Goal: Transportation system integration is the ultimate goal that ensures smooth movement, improved accessibility, and a better user experience. Integration goes beyond physical connectivity to include harmonization of processes, information, and fares (Ramadhan and Buchori 2018).
- Synergy: Synergy between these three pillars is key. Information technology facilitates integration by providing a platform for real-time information sharing, integrated payment systems, accurate shipment tracking, and efficient operational management. As such, IT realizes the full potential of a multimodal transport system. Without IT, multimodal integration will remain a difficult concept to effectively realize, especially on a large scale in an archipelago like Indonesia.

IT not only supports integrated multimodal transportation, but is also a critical component to achieving the efficiency and seamlessness promised by the multimodal concept. IT serves as the "nervous system" of the multimodal transportation network, which means that IT is not just a supporting component, but an intrinsic component that allows the various modes and system elements to communicate and collaborate with each other. As a result, investments in IT should be considered as investments in the foundation of the

transportation system itself, not as add-ons. If IT adoption is not thorough, the potential for investment in physical infrastructure will be severely limited (Pane 2016).

METHOD

This research uses a systematic literature review (SLR) approach. A systematic literature review is a thorough and planned secondary a thorough and planned secondary research technique, aiming to find, assess and combine all information related to the research. The main goal of a systematic literature review is to present an objective summary, identify gaps in existing research in the literature, and provide a solid foundation for further research or better policy development.

The choice of SLR approach is appropriate for the title of this journal for several reasons. First, the topic is multidisciplinary, encompassing aspects from transportation engineering, logistics, information technology, and public policy. SLR enables the synthesis of knowledge from these various perspectives. Second, the fields of information technology and transportation are evolving rapidly, so the SLR allows the identification of the latest trends and innovations (especially in the 2010-2025 timeframe) without having to conduct time and resource-consuming primary data collection. Third, given the broad scope of the topic and the need to integrate different types of data (conceptual, empirical, regulatory), SLR is the most efficient and effective method. It allows researchers to build strong, evidence-backed arguments from multiple sources, identify global and local trends, and highlight gaps in the literature that future researchers can focus on. Data for this study was collected from various relevant and credible secondary sources.

Scientific journals, articles from leading journals in the fields of transportation, logistics, information technology, and supply chain management are the main sources. Priority is given to recent publications (2020-2025) to ensure relevance and actuality of the information. Industry Articles and Reports are publications from research and trend organizations. And the retrieval method is cited from several case studies, Government Regulations, ie. laws, government regulations, Ministerial regulations, and others. The data collection process is done systematically through steps such as academic database search, which is using reputable academic databases from Google Scholar, Scopus, ScienceDirect, and other journal portals. In addition, the collection process is also from article selection, and regulatory data collection. The collected data was analyzed qualitatively using several techniques such as thematic content analysis, which contains coding by labeling text relevant to a particular concept or theme (e.g. IoT, Cost Efficiency, etc.). In addition, there was identification of causal relationships and implications, comparisons and contrasts and qualitative case studies.

RESULTS AND DISCUSSION

Information technology has become a key driver of transformation in the transportation sector, enabling more efficient, transparent, secure and user-oriented systems. The role of IT is particularly crucial in the context of integrated land multimodal transportation. IT fundamentally changes the way multimodal transportation operations are managed, from planning to execution.

- **Global Positioning System (GPS)**
  It is essential to manage a fleet well because GPS enables real-time location monitoring of delivery vehicles. Operators can optimize travel routes with accurate location data to save time and fuel costs and avoid traffic jams and bad weather that can hamper deliveries, Gojek, for example, uses GPS to track the real-time location of drivers, increasing transparency and providing convenience to customers (Miqdam2025).

- **Internet of Things (IoT)**
  The Internet that exists between transportation components and the Internet of Things data collection is constantly changing. Sensors installed at bus stops and buses can collect real-time data on passenger numbers and vehicle locations. This information is then distributed to passengers through apps or panels at bus stops, increasing passenger satisfaction and encouraging the use of public transportation, thereby reducing congestion. Smart Parking reduces the time wasted looking for parking by using sensors to find empty parking spaces and providing this information to users in real-time. IoT-enabled vehicle monitoring systems are helpful for enterprise supply chain management as they enable vehicle location tracking, departure scheduling, fuel consumption monitoring, driver assignment. In addition, IoT enables proactive maintenance of logistics equipment and vehicles by monitoring their condition continuously (Miqdam 2025).
- **Transportation Management System (TMS)**
  Transportation Management Systems (TMS) are software tools that help companies plan the best delivery routes, monitor fleets in real time, and analyze delivery performance. Applications like Flits, TMS are specifically designed for trucking expedition management and support multi-modal operations, helping to reduce time wastage and speed up the distribution process.
- **Optimasi Rute**
  To optimize routes, various calculation and mathematical techniques are used, including linear programming and saving matrix, which take into account vehicle capacity and operational constraints (Setiani and Lukmandono 2021).

The massive amount of real-time data generated by the Internet of Things and GPS not only improves operational efficiency today, but also serves as the basis for predictive modeling and Al-based decision-making in the future. Big Data and Machine Learning algorithms rely on the "fuel" of these large volumes of real-time data. With the help of this, systems can analyze complex patterns, predict problems (such as congestion and vehicle breakdowns), and even automate decision-making processes. Therefore, IT is transforming transportation management, moving from a reactive approach to a proactive and predictive approach. This approach will be essential for a more resilient and flexible multimodal system in the future. IT increases visibility across the multimodal supply chain, which is crucial for coordination and accountability.

- **Real-Time Tracking**
  Tracking technologies such as GPS, RFID, and Internet of Things devices allow users to monitor cargo movements in real-time. This gives customers full transparency into the status of their goods and significantly improves the timeliness of delivery. This capability is essential for contemporary supply chain management (Tohir et al. 2023).
- **Electronic Data Interchange (EDI)**
  Using EDI, all parties involved in the supply chain can exchange data electronically. This reduces the need for physical documents, reduces data errors, saves delivery time, and ultimately reduces administrative costs associated with manual processes (Pane 2016).
- **Integrated Information System**
  These systems enable integration, synchronization, visibility and responsiveness across the supply chain. With an integrated system, all parties have access to the latest data, which enables better coordination (Anandhita and Dwiardi 2018).

Stakeholder trust in multimodal supply chains is increasing as a result of increased IT transparency and visibility. Many parties are involved in multimodal logistics, including

shippers, mode operators, receivers, and customs. Mistrust, conflict, and inefficiency may occur due to lack of or asymmetric information. With the help of IT, transparency and visibility are changing the way stakeholders interact in a multimodal transportation environment. If everyone has access to the same, accurate data, trust increases, which reduces the need for repeated manual verification, and enables more effective cooperation. This results in faster decision-making, more effective problem-solving, and ultimately, improved overall system performance that goes beyond technical efficiency.

IT contributes greatly to improving safety and security in transportation operations

- **Intelligent Transportation System (ITS)**
  Contemporary data-driven methods aim to improve the safety, efficiency, and sustainability of transportation networks by using modern technologies such as sensors, communication networks, data analysis, and real-time monitoring to increase traffic efficiency, reduce congestion, and improve road safety.
- **Emergency Notification System (eCall)**
  Following the events in Europe, the eCall system automatically provided emergency services and sent critical data and location information to relevant parties. While this concept is yet to be fully implemented in Indonesia, this idea shows the potential of IT in emergency response.
- **Automatic Road Enforcement**
  Users of speed cameras, red lights, bus lanes and railroad crossings can detect traffic violations. This improves road safety and driver compliance with regulations.
- **Vehicle and Infrastructure condition monitoring**
  Sensors built into the vehicle can detect hazardous conditions such as sudden braking or bad weather, providing early warning to the driver. ITS can also predict infrastructure damage and recommend repairs before serious problems arise.
- **VTMIS (Vessel Traffic Management Information System) & RIS (River Information Services)**
  These systems are vital to marine and river transportation operators as they help reduce traffic congestion at ports and waterways, reduce the risk of accidents, and provide real-time information on current conditions (Pane 2016).

Sophisticated management is required to manage large volumes of data in modern transportation

- **Big Data Analytics**
  The collection and analysis of big data from various sources, such as travel apps, early warning systems, vehicle sensors, and road infrastructure, enables better public transportation schedules, congestion reduction, and even accident prediction.
- **Cloud Computing**
  This technology enables the integration of devices and internal corporate networks as well as flexibility in data storage, processing, and delivery. This is crucial for ensuring a visible supply chain and ensuring that goods are delivered in good condition.
- **Artificial Intelligence (AI) / Machine Learning (ML)**
  Intelligent algorithms can analyze complex data patterns to provide quick solutions, such as dynamically adjusting traffic light timing according to actual traffic conditions. Machine Learning is also utilized to forecast driver travel paths and improve delivery route planning. The Digital Twin concept enables simulation of various operational situations and prediction of delays, which provides critical information for decision-making.
  Supporting IT user-based services drives adoption of public transportation and improves user experience.

- **Mobile Applications (Mobility as a Service – MaaS)**
  MaaS is a digital platform that combines different types of transportation, such as public transportation, bicycle, and car services. The app provides real-time information on traffic, weather, and the best routes, allowing users to make better travel decisions (Dr. Eng 2023).
- **Electronic Payment System (EPS)**
  Cross-modal payments are easier with EPS, such as integrated fare systems that allow customers to pay once for multiple modes of travel. One example is JakLingko Smart Apps in Jakarta, which uses QR Code-based payments and Account-Based Ticketing, allowing users to combine balances and get special fares that suit their profile. For example, those who are 65 years old, students (Asty Supriati 2025).
- **Advanced Traveller Information System (ATIS)**
  ATIS presents real-time traffic data, helping users reduce congestion and choose the best route to reach their destination (Adolph 2016).

Implementation of Information Technology in Integrated Land Multimodal Transportation in Indonesia.

Although still facing many challenges, the use of information technology in Indonesia shows great potential to advance integrated land multimodal transportation systems. Smart Transportation Systems (ITS) in Major Cities Indonesia has implemented smart transportation systems (ITS) to solve traffic problems and improve efficiency.

- Jakarta and Surabaya: The use of ITS in cities such as Jakarta and Surabaya has reduced delivery time and travel distance by optimizing routes. However, performance has not been fully optimized, and there is a need for continuous improvement and renewal of road infrastructure (Novita 2022).
- Palangka Raya: The purpose of the Area Traffic Control System (ATCS) in Palangka Raya is to optimize traffic flow and reduce travel delays. The system also improves intersection performance and road services.
- IKN Nusantara: The smart transportation concept in the Capital City of the Archipelago
- (IKN) is a grand plan that will incorporate nine key IT-based services. These services include Electronic Payment System (EPS), Mobility as a Service (MaaS), Advanced Traveler Information System (ATIS), Advanced Traffic Management System (ATMS), Incident Management System (IMS), Digital Twin, Advanced Parking Management System (APMS), and Advanced Public Transportation System (APTS). IKN's vision is to create a smart, green, and people-oriented city, with a target of 80% public transportation mode by 2045 (Maharani et al. 2024). The IKN project with its smart transportation masterplan is not only a technology showcase, but also serves as a national-scale testing and learning platform for the implementation of an IT-based integrated land multimodal transportation system. Success in integrating various IT services in IKN will provide an operational and policy model that can be replicated and customized for other metropolitan cities in Indonesia Conversely, the challenges faced in IKN will provide valuable insights into practical barriers at scale, which can inform future improvements to national policies and strategies.

Integration of Public Transportation Payment and Information

JakLingko is an important public transportation initiative in DKI Jakarta and the surrounding region that aims to integrate the public transportation system. Firstly, this integration includes payment systems, fares, and intermodal routes.

- JakLingko Smart Application and Payment System: The JakLingko Smart App and Card allows payment using QR codes. The app has the ability to determine the user's departure and destination points, and will then notify the user of available transportation routes.
- Mobility as a Service (MaaS): JakLingko's two implementation phases include the development of the "Mobility as a Service" (MaaS) concept, which aims to integrate various transportation services into a single platform that can be easily accessed by users.
- Account-Based Ticketing: By using individual age-based tickets, users can connect all their belongings and receive fares that match their demographics, such as students, employees, or travelers.

JakLingko, with its MaaS and account-based ticketing ambitions, represents a paradigm shift from mere "transportation" to "mobility as a service". It demonstrates that IT not only optimizes operations, but also transforms user experience and transportation business models, potentially increasing the use of public transport and reducing dependence on private vehicles. The implementation of JakLingko marks an important evolution in Indonesia's public transportation system, moving beyond mere operational efficiency towards a user-centric mobility experience. With MaaS and account-based ticketing, it enables personalization of services, fairer fares based on user profiles, and encouraging people to use public transport instead of private cars. This has significant socio-economic implications, such as reduced congestion and emissions, and improved accessibility for different segments of society, demonstrating that IT is a key driver of behavioral change and sustainability in the transportation ecosystem.

Digitalization of Railway Logistics.

Digitalization efforts are also seen in the logistics sector, particularly in the truck and rail modes.

KAI Logistics: With the tagline "KAI Logistik Impossible," highlighting their ability to provide comprehensive logistics solutions ("End-to-End Services"), PT Kereta Api Logistik (KAI Logistik) has committed to digitalization and integrated services. Customers can use the KAI Logistik TRAX app to send, receive, and track their shipments in real time for the KALOG Express service. They provide a "door to door service" business model supported by information technology in each logistics area.

Digitalization in general, The use of technology in general can automate various manual work processes, which in turn can increase employee productivity and efficiency. Digital data entry into an integrated system also greatly facilitates coordination and supervision in logistics operations (Syaputra 2024).

Despite digitization efforts such as KAI Logistics TRAX, the application of information technology in multimodal logistics in Indonesia as a whole is still "very slow". This suggests that the potential of technology and its actual implementation differ significantly. A comparison between successful digitization initiatives (such as KAI Logistics) and comprehensive IT adoption in Indonesian multimodal logistics shows that the latter is more dependent on technological advancements. This highlights issues of institutional capacity, human mortality, and fragmentation of the logistics system. The success of certain initiatives is often isolated and difficult to diplocate without a holistic policy framework and strong incentives to encourage cross-sector collaboration and sustained investment from all stakeholders.

The Role of Dry Port in Land Logistics Integration: Analysis of Cikarang Dry Port

Dry ports, also known as inland ports, serve as an important component of the multimodal land transportation system, facilitating integration between sea and land modes.

- Cikarang Dry Port (CDP), CDP is one of the important dry terminals in Indonesia that effectively supports export and import activities and supply networks, especially in the Greater Jakarta and Cikarang areas.
- IT Utilization in Dry Ports, the successful development of dry ports is significantly influenced by the use of smartphones and the internet. In the management of dry port supply chains and physical distribution, digitization and integration of information from multiple sources is essential.

Dry ports serve as an important component of multimodal inland transport, and their successful digitization (such as the use of smartphone apps) shows how IT can reduce congestion at major inland ports by improving integration from the sea. The goal of dry port digitization through smartphone apps and integrated information systems is to improve the efficiency of multimodal integration from sea to further inland networks (Jourdan et al. 2018). This enables better container management, seamless cargo tracking, and simplified customs procedures in inland locations. This means that IT in dry ports not only improves efficiency in those areas, but also significantly reduces congestion at ports and improves the flow of goods in all directions in the inland multimodal chain (Maharani et al. 2024).

Regulations Regarding the Development of Multimodal Transportation Systems in Indonesia

Indonesian regulations have established a commitment to promote the development of multimodal transport and digitalization. However, the effectiveness of the implementation of these regulations still requires more careful consideration.

Government Regulation No 8 Year 2011 on Multimodal Transportation

Government Regulation (PP) No. 8 Year 2011 provides the basis for the multimodal transportation system in Indonesia. It describes multimodal shipments that involve at least two different types of transportation with one contract acting as the document for multimodal shipments, from the point where the goods are received by the multimodal transportation service provider and then transported to the delivery location. It also sets out the responsibilities of the multimodal transportation company from the moment the goods are received from the customer until they are handed over to the consignee.

PP 8/2011 builds a solid legal foundation for the concept of "one contract" in multimodal transportation. However, the efficient implementation of this "one contract" is highly dependent on the existence of an integrated information system that can manage and monitor all intermodal trips. The regulation emphasizes more on the legal aspects and responsibilities, without much explanation on the operational mechanisms and technologies needed to achieve the efficiency of "one contract". This situation creates a gap in the regulation where the legal framework is in place, but lacks detailed guidance on IT integration to support this concept, potentially hindering faster and more effective IT adoption.

Minister of Transportation Regulation No. 8/2012 on the Implementation and Operation of Multimodal Transport

Regulation of the Minister of Transportation (PM) No. 8/2012 regulates multimodal transportation activities that can be carried out by multimodal transport companies, both domestic and foreign. This regulation clearly highlights the importance of developing information systems based on information and communication technology (ICT) in the

supervision of multimodal transport companies. ICT is expected to create services that meet safety and security standards in transportation. In addition, the rule also emphasizes that the workforce in multimodal transportation must have competencies in providing information and communication systems, as well as other logistics services (Multimoda 2019).

PM 8/2012 gradually requires the development of ICT-based information systems for monitoring and improving service quality. However, the main challenge lies in the fragmented logistics and transportation ecosystem in Indonesia. With multiple operators and disparate systems, ensuring interoperability and standardization of data and platforms is critical. Without solid standardization and a push for adoption, this mandate has the potential to become a "paper tiger" or only half-implemented half- implemented, thus limiting opportunities for true integration and efficiency.

Presidential Instruction No. 5/2020 on Structuring the National Logistics Ecosystem (NLE)

Presidential Instruction (Inpres) No. 5/2020 is a strategic policy designed to improve logistics performance at the national level, create a better climate for investment, and increase the country's economic competitiveness. It directs an organized and integrated effort in regulating the national logistics ecosystem (GR No. 14 1992). Specifically, the Minister of Finance was given the responsibility to simplify the business processes of government services in the logistics sector based on information technology in order to reduce repetition and duplication, and encourage cooperation between logistics service actors, both abroad and within the country (Seda et al. 2019). In addition, the Minister of Transportation was also instructed to merge the licensing system as well as export, import, and logistics services within the ministry with the national logistics ecosystem through the Indonesia National Single Window (INSW).

Presidential Instruction 5/2020 explicitly targets digitalization and system collaboration to solve the problem of repetition and duplication in logistics. However, data shows that Indonesia's Logistics Performance Index (LPI) in 2023 has decreased compared to 2018, despite the implementation of the National Logistics Ecosystem (NLE). There is a mismatch between the policy objectives and how well they are being implemented. The gap could be due to resistance from the bureaucracy, lack of adequate digital infrastructure in many regions, or challenges in convincing various parties to collaborate and build joint information and communication technology (ICT) applications. Therefore, the decline in the LPI despite the ambitious Presidential Instruction 5/2020 shows that digitization in logistics is a complex challenge and goes beyond the issuance of regulations. It signals a huge gap between the policy vision and the real conditions on the ground, which may be due to resistance from the bureaucracy, lack of human resource capability to adopt the technology, data segregation among agencies, or the absence of sufficient incentives for the private sector to invest and cooperate. The future success of NLEs largely depends on the government's ability to overcome these non-technical barriers, including building trust and promoting better coordination among stakeholders (Anandhita and Diwiardi 2018).

Presidential Regulation No. 26/2012 on Blueprint for National Logistics System Development

Presidential Regulation No. 26 of 2012 establishes the National Logistics System Development Blueprint (SISLOGNAS) for use by parties involved in logistics policy setting and development. SISLOGNAS is intended to facilitate the distribution of goods in an effective and efficient manner, in order to ensure the fulfillment of the basic needs of the community and to increase the competitiveness of local products in domestic, regional and global markets. One of the six key elements in the development of SISLOGNAS identified is Information and Communication Technology (ICT) (Dr. Siti Maimunah, et al 2018).

Perpres 26/2012 clearly lists ICT as one of the six key elements in SISLOGNAS. This indicates an early recognition of the importance of information technology in national logistics. However, as this regulation was issued in 2012, this plan may require updating to reflect the latest advancements in IT, such as Artificial Intelligence (AI), blockchain, and digital twin, as well as the challenges that are being posed more complicated in its implementation that emerged after ten years (Muhammad Abdul Rohman). The recognition of IT as an important part of SISLOGNAS since 2012 shows that the government had foresight. However, the rapid pace of technological development since that time suggests that this plan may need to be revised or adjusted to remain relevant and helpful in the development of national logistics by utilizing the latest innovations in IT. It also shows that policy implementation needs to be adaptive to rapidly changing technology.

National Transportation Masterplan and Smart Transportation Policy (IKN Nusantara Case Study)

The smart transportation system masterplan in the Capital City of the Archipelago (IKN) is an important element of IKN's development vision as an efficient and environmentally friendly modern city. The plan is aimed at creating an urban mobility system that supports nine key technology-based services, including Electronic Payment System (EPS), Mobility as a Service (MaaS), Advanced Travel User Information System (ATIS), Advanced Traffic Management System (ATMS), Incident Management System (IMS), Digital Twin, Advanced Parking Management System (APMS), and Advanced Public Transportation System (APTS). The long-term vision of Otorita IKN Nusantara (OIKN) includes ambitious goals of 80% public transportation by 2045, optimal mobility within 10 minutes to critical facilities, and achieving zero emissions (Asty 2025).

IKN is not just a physical construction project, but also a laboratory for smart transportation policies in Indonesia. The success or failure of the integrated IT model in IKN will be an important lesson that can be applied or adapted for other cities in Indonesia The IKN project with its smart transportation masterplan not only demonstrates technology, but also serves as a national-scale experiment and learning platform for the unplementation of IT-based integrated multimodal transportation systems. Successfully incorporating various IT services in IKN will provide an operational and policy model that can be replicated and modified for other metropolitan cities in Indonesia. On the other hand, the challenges faced in IKN will provide important insights into practical constraints on a large scale, which can help in the improvement of future national policies and strategies (Asty 2025).

Benefits of Information Technology Implementation in Integrated Land Multimodal Transportation

The implementation of information technology in integrated land multimodal transportation provides a number of benefits, including increased time and cost efficiency through automation of manual processes, optimization of delivery routes, and reduction of waiting times that drastically reduce shipping costs and speed up the distribution of goods (Setiani and Lukmandono 2021); improved service quality thanks to real-time access to information, precise tracking of shipments, and an integrated payment system that increases customer satisfaction and ensures that shipments are made on time (Tohir et al. 2023); reducing congestion and greenhouse gas emissions by improving traffic flow through smart transportation systems (ITS), as well as encouraging more efficient utilization of public transportation, and smart route planning that supports sustainable transportation; improving connectivity and accessibility through the integration of various modes of transportation and information that facilitate switching between modes, especially in previously hard-to-reach areas (Ramadhan and Buchori 2018); and increasing the competitiveness of national logistics through the digitization of standardized logistics systems, enabling the delivery of Indonesian

products to the global market with a high level of efficiency faster and more efficiently, and ultimately support exports and national economic growth.

Challenges of Information Technology Implementation in Integrated Multimodal Land Transportation

Challenges in implementing information technology for integrated land multimodal transportation in Indonesia include gaps in digital infrastructure. Limitations in internet access and a lack of supporting digital systems prevent the technology from being deployed evenly, especially in areas outside Java. There is also a shortage of human resources and a low level of digital literacy in transportation and logistics, which requires substantial investment in training and education. Another issue faced is the lack of interoperability between modal systems and between agencies, due to a lack of coordination, absence of standardized documents, and lack of effective data exchange, all of which contribute to system fragmentation (Anandhita and Dwiardi 2018). In addition, the high initial cost of modern technologies such as transportation information systems (ITS) and integrated supply chain management is a major barrier, especially for micro, small, and medium enterprises (MSMEs) (Tohir et al. 2023). There is also resistance to change from bureaucratic and operational staff who are less willing to adapt to technological innovations. Finally, there is a lack of digital leadership, where top leaders, especially in traditional or family firms, tend to be hesitant to run and drive the digital transformation process, which hinders the progress of information technology implementation (Anandhita and Dwiardi 2018).

The challenges in implementing information technology in Indonesia lie not only in technical aspects such as infrastructure and interoperability, but also include structural and cultural aspects such as human resources, resistance, and leadership. This suggests that solutions need to be comprehensive, combining investments in technology with human capacity building programs and organizational culture transformation. Research into these challenges shows that the main barriers to implementing information technology for integrated multimodal transportation in Indonesia are diverse. These issues are not only related to the availability or rate of technological advancement, but also include the ability of organizations and individuals to adapt, political will and leadership, in addition to business models and financial incentives. As such, the development strategy that needs to be implemented should be comprehensive, focusing not only on the provision of technology but also on strengthening the enabling ecosystem, including human resource development, cultural change, and flexible regulatory infrastructure and incentives.

Based on a comprehensive analysis of the role, benefits, and challenges of information technology in the development of an integrated land multimodal transportation system in Indonesia, strategic recommendations that can be considered by policy makers, industry players, and academics, strategies to address the issues of implementing information technology in integrated land multimodal transportation include increased investment in equitable digital infrastructure, with a focus on developing communication networks such as 5G and optical fiber in all areas of Indonesia, including remote areas, as the main basis for real-time connectivity; development of human resource capabilities and digital knowledge through continuous training programs for workers in the transportation and logistics sector, from operational to managerial levels, as well as the creation of e-leadership at the leadership level to support digital transformation; standard setting and system interoperability with the implementation of data standards and communication protocols that consistent between modes and institutions, supporting initiatives such as the National Logistics Ecosystem (NLE) and the Asperindo Logistic Integration Solution (ALIS) platform; increased cooperation between all stakeholders through platforms and joint ventures between government, service providers, technology providers, academia, and customers to address challenges, exchange best practices, and develop creative solutions according to local

contexts; the development of policies that support innovation as well as fiscal and non-fiscal incentives for companies committed to digitization and system integration, as well as regulatory adjustments to new technologies such as Al, blockchain, and autonomous transportation (Wibowo and Chairuddin 2017); and the implementation of pilot studies in various locations with different characteristics to gain insights from the successes and constraints of projects such as IKN Nusantara, while building replicable models according to local needs to accelerate the implementation of information technology nationwide through a phased approach from small to wider scale.

CONCLUSION

This journal thoroughly studied how information technology contributes to the development of an integrated land multimodal transportation system in Indonesia. Important results show that information technology plays a critical and transformative role. IT enables major improvements in efficiency, transparency, safety, and quality of transportation services, in addition to serving as an operational and strategic support tool and foundation.

The use of IT has many significant benefits. These include reduced logistics costs, more efficient travel times, increased supply chain visibility, decreased greenhouse gas emissions, and improved connectivity and accessibility. Ultimately, this improves national logistics competition. Case studies in Indonesis such as JakLingko, KAI Logistics, and Cikarang Dry Post show the great potential of IT to realize integration and efficiency in the industry.

Nonetheless, IT implementation faces complex and multi-level issues. They include uneven digital infrastructure, limited digital literacy and human resources, system interoperability issues between agencies and modes, high initial investment costs, resistance to change from various parties, and the need for strong e-leadership at the management level.
The regulatory framework in Indonesia has shown support for transport that combines multiple modes and digitalization, as seen in Government Regulation No. 8/2011, Minister of Transportation Regulation No. 8/2012. Presidential Instruction No. 5/2020, Presidential Regulation No. 26/2012, and the IKN Nusantara Intelligent Transportation Master Plan. However, analysis indicates that the implementation of these regulations still requires improved coordination as well as ongoing adjustments to changes in technology and conditions on the ground.

The findings of this journal have several significant implications. First, it emphasizes the importance for governments and industry players to place comprehensive investment in information technology as a priority. This investment includes not only physical infrastructure but also human resource skills development, system standardization, and flexible policies Secondly, the journal emphasizes the importance of a coordinated strategy that myolves cooperation between sectors as well as all relevant parties. This cooperation is essential to of excome the separation that occurs in the multimodal transportation ecosystem and ensure an effective witerconnected systeem Thardly, policirs need to be mere responsive and flexuble to rapid technological changes, as well as provide clear incentives to encourage the adoption of technology and innovation across the transportation value chain.
Menyediakan insentif yang jelas untuk mendorong penerapan teknologi dan inovasi di seluruh rantai nilai transportasi.

This journal has limitations as it largely relies on a review of existing literature. While using a systematic literature review method to ensure breadth and objectivity, this study did not involve primary data collection through questionnaires, direct interviews, or field observations with relevant parties in Indonesia. Therefore, a deeper understanding of implementation experiences on the ground, specific barriers at the operational level, as well as direct views from actors and users may not have been fully revealed.

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