

Implementation of Green Logistics on the Development of Cargo Logistics in the Free Trade Zone Area: a Case Study of PT Bandara Internasional Batam

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Abstract

This study focuses on the implementation of green logistics at PT Bandara Internasional Batam to analyze strategic findings from the application of green logistics in supporting the development of cargo logistics in the Free Trade Zone (FTZ) area. The research adopts a qualitative approach using a case study method. Data were collected through in-depth interviews with key informants, field observations, and document analysis. The data analysis technique refers to the Miles and Huberman model, which includes data reduction, data display, and conclusion drawing. The results show that the findings at PT Bandara Internasional Batam have not been fully implemented comprehensively in terms of green logistics, particularly through a semi-automated Warehouse Management System (WMS) and document digitization (paperless system). However, challenges such as high investment costs, limited infrastructure, and human resource readiness remain major obstacles. The implementation of a cloud-based WMS and optimization of the sorting warehouse have proven to improve time efficiency, data accuracy, and reduce environmental impact.

Keywords: Green Logistics, Cargo Logistics, Free Trade Zone, Warehouse Management System, Paperless

INTRODUCTION

The mobility of people and goods in the current era of globalization has experienced a significant increase, driven by technological advancements. One of the rapidly growing sectors is freight or cargo services, which form an integral part of air transportation. According to The Air Cargo Tariff and Rules (TACT Rules) by the International Air Transport Association (IATA), cargo is classified into three main categories: General Cargo, Special Cargo, and Dangerous Goods. Airlines now transport more than 52 million tons of cargo annually, representing over 35% of global trade value, despite accounting for less than 1% in terms of volume. The total value of cargo shipped each year reaches USD 6.8 trillion, or approximately USD 18.6 billion per day. On average, the cargo business contributes 9% of total airline revenue—twice the revenue generated from first-class ticket sales. (Akmal, 2019).

Specifically, green logistics refers to the efficient and sustainable use of resources without harming the environment. It involves careful planning and management of materials to optimize their use and minimize ecological impact. (Sadam et al., 2023). This approach supports operational efficiency and contributes to global efforts in reducing the carbon footprint and preserving environmental sustainability. Logistics refers to a series of activities that include the planning, implementation, and control of the flow and storage of goods, services, and information. The process aims to ensure that deliveries are carried out efficiently and effectively, from the point of origin to the end consumer. In practice, logistics not only focuses on speed and accuracy but also strives to minimize operational costs without compromising quality. (Adelina et al., 2024).

Logistics plays a vital role in managing the shipment, storage, and distribution of goods to ensure timely and efficient delivery. In general, the primary goal of logistics is to reduce operational costs, particularly in transportation. Additionally, logistics focuses on improving delivery times and service reliability, with flexibility being a top priority in providing optimal service. In this regard, companies involved in the distribution of physical goods strive to support innovative strategies that enable them to lower transportation costs amid increasingly intense competition. (Safira et al., 2024).

Environmentally friendly efficiency in the logistics sector is not only focused on the impact of industrial activities on the surrounding environment but also includes efforts to reduce the overall ecological footprint. The concept of green logistics emerged in response to the deteriorating global environmental conditions, particularly due to the high carbon emissions produced by large-scale operational vehicles. The negative impact of these emissions has driven the logistics industry to adopt more sustainable approaches, such as the use of eco-friendly technologies, optimization of transportation routes, and the implementation of renewable energy to reduce their contribution to environmental degradation. (Safira et al., 2024). The logistics industry plays a crucial role in supporting a country's economy, particularly in driving economic growth and strengthening international trade. (Sadam et al., 2023). In its development, innovation has become the key to addressing global challenges, one of which is through the implementation of green logistics. This concept has emerged as a new approach aimed at reducing the negative environmental impact of logistics activities while also encouraging behavioral change in society toward greater environmental awareness. Thus, green logistics is not only an innovation but also part of a sustainable strategy that provides significant benefits for organizations. (Sadam et al., 2023).

This study aims to analyze the strategic steps that can be implemented by PT Bandara Internasional Batam based on findings from interview data collected from selected informants, in order to support the implementation of the Green Logistics concept in cargo logistics operations within the Free Trade Zone (FTZ) area. The main focus of this research is to identify transformation strategies for the implementation of the Warehouse Management System (WMS), based on interview findings with the informants. WMS is a software system designed to manage and control daily warehouse operations. Its main

functions include real-time inventory tracking, management of receiving and shipping processes, warehouse layout planning, and optimization of resources such as labor and storage space, while also reducing dependence on physical documents through the adoption of a paperless system. This research is expected to provide theoretical benefits for future researchers as a source of information and reference for comparing similar concepts and ideas or for further developing studies on sustainable logistics. The practical benefits for institutions lie in enhancing and improving the application of Green Logistics to support operational efficiency in cargo logistics within the FTZ area.

THEORITICAL REVIEW

The term green logistics refers to a set of practices and strategies in supply chain management designed to reduce negative environmental impacts and optimize energy use throughout the distribution process. This concept encompasses various activities such as material management, waste reduction, packaging innovation, and improved transportation efficiency. Green logistics involves all activities focused on managing goods, information, and product flows in an environmentally friendly manner, both in the forward and reverse flow from the point of origin to the final point of consumption. The goal is not only to meet but also to exceed customer needs and expectations. Thus, green logistics not only supports operational efficiency but also contributes to environmental sustainability by applying principles that balance economic goals, ecological responsibility, and customer satisfaction. (Adelina et al., 2024).

The primary goal of green logistics is to minimize the negative environmental impact and energy consumption resulting from goods distribution activities. The main focus of this concept includes several important aspects such as material handling, waste management, sustainable packaging, and efficient transportation. Green logistics aims to create an environmentally friendly distribution system by considering social impacts while maintaining economic benefits. This concept also encompasses the management of the entire flow of goods, information, and services from the point of origin to the consumer, including reverse logistics processes. Therefore, green logistics is not only related to supply chain efficiency but also integrates sustainability principles that comprehensively balance environmental, social, and economic needs. (Adelina et al., 2024).

According to Regulation Number 53 of 2017, cargo is defined as any goods transported by aircraft, except for items required for the flight, postal items, and unaccompanied or mishandled baggage. Additionally, cargo can also be defined as goods or commodities transported based on a shipping contract. All types of goods, except for passenger baggage, can be classified as cargo. (Noerhaeni & Dewantari, 2024).

Simply put, cargo refers to all goods shipped by air (airplane), sea (ship), or land (container truck), usually for trade purposes either domestically (between regions/cities) or internationally (known as export-import). Regardless of the type, all shipped goods (except postal items and passenger baggage), whether for commercial purposes (export-import) or non-commercial purposes, and accompanied by shipping documents such as a Master Airway Bill (MAWB) or Airway Bill, are considered cargo. (Purnomo et al., 2022).

There are two main processes in handling air cargo:

- **Outgoing cargo** this refers to the handling process of goods to be shipped or dispatched. Also known as export cargo, this process involves a series of coordinated steps to ensure the cargo is documented, packed, inspected, and loaded onto the aircraft safely and efficiently. The main stages include:

- a. **Cargo Acceptance**

The initial stage where goods are handed over by the shipper to the cargo terminal and their packaging, labeling, and regulatory compliance are inspected.. Dangerous goods, perishables, live animals, or valuable items require specific documentation and packaging according to IATA (International Air Transport Association) regulations.

- b. **Document Verification**

Cargo handling agents or ground staff verify all required shipping documents, such as:

1. Air Waybill (AWB)
2. Commercial invoice
3. Export licenses (if applicable)
4. Packing list
5. Shipper's declaration for dangerous goods (if any). Proper documentation is crucial to ensure smooth customs clearance and transportation.

c. Security Screening

Due to strict international aviation security regulations, all outgoing cargo must undergo screening to detect prohibited or hazardous items. Screening methods include X-ray scanning, explosive trace detection, or manual inspection, depending on the type of cargo and country regulations.

d. Cargo Build-Up

After cargo acceptance and clearance, the cargo is consolidated and arranged according to the flight schedule. Cargo is grouped based on destination and type, then loaded into Unit Load Devices (ULD) such as containers or pallets. The cargo is weighed and secured to prevent shifting during the flight.

e. Customs Clearance

Customs authorities inspect and approve the cargo for export based on submitted documentation. Once approved, the cargo is sealed and ready to be transported to the aircraft.

f. Transport to Aircraft & Loading

Finally, the cargo is transported from the warehouse to the aircraft apron using specialized ground handling vehicles. It is then loaded into the aircraft's cargo hold according to the loading plan and weight balance requirements. This stage is critical to maintaining flight safety and efficiency.

- Incoming cargo refers to the handling process of newly arrived goods. Incoming cargo, or import cargo, refers to the process of handling goods that arrive at the airport from different locations. This process involves several key procedures to ensure that the cargo is received, inspected, cleared, and delivered to the consignee or logistics provider safely and accurately.

a. Unloading from Aircraft

After the aircraft lands, ground handling staff begin unloading the cargo from the aircraft's hold. Specialized equipment such as high loaders and conveyor belts are used to safely move Unit Load Devices (ULDs) or loose cargo items.

b. Transport to Cargo Terminal

After unloading, the cargo is transported from the aircraft to the cargo terminal or warehouse using cargo trucks and specialized vehicles. Time-sensitive items such as perishables or pharmaceuticals are prioritized to maintain their quality.

c. Breakdown Process

In the warehouse, the cargo is removed from the Unit Load Devices (ULDs) and separated according to each shipment. This process is known as the sorting stage. Each shipment is sorted based on the Air Waybill and its destination within the airport area.

d. Customs Clearance & Inspection

Incoming cargo must undergo inspection and customs clearance. Customs officers will verify the accompanying documents and may conduct a physical inspection to ensure compliance with import regulations, detect smuggled goods, or assess duties and taxes. The required documents include:

1. Import declaration
2. Commercial invoice
3. Air Waybill

4. Certificate of origin (if needed)

e. Security & Safety Checks

Just like outgoing cargo, certain categories of incoming cargo may be subject to additional security screening to prevent the entry of illegal or dangerous goods. Additionally, perishable or hazardous cargo is stored in specialized facilities under controlled conditions.

f. Storage and Notification

Cleared cargo is stored in designated warehouse areas until collected by the consignee or appointed logistics provider. The airline or ground staff notifies the cargo recipient of the cargo's arrival through a Cargo Arrival Notice.

g. Cargo Release & Delivery

After all customs duties and taxes are paid and the required documents are presented, the cargo is released to the consignee. The consignee can either pick up the cargo directly or arrange further transportation via truck or courier service.

According to (Purnomo et al., 2022), the outgoing cargo process involves receiving goods from agents or shippers to be loaded onto the aircraft. The stages include:

1. Preparation: Preparing the goods for X-ray inspection and storing them in the warehouse before acceptance.
2. Acceptance: After the X-ray inspection, the goods are re-weighed and physically inspected. This stage issues the BTB (Goods Weighing Evidence) document.
3. Storage: The re-weighed and inspected goods are stored in designated areas in the warehouse based on the airline and destination while waiting for the aircraft to arrive.
4. Cargo Dispatch: Goods are sorted by airline and destination in preparation for departure.
5. Document Processing: After sorting, the airline loading officer prepares the documents based on the inspector's checklist for loading.
6. Ready for Transport: Once the aircraft lands, the goods are transported to the apron using a train pulled by a BTT (Baggage Tow Tractor).
7. On the Aircraft: The goods are loaded onto the aircraft and are ready for departure.

According to (Achir et al., 2022), incoming cargo is the process of receiving goods starting from unloading until the goods are accepted by the consignee. Supporting documents in handling incoming cargo include:

1. Inbound Cargo Manifest
2. Airway Bill (SMU)
3. Animal Quarantine Certificate (SRT) for live animals
4. Transit Logbook

Cargo is generally divided into two main categories based on handling: general cargo and special cargo. According to IATA regulations, air cargo is classified into three categories:

• General Cargo

General cargo refers to goods that do not require special handling or have no special transportation requirements. This type of cargo is generally non-perishable, non-hazardous, and does not pose risks to the aircraft or personnel. They are relatively easy to transport and store. Examples include:

1. Consumer electronics (e.g., mobile phones, laptops)
2. Textiles and garments
3. Machine parts and industrial equipment
4. Books and documents

Characteristics:

1. No special packaging required

2. Standard temperature and humidity tolerance
3. No safety or health risks during air transport

- Special Cargo

Special cargo includes goods that are not directly hazardous but require special handling, packaging, or documentation due to their physical characteristics, value, or sensitivity. IATA has developed specific handling procedures for each type of special cargo.

Types of Special Cargo:

1. Perishable Cargo: Items that spoil easily such as fruits, vegetables, flowers, meat, and seafood that require specific temperature conditions.
2. Live Animals (AVI): Live animals transported under strict regulations to ensure their welfare.
3. Valuable Cargo (VAL): High-value items such as jewelry, precious metals, and cash that require high security.
4. Human Remains (HUM): Human remains handled with respect and according to legal and cultural protocols.
5. Fragile Cargo: Fragile items such as glass or artwork requiring extra care..
6. Pharmaceuticals (HEA): Pharmaceutical products that require temperature-controlled transport and real-time monitoring.

Characteristics:

1. Require special handling and storage conditions
2. Need additional documentation and compliance
3. Must follow specific IATA handling guidelines (e.g., Temperature Control Regulations for perishables and pharmaceuticals)

- Dangerous Goods

Dangerous goods, or hazardous materials (hazmat), are substances or items that pose risks to health, safety, property, or the environment when transported by air. These goods are strictly regulated by the IATA Dangerous Goods Regulations (DGR), aligned with ICAO Technical Instructions.

Examples include:

1. Explosives (e.g., fireworks, ammunition)
2. Flammable liquids (e.g., gasoline, alcohol)
3. Toxic and infectious substances (e.g., laboratory samples)
4. Radioactive materials
5. Corrosive substances (e.g., acids)
6. Batteries (e.g., lithium-ion batteries)

Characteristics:

1. Require special packaging, labeling, and documentation
2. Must be handled only by DGR-certified personnel
3. Must be segregated and securely stored on the aircraft
4. Must comply with international and local regulations

Cargo handling refers to all service activities related to goods (both incoming and outgoing) through the airport. This includes the processes of loading and unloading goods, transferring them from the aircraft to the warehouse (and vice versa), sorting and storing goods, as well as delivery to the owner or receipt from the sender, storage in the warehouse, and loading onto the aircraft. All these processes must be carried out by personnel who have adequate knowledge and skills (Achir et al., 2022). Cargo service is a specialized service for transporting cargo by aircraft. This service can be provided by regular airlines that also carry passengers or by companies specializing in air freight

transportation (Achir et al., 2022).

Previous studies related to the implementation of green logistics in the Free Trade Zone (FTZ) have mostly focused on definitions and conceptual frameworks, as well as the benefits and challenges of applying green logistics practices. For example, a study by (Safira et al., 2024), Regarding "Challenges and Opportunities in Implementing Sustainable Logistics Networks: Towards Efficiency and Environmental Friendliness," it concluded that the main challenges in implementing green logistics are high initial costs, complexity in assessing environmental impacts, and low public awareness. However, sustainable logistics provide long-term efficiency and environmental benefits. Similarly, another study by (Adelina et al., 2024), It emphasizes the importance of implementing environmentally friendly logistics practices to reduce negative environmental impacts and support sustainability. The study also highlights the role of government regulations and policies, such as the Paris Agreement and national carbon emissions laws, in facilitating green logistics.

Previous research tended to be theoretical and descriptive, whereas contemporary studies are more application-oriented and data-driven. Modern research emphasizes the importance of collaboration between the public and private sectors to achieve sustainability goals in logistics. Current studies also identify practical challenges in implementing green logistics in the FTZ area, such as a lack of infrastructure and low awareness among industry players about the importance of environmentally friendly practices. Based on the literature review presented, the research framework designed for this study is as follows:

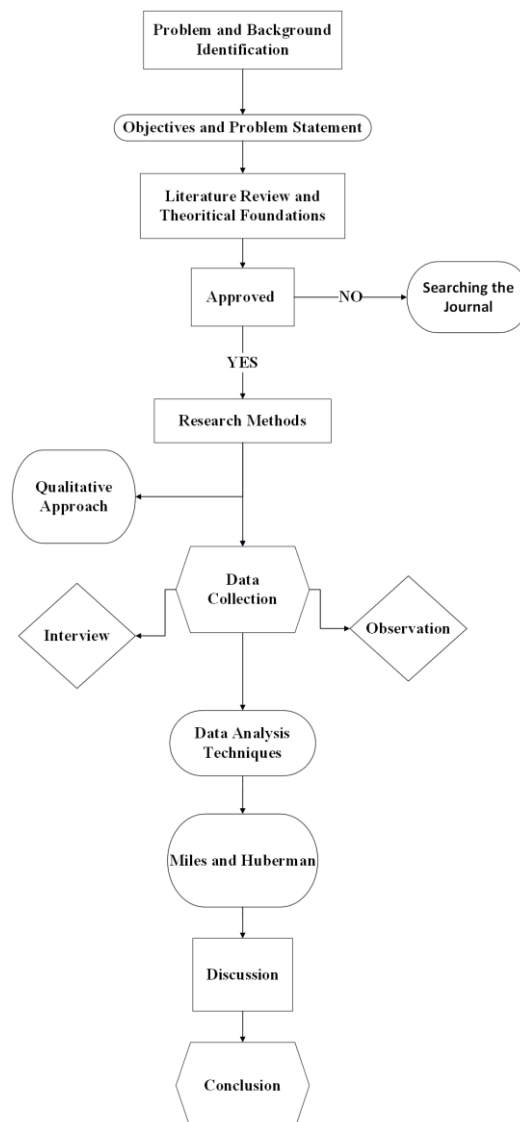


Figure 1The Research Framework

RESEARCH METHOD

This research is classified as qualitative research. The method used is a qualitative approach, which focuses on detailed descriptions and explanations of the meanings contained in various phenomena, symptoms, and existing social situations. Through this method, the researcher can identify and analyze subjective and complex aspects, as well as understand the context behind the events or conditions being studied.

The object of this study is the interview results concerning the findings from the implementation of green logistics in the development of cargo logistics in the Free Trade Zone area.

According to (Hidayat et al., 2022), the research subjects or respondents are individuals who serve as sources of information in a study. Informants are individuals selected as subjects in a research project because they possess knowledge, experience, or insights relevant to the phenomenon or issue being studied. The following are the selected informants who have been identified:

Table 1. Informants or Research Subjects

No	Informant Name	Type of Informan	Position
1	Daniel Christian	Key Informant	Analyst
2	Wayan Wijana	Primary Informant	Senior Manager
3	Ibrahim	Supporting Informant	Analyst

This study employs the data analysis technique developed by Miles and Huberman, which consists of three main processes that occur simultaneously: data reduction, data display, and conclusion drawing or verification. Qualitative data analysis is a continuous, iterative, and ongoing process. The stages of data reduction, data display, and conclusion drawing/verification represent the success of the analysis as a series of interconnected activities. However, the other two aspects remain important components of the field context (Nurfaridah & Arnesih, 2019).

Data reduction is the process of selecting, focusing, simplifying, abstracting, and transforming raw data obtained from field notes. This process occurs continuously throughout the implementation of qualitative research. The transformation or reduction of data continues until the final stage, which is the preparation of a complete research report. (Nurfaridah & Arnesih, 2019).

The second important stage in the analysis is data display. This refers to an organized collection of information that allows for conclusion drawing and decision making.

According to (Nurfaridah & Arnesih, 2019), the third step in qualitative data analysis is drawing conclusions and verifying data. From the beginning of data collection, a qualitative analyst begins to search for meaning in the obtained data by noting patterns, regularities, explanations, configurations, causal flows, and emerging propositions. Initial conclusions drawn are tentative and may change if strong evidence is not found in subsequent stages of data collection. However, if these initial conclusions are supported by valid and consistent evidence during further data collection, they become credible. Therefore, conclusions in qualitative research can answer the initial research questions, but they may also change, as research problems and questions in qualitative studies are often provisional and evolve based on field findings.

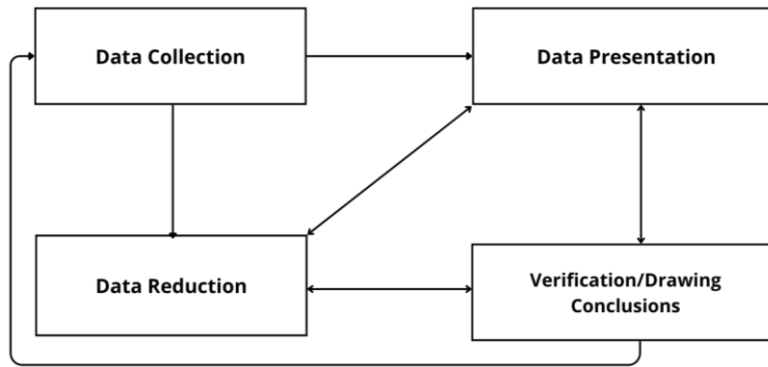


Figure 2 Miles and Huberman's Data Analysis Model

RESULTS AND DISCUSSION

Result of Interview with informan

In this section, the researcher will discuss in detail the findings obtained from the study based on the results of interviews with the informants.

Table 2. Research Findings

No	Aspects	Key Findings
1	Operational Constraints	Outdated cargo infrastructure/facilities and equipment, customs procedures, and licensing processes
2	Green Logistics	Many still dispose of cargo waste improperly and smoke in undesignated areas
3	Warehouse Management System (WMS)	Cargo processing is still conventional or manual and not yet systematic
4	Barriers to WMS Implementation	High investment costs; no operators with specific expertise in implementing the WMS have been found
5	Paperless System	There is still a reliance on manual documents for invoices and weighing slips

The parties selected as data sources who can provide information about the research problem are as follows:

1. Based on the research conducted by interviewing informants from PT Bandara Internasional Batam named Daniel Christian, Wayan Wijana, and Ibrahim, the researcher obtained a lot of information regarding findings that have not yet been addressed by PT Bandara Internasional Batam. The results of the research are as follows:
 - a. Operational Constraints: The interview results obtained from the key informant Daniel Christian explain that, "Currently, PT BIB still uses facilities, warehouses, and cargo equipment that were previously managed by BP Batam." (D. Christian, Interview, June 3, 2025). At the same time, informants Wayan Wijana and Ibrahim (interview, June 3, 2025) also explained that, "Of course, as in other regions, logistics operations in Batam are not free from several constraints and influencing factors. Although Hang Nadim Airport has an adequate runway, supporting facilities such as logistics warehouses, modern warehousing systems, and

specialized handling equipment for certain cargo still need to be improved. The licensing and customs clearance processes also sometimes pose challenges."

Field findings indicate that in cargo operational activities, there are still several significant obstacles, one of which is the inadequate condition of infrastructure and supporting facilities. Many of the cargo equipment currently in use are outdated and have not been updated in line with technological advancements, which affects the efficiency of loading and unloading processes and handling of goods. This condition causes longer processing times, increased risk of damage to goods, and requires more labor compared to using modern systems and equipment. This impacts the efficiency and effectiveness of loading and unloading processes as well as goods distribution.

- b. Green Logistics: The interview results obtained from the key informant Daniel Christian (interview, June 3, 2025) explain that, "Regarding green logistics, in our opinion, PT BIB is currently very concerned about it. This is evidenced by the fact that we have invited several external consultants related to waste management, hazardous materials (B3), environmental issues, as well as the regulation of habits among cargo service users who still often litter and many still smoke in outdoor areas. However, PT BIB is still in the process of improving towards the green logistics stage." Furthermore, the key and supporting informants also explained that, "Certainly, PT Bandara Internasional Batam fully understands the importance of the Green Logistics concept in facing global challenges related to sustainability and logistics efficiency. However, many bad habits that could impact the terminal area are still found. Green Logistics is an effort we can make to reduce the environmental impact of logistics activities by improving energy efficiency, reducing carbon emissions, and managing waste more responsibly." (Wijana & Ibrahim, interview, June 3, 2025).

The implementation of the green logistics concept still faces various challenges in the field. One of the main issues is the low environmental awareness among workers and logistics service users. There are still bad habits among both workers and logistics service users that do not align with sustainability principles. One common problem is the improper disposal of cargo waste or trash around warehouse and terminal operational areas. This not only causes environmental pollution but can also affect occupational health and safety in the surrounding areas. Additionally, the habit of smoking in prohibited areas, including near storage areas, poses an additional risk to health and safety at work and reflects the incomplete implementation of environmentally friendly logistics principles.

- c. Warehouse Management System (WMS): The interview conducted with the key informant Daniel Christian explained that, "The WMS is indeed very interesting for Batam because currently we are still carrying out cargo processes conventionally or manually, and all the activities we perform are still done manually and not yet systematic." (D. Christian, interview, June 3, 2025). Furthermore, informants Wayan Wijana and Ibrahim (interview, June 3, 2025) explained that, "PT Bandara Internasional Batam will begin implementing a Warehouse Management System (WMS) at the new Hang Nadim Cargo Terminal to support operational efficiency, although the current system is still manual or conventional. This is an initial step towards full digitalization in logistics and warehousing management in the

cargo terminal area.”

The warehouse management system (WMS) has not been optimally implemented in the cargo logistics process. Most of the warehouse management activities, from recording to arranging the position of goods, are still carried out conventionally or manually. The irregularity in this system causes low work efficiency and a high potential for human error, especially in recording and tracking the position of goods. Reliance on manual work also slows down the distribution process and hinders data integration that could otherwise be carried out digitally and in real-time.

- d. **Barriers to WMS Implementation:** The interview results with key informant Daniel Christian (interview, June 3, 2025) explained that, “Of course, there are definitely obstacles related to technical aspects. First, we need to find operators capable of carrying this out, because we see that implementing this requires a very significant cost, approximately 30 billion IDR or more.” Additionally, the key and supporting informants also explained that, “Regarding the implementation of the Warehouse Management System (WMS) in the Free Trade Zone (FTZ) area, PT Bandara Internasional Batam faces several barriers. Technology infrastructure such as high speed internet networks and hardware supporting the WMS are not yet fully optimal. This affects the smooth operation of the system, especially for real-time data processing. WMS operations require personnel with specialized skills, particularly in managing semi-automated to automated technology. There is still a competency gap that needs to be addressed through continuous training.” (Wijana & Ibrahim, interview, June 3, 2025).

One of the main obstacles in implementing the WMS system is the lack of personnel with specialized skills in this field. The current operators do not yet have adequate technical competencies to operate or utilize the WMS optimally. As a result, despite the desire to implement this system, the process is hindered by limited training, socialization, and support from trained human resources who are capable of adapting to new technology. Furthermore, the cost of implementing the WMS is still considered quite high.

- e. **Paperless System:** The interview results obtained from the key informant Daniel Christian explained that, “Regarding paperless, it is indeed very possible to implement. However, currently in Batam, cargo documents that we need to issue are still handled manually. For example, we have to issue invoices or receipts to service users manually. Additionally, we also have to issue weighing slips manually.” (D. Christian, interview, June 3, 2025). Furthermore, informants Wayan Wijana and Ibrahim (interview, June 3, 2025) explained that, “Many employees understand the importance of implementing a paperless system to support work efficiency and environmental sustainability. Employees also realize that the paperless system aligns with Green Logistics initiatives and can reduce environmental impact caused by excessive paper use. However, currently, in many logistics activities, physical document proofs are still issued for every document. Therefore, excessive paper use is still commonly encountered.”

Efforts to implement a paperless system in logistics document management are still not fully operational. In practice, there is still a high dependence on physical documents, such as invoices and weighing slips. This indicates that the digitalization of documents has not yet been fully implemented comprehensively and still requires system improvements as

well as changes in work culture. Dependence on manual documents not only slows down administrative processes but also carries the risk of losing or damaging important data.

2. Based on the research findings obtained from interviews with informants from PT Bandara Internasional Batam named Daniel Christian, Wayan Wijana, and Ibrahim, the researcher concludes the potential impacts related to the findings that have not yet been addressed by PT Bandara Internasional Batam. The impacts arising from each of these findings are as follows:
 - a. Decrease in operational efficiency: The use of outdated equipment that does not follow technological advancements results in slower loading and unloading processes. Consequently, logistics turnaround time increases, hindering the smooth flow of inbound and outbound goods distribution at the airport.
 - b. Increased risk of cargo damage: The lack of specialized handling equipment and inadequate infrastructure increases the potential for damage, especially for cargo requiring special care such as perishable goods, electronics, or special cargo.
 - c. Impact on customer trust: Delays, damage risks, and unreliable logistics processes can reduce customer satisfaction and trust (both export-import and domestic), which ultimately may lead to a decline in cargo volume handled.
 - d. Environmental pollution in operational areas: Improper disposal of cargo waste and trash by workers and users causes garbage accumulation around warehouses and terminals. This pollutes the airport environment and worsens the aesthetics, air quality, and soil conditions.
 - e. Failure to meet environmental standards: Non-compliance with environmental management standards (e.g., hazardous waste management, smoke free zones, waste treatment) could result in violations of government regulations or international standards. This may lead to administrative sanctions, fines, or revocation of operational permits.
 - f. Obstacles to full transition toward green logistics: Low environmental awareness among workers and service users is a major barrier to achieving green logistics transformation. Efforts such as improving energy efficiency, waste management, or emission reduction are difficult to implement without changes in culture and operational discipline.
 - g. Low warehouse operational efficiency: Manual warehouse management results in longer and suboptimal work times. Processes such as recording, item placement, and cargo retrieval take more time compared to automated and integrated systems.
 - h. Hindered data and digital system integration: The use of conventional systems makes it difficult to integrate warehouse management with other systems such as customs, inventory management, or shipment tracking. This slows down digitalization and innovation of overall logistics services.
 - i. Delays in goods distribution: Manual systems slow down the entire workflow from receipt, storage, to dispatch of goods, ultimately hindering distribution and reducing PT BIB's competitiveness as a logistics service provider.
 - j. Delayed logistics digitalization: Limited technology infrastructure and unprepared workforce hinder the transition from manual to digital systems. This slows down PT BIB's progress in fully implementing modern technology based logistics management.
 - k. Continued reliance on manual systems: Because the WMS has not been fully implemented, warehousing and logistics activities still rely on manual methods. This dependency results in ongoing issues with efficiency,

accuracy, and speed in logistics operations.

- l. Administrative inefficiency: Dependence on physical documents such as invoices, receipts, and weighing slips causes administrative processes to be slower and less practical. Data entry and document distribution take longer compared to instantly accessible digital systems.
 - m. High risk of data loss and damage: Physical documents are vulnerable to damage, loss, or storage negligence. This can disrupt workflows, impede document tracking, and potentially cause conflicts or administrative errors in logistics processes.
 - n. Increased operational costs: Large scale use of paper adds costs for stationery, printing, and archive storage. In contrast, digital systems can save long-term costs by reducing the need for physical materials and administrative labor.
 - o. Slow transition to full digitalization: System and work culture unpreparedness to adopt paperless processes delays the digital transformation that should support logistics service integration. This hampers innovation and efficiency in comprehensive logistics information management.
3. Based on research findings obtained through interviews with informants from PT Bandara Internasional Batam, namely Daniel Christian, Wayan Wijana, and Ibrahim, it can be deduced that the failure to implement green logistics at PT Bandara Internasional Batam is caused by three main issues: (1) outdated technology and infrastructure, (2) low environmental awareness at the operational level, and (3) suboptimal digitalization systems and human resource competencies. Each of these elements has significant implications for the sustainability of the logistics system in the free trade zone area.

The following are the main findings and implications that led to the failure to achieve green logistics, analyzed using a deductive-analytical approach based on interview findings with the informants.

a. Lagging Infrastructure and Operational Technology

Although green logistics emphasizes energy efficiency and process optimization, field observations reveal that most of the equipment used is outdated and environmentally unfriendly. This results in slow loading and unloading processes, excessive energy consumption, and high labor demand, which contradict the efficiency principles of green logistics.

Implication: Slow operational activities, energy inefficiency, and an increased corporate carbon footprint due to the use of conventional heavy equipment.

b. Low Environmental Awareness in the Workplace

The behavior of workers and logistics service users that contradicts sustainability principles such as littering and smoking in prohibited areas—demonstrates that the work culture does not yet support the implementation of green logistics.

Implication: Environmental pollution in terminal and warehouse areas, increased risk of workplace accidents, and the company's failure to establish a clean and safe logistics ecosystem.

c. Suboptimal System Digitalization and Limited Human Resource Competence

The warehouse management system (WMS) and paperless systems have not been running optimally. The continued dominance of manual processes indicates that digital transformation has not been fully accepted or supported by competent human resources. Another major obstacle lies

in the high cost of technology implementation and the lack of training.

Implication: Logistics processes inefficient, prone to human error, difficult to monitor in real time, and pose a risk of losing important data. This contradicts the principles of green logistics, which promote efficiency and the use of environmentally friendly technology.

Discussion

Based on the findings from the interview data analysis with the informants, it can be concluded that there are several key aspects that have not yet been fully implemented by PT Bandara Internasional Batam (PT BIB) in optimizing cargo operations at Hang Nadim Airport. The interview findings indicate that most of the infrastructure and cargo equipment used by PT Bandara Internasional Batam (PT BIB) are inherited from the previous management and have not undergone significant upgrades. According to (Kuruvilla et al., 2020), this condition contradicts the fundamental principles of green logistics, which aim to reduce environmental impact through operational efficiency, the use of clean energy, and the modernization of logistics systems.

Furthermore, according to informants Wayan Wijana and Ibrahim, although Hang Nadim Airport has an adequate runway, supporting facilities such as modern logistics warehouses, up-to-date warehouse management systems, and specialized handling equipment for certain types of cargo are still not optimally available. These findings indicate that PT BIB has not made sufficient investments in the modernization of logistics infrastructure, both in terms of technology and physical facilities. The equipment currently in use is considered outdated and does not keep up with the latest technological developments, thereby hindering loading and unloading efficiency and increasing the risk of cargo damage.

The handling process also becomes slower and requires more labor, which ultimately has a negative impact on the efficiency and effectiveness of goods distribution. Furthermore, the use of renewable energy can reduce daily carbon emissions as a form of mitigation against global climate change and support sustainability efforts in the airport's surrounding environment (Pinatik et al., 2023). This highlights the need for strategic action by PT BIB to modernize logistics facilities and equipment as part of efforts to develop a more professional and competitive cargo system, especially in the Free Trade Zone area.

Therefore, in 2025, PT BIB began relocating the old cargo terminal to a newly completed cargo terminal. Previously, the old cargo terminal covered only 1,600 m². However, the new cargo terminal is significantly larger, covering around 9,600 m². With this considerably larger facility, PT BIB has started to simulate a semi-automatic system concept, which still requires human labor for tasks such as data entry, weighing, and random document checks. Consequently, in this new cargo terminal, PT BIB is also beginning to implement a semi-automatic system connected to the Warehouse Management System (WMS), including components such as a sortation system, pallet tracking system, autogate system, and also the online temporary storage facility (TPS).

Consequently, PT BIB has not yet fully implemented a comprehensive green logistics system and still needs to adopt a more systematic approach through the strengthening of internal regulations, continuous education for all stakeholders, and stricter operational oversight in order to create an environmentally friendly and sustainable logistics ecosystem. In addition, the implementation of green logistics practices can lead to operational efficiency and cleaner production (Karaman et al., 2020).

In response to various operational obstacles identified through the research data analysis, PT Bandara Internasional Batam has begun implementing a forward-looking strategic plan. First, it is revitalizing environmentally friendly logistics facilities and infrastructure by renewing and replacing outdated cargo equipment with energy-efficient technologies such as electric forklifts, automated conveyors, and smart warehouse systems. Second, the company is establishing strategic partnerships with potential investors to develop supporting infrastructure such as servers, networks, and cloud-based software that

are also energy-efficient. In addition to enhancing operational effectiveness, the use of this technology aligns with the principles of Green Logistics by reducing the consumption of physical resources such as paper and fuel. Third, PT BIB is gradually implementing an integrated paperless system across all logistics processes, especially at the Cargo Terminal.

This transformation can begin with the digitization of key documents such as invoices, receipts, and weighing slips through secure, cloud-based electronic systems that are easily accessible to service users. The use of digital signatures and integration with electronic customs systems can also accelerate document processing without the need for physical printouts. To support this implementation, PT BIB provides technical training to all employees to ensure they can operate the software and fully understand the digital document procedures.

Another study conducted by (Suryan et al., 2024), on the implementation of eco green airports in reducing carbon emissions: a systematic review, states that the application of eco green airport strategies requires the use of renewable energy, energy efficiency, waste management, green transportation, greening initiatives, and proper water management. This aims to minimize environmental pollution caused by airport operational activities and reduce costs so that the savings can be redirected to more urgent needs. Although there are still challenges in implementing eco airports, collective commitment and continuous innovation can help achieve the goal of significantly reducing carbon gas emissions.

Another study conducted by (Zulfikri, 2024), entitled *Integrating Green Procurement and Logistics: Overcoming Barriers for Sustainable Supply Chains* explains that, on the green logistics side, commonly used strategies include route optimization, load consolidation, and the use of transportation management technologies to reduce greenhouse gas emissions. According to (Zulfikri, 2024), the study highlights the role of information technology in enabling real-time monitoring and improving sustainable logistics performance.

CONCLUSION

Based on the interview findings, cargo logistics operations at the research site still face various challenges, such as outdated infrastructure and equipment, low environmental awareness, suboptimal implementation of the Warehouse Management System (WMS), and reliance on physical documents. These obstacles affect the efficiency, effectiveness, and sustainability of operations. Therefore, there is a need for facility modernization, improvement of human resource competencies, process digitalization, and a shift in work culture toward more environmentally friendly and sustainable logistics practices.

PT Bandara Internasional Batam is advised to increase investment in environmentally friendly technologies, such as renewable energy and electric-powered operational vehicles that suit the logistics environment within the Free Trade Zone (FTZ). For the government and FTZ administrators, it is hoped that they will support logistics companies in adopting sustainable practices by providing incentives, supportive regulations, and eco-friendly infrastructure within the FTZ area. For future researchers, this study is limited to a single case study. Future research is encouraged to broaden the scope by including other logistics companies within the FTZ area or conducting comparative studies between FTZ and non-FTZ regions to gain a more comprehensive understanding of green logistics implementation.

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