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Resilient Ecosystems: Key to Environmental Disaster Resilience and Logistics Efficiency

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Abstract: One sector that is significantly affected is the logistics sector. Disruptions to transportation infrastructure, communication networks, and supply chains can hamper the distribution of humanitarian aid, evacuation of victims, and post-disaster economic recovery. This research was conducted in Gowa Regency, from the Gowa Regency disaster incident that occurred from 15-25 December 2024, and January 2025. Strong winds and landslides caused damage to residents' houses, agricultural land, and road infrastructure. The purpose of this study is to examine Resilient Ecosystems: Key to Environmental Disaster Resilience and Logistics Efficiency. Descriptive research methods aim to provide a clear and detailed picture of a phenomenon, event, or characteristic of a particular population. The results of this study explain: The function of the ecosystem is as a habitat for living things; as a natural resource; as a regulator of environmental balance; as a place of protection; oxygen production; carbon dioxide absorption; climate regulation; erosion prevention; pollination; pest and disease control; provision of clean water: the role of resilient ecosystems in environmental disaster resilience: disaster risk reduction; coastal protection; climate regulation; provision of resources; ecosystem restoration: several efforts to build resilient ecosystems: biodiversity conservation; ecosystem restoration; sustainable resource management; reduction of greenhouse gas emissions; increasing public awareness.

Keywords: Environmental disasters; Key to resilience; Logistics efficiency; Resilient ecosystem

Introduction

Environmental disasters, whether caused by nature or human activities, pose a serious threat to the sustainability of ecosystems and human life (Gunjyal et al., 2023; Tong et al., 2022). These disasters can cause huge losses, environmental damage, and loss of life. In this context, logistics efficiency plays a crucial role in disaster impact mitigation and post-disaster recovery. Indonesia, as an archipelagic country located on the Pacific Ring of Fire, has a high level of vulnerability to various types of natural disasters, such as earthquakes, tsunamis, floods, landslides, and volcanic eruptions. In addition to natural disasters, environmental disasters caused by human activities, such as deforestation, pollution, and climate change, are also increasing. These disasters not only damage the environment but also disrupt economic and social activities of the community. One sector that is significantly affected is the logistics sector. Disruptions to transportation infrastructure, communication networks, and supply chains can hamper the distribution of humanitarian aid, evacuation of victims, and post-disaster economic recovery. In this study Based on data from the Regional Disaster Management Agency (BPBD) of Gowa Regency, from the Gowa Regency disaster incident that occurred from December 15-25, 2024, and January 2025. Strong winds and landslides caused damage to residents' homes,

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agricultural land, and road infrastructure. Several roads were even cut off due to landslides, hampering accessibility and the economy of the local community. In addition to strong winds and landslides, strong winds that hit several areas in Gowa also caused trees to fall at various points. These fallen trees hit residents' homes and closed road access, causing transportation disruptions and endangering road users.

The Mitigation Efforts carried out by the Gowa Regency Government, together with BPBD and related agencies, have made various disaster management efforts. The SAR team was deployed to evacuate and rescue affected residents. Logistical and medical assistance was also distributed to disaster victims. In addition, the government is also trying to repair infrastructure damaged by the disaster, such as roads and bridges that were cut off. Recovery efforts are also being carried out in the agricultural sector, by providing assistance to farmers who have suffered losses due to floods and landslides and strong winds. Appeal to the Community Given the potential for extreme weather, the Gowa Regency BPBD urges the public to remain vigilant and careful. The public is asked to monitor weather developments through information from BMKG and follow directions from the local government. Some anticipatory steps that the public can take include: Avoiding disaster-prone areas, such as riverbanks and hillsides; Cleaning water channels so that they do not become clogged and cause flooding; Cutting down trees that are likely to fall; Preparing a disaster preparedness bag containing emergency needs.

In dealing with environmental disasters, logistics efficiency is an important key to ensuring that aid can reach victims quickly and accurately, as well as restore conditions in disaster-affected areas. However, obstacles are often found in the implementation of disaster management logistics, such as: Ineffective Coordination (Timperio et al., 2020): Lack of coordination between various related parties, such as the government, non-governmental organizations, and volunteers, can hinder the distribution of aid and slow down the recovery process. Damaged Infrastructure: Damage to transportation and communication infrastructure due to disasters can hinder accessibility and slow down the distribution of aid. Limited Resources: Limited human and financial resources can hinder logistics efforts in disaster management. Lack of Information: Lack of accurate and up-to-date information on the conditions of disaster-affected areas can hinder logistics planning and implementation.

Ecosystem is an ecological system formed by the reciprocal relationship between living things and their environment (Baedke et al., 2021). Ecosystem is a complete and comprehensive unity between all elements of the environment that influence each other (De Bernard et al., 2022). Definition of Ecosystem According to Experts: Woodbury: Ecosystem is a complex unity in an area with habitat, plants, and animals. This condition is considered as a complete unit, so that everything can be a chain of material cycles and energy flows; Odum: Ecosystem is a group of living things that interact with each other with their environment and form a unity. Soemarwoto: Ecosystem is a system formed by the unity of biotic and abiotic elements that interact with each other. A resilient ecosystem is an ecosystem that has the ability to recover quickly after experiencing disturbances or stresses, including natural disasters. These ecosystems have several key characteristics (Cobben et al., 2022; Weiskopf et al., 2020): High Biodiversity: High species diversity helps ecosystems adapt more easily to change. If one species becomes extinct, others can fill its role; Strong Connectedness: Complex networks of interactions between species make ecosystems more stable. If one species is affected, other species involved can still help maintain ecosystem function; Adaptive Capacity: Resilient ecosystems have the ability to adapt to changing environmental conditions, such as climate change or natural disasters; Nutrient Balance: Healthy nutrient cycles ensure that essential resources such as water and nutrients are available to all components of the ecosystem.

Resilient ecosystems play a vital role in reducing disaster risk and helping communities recover more quickly after disasters (Zaman & Raihan, 2023). Here are some examples: Natural Protection: Mangroves, coral reefs, and wetlands can protect coastal areas from storm surges and tsunamis; Water Regulation: Forests and wetlands help absorb rainwater and reduce the risk of flooding; Soil Stability: Vegetation helps prevent soil erosion and landslides; Rapid Recovery: Healthy and diverse ecosystems recover more quickly from disaster damage. Building resilient ecosystems requires efforts from a variety of stakeholders, including governments, communities, and the private sector. Here are some steps that can be taken: Biodiversity Conservation: Protecting species and natural habitats is essential to maintaining the biodiversity of ecosystems; Ecosystem Restoration: Restoring damaged ecosystems, such as deforested forests or damaged coral reefs, can increase ecosystem resilience; Sustainable Resource Management: Managing natural resources such as water and forests wisely can help maintain healthy ecosystems; Pollution Reduction: Reducing pollution of water, air, and land can help maintain environmental quality and ecosystem health; Public Awareness: Raising public awareness of the importance of resilient ecosystems can encourage actions to protect and conserve the environment. Logistics efficiency is a

measure of success in the management and implementation of logistics activities with the aim of achieving optimal results with minimal use of resources (Chen et al., 2024; Ferraro et al., 2023). In a business context, logistics efficiency covers various aspects, from planning, procurement, storage, transportation, to distribution of goods or services to end consumers.

The main objectives of logistics efficiency are: Reducing Costs: By optimizing the logistics process, companies can reduce operational costs such as transportation, storage, and material handling costs; Increase Speed and Accuracy: Logistics efficiency ensures that goods or services can reach consumers quickly and on time; Increase Customer Satisfaction: With fast and accurate delivery, companies can increase customer satisfaction and loyalty. Increase Competitiveness: Companies that have an efficient logistics system will have a competitive advantage over their competitors. Some factors that affect logistics efficiency include: Mature Planning: Good planning is very important in determining the right logistics strategy (Rakyta et al., 2022; Mittal et al., 2018). This includes planning needs, procurement, storage, and distribution; Technology: The use of technology such as logistics management information systems (WMS), shipment tracking systems, and warehouse automation can significantly improve logistics efficiency. Infrastructure: The availability of adequate infrastructure such as roads, ports, and airports is essential for smooth logistics processes (Wagner et al., 2022; Munim & Schramm, 2018); Human Resources: A well-trained and competent workforce also plays a significant role in logistics efficiency; Collaboration with Third Parties: Collaborating with third-party logistics (3PL) providers can help companies focus on their core business; Some ways to improve logistics efficiency include: Optimizing Shipping Routes: Using software or applications to plan the most efficient shipping routes can reduce transportation costs and delivery times; Managing Inventory Effectively: Using a good inventory management system can help companies avoid shortages or excess inventory.

Automating Warehouse Processes: Using automation technologies such as robots or conveyor systems can increase efficiency and reduce errors in the storage and retrieval process.; Improving Supply Chain Visibility: Using tracking technology, companies can monitor the movement of goods in real-time and identify potential problems early on; Building Strong Partnerships: Collaborating with suppliers, logistics providers, and other stakeholders can help companies improve overall logistics efficiency. Previous research has been conducted on Rodriquez et al. (2022), Identifying the Importance of Disaster Resilience Dimensions across Different Countries Using the Delphi Method (Tsvetkova et al., 2025). Based on the background above, this study aims to examine Resilient Ecosystems: The Key to Resilience to Environmental Disasters and Logistics Efficiency.

Method

Descriptive research methods aim to provide a clear and detailed picture of a phenomenon, event, or characteristic of a particular population. In this study, based on data from the Regional Disaster Management Agency (BPBD) of Gowa Regency, from the disaster incidents in Gowa Regency that occurred from 15-25 December 2024, and January 2025. Strong winds and landslides caused damage to residents' houses, agricultural land, and road infrastructure. The flow of descriptive research generally follows these steps:

Identification and Formulation of the Problem

This research is descriptive research that begins by identifying the problem or phenomenon to be studied. This problem must be clear and specific, and relevant to the field of interest: After the problem is identified, the researcher formulates the research objectives to be achieved. These objectives must be in line with the problems that have been identified.

Literature Study

Researchers conduct literature studies to collect information and theories relevant to the research problem. This literature study helps researchers understand the context of the problem, develop a theoretical framework, and formulate hypotheses (if any).

Development of Research Instruments

Researchers develop research instruments that will be used to collect data. These instruments can be questionnaires, interviews, observations, or documentation studies. Research instruments must be valid and reliable to ensure that the data collected is accurate and consistent.

Data Collection

Researchers collect data from predetermined research subjects. Data collection methods must be in accordance with the type of data needed and the research instruments that have been developed.

Data Analysis

The data that has been collected is analyzed to answer research questions or test hypotheses. The data analysis method used must be in accordance with the type of data and research objectives.

Conclusion Drawing

Based on the results of the data analysis, the researcher draws conclusions that are relevant to the research problem. This conclusion must be supported by the data and analysis that has been carried out.

Report Preparation

The researcher prepares a research report that contains a complete description of the research that has been conducted, including the background, objectives, research methods, data analysis results, and conclusions.

Visual Descriptive Research Flow

Problem Identification --> Literature Study --> Instrument Development --> Data Collection --> Data Analysis.

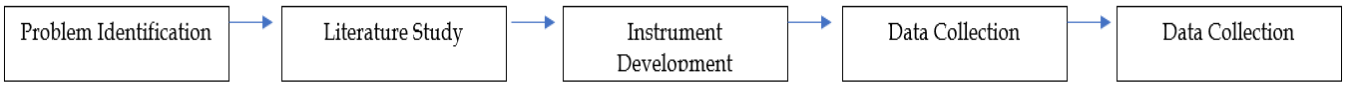

Figure 1. Visual descriptive research flow

Result and Discussion

Ecosystem is an ecological system formed by the reciprocal relationship between living things and their environment. Ecosystem is a complete and comprehensive unity between all elements of the environment that influence each other (Cao et al., 2024; Adner, 2017). The following is a study of Ecosystem Functions, the Role of Resilient Ecosystems in Resilience to Environmental Disasters, Efforts to Build Resilient Ecosystems:

Ecosystem Functions

An ecosystem is a complex and dynamic system, where living things interact with each other and with their environment. These interactions produce various functions that are important for life on Earth. In general, ecosystem functions can be grouped into (Kandziora et al., 2013; Keith et al., 2022; Gascon et al., 2015).

As a Place for Living Things

Ecosystems provide habitats for various types of living things, from plants, animals, to microorganisms. Each living thing has its own role and function in the ecosystem.

As a Natural Resource

Ecosystems provide various natural resources that are important for human life, such as (Jacob et al., 2020; Adla et al., 2022): Water: A source of clean water for daily needs, irrigation, and industry; Food: A source of food from plants and animals; Fuel: A source of energy from wood, petroleum, and natural gas; Medicines: A source of raw materials for medicines from plants and animals.

As a Regulator of Environmental Balance

Ecosystems play an important role in maintaining environmental balance, including through (Córdoba Hernández & Camerin, 2024): Water cycle: The process of recycling water through evaporation, transpiration, condensation, and precipitation; Carbon cycle: The process of exchanging carbon between the atmosphere, plants, animals, and soil; Nitrogen cycle: The process of nitrogen changing from inorganic to organic form and vice versa.

As a Shelter

Ecosystems, especially forests, function as a shelter for various types of living things. Forests also play an important role in preventing natural disasters such as floods and landslides.

Oxygen Production

Plants in ecosystems produce oxygen through the process of photosynthesis. Oxygen is very important for the lives of most living things on Earth.

Carbon Dioxide Absorption

Plants in ecosystems absorb carbon dioxide from the atmosphere through the process of photosynthesis. This helps reduce the greenhouse effect and climate change.

Climate Regulation

Forests and other vegetation in ecosystems help regulate local and global climates. Forests play a role in maintaining air humidity, reducing extreme temperatures, and influencing rainfall patterns.

Erosion Prevention

Plant roots in ecosystems help prevent soil erosion. Vegetation also protects the soil from wind and rain that can cause erosion.

Pollination

Several types of animals, such as insects and birds, play a role in pollinating plants. Pollination is important for plant reproduction and the production of fruits and seeds (Khalifa et al., 2021; Pioltelli et al., 2024).

Pest and Disease Control

A healthy ecosystem has high biodiversity. This diversity helps control pest and disease populations naturally.

Providing Clean Water

Forests and wetlands in the ecosystem play an important role in providing clean water. Vegetation helps filter water and maintain groundwater quality.

Understanding Resilient Ecosystems

A resilient ecosystem is an ecosystem that has the ability to recover after experiencing disturbances or stresses, including environmental disasters. The resilience of this ecosystem is determined by various factors, such as biodiversity, complex trophic structure, and species adaptability (Thorogood et al., 2023).

Characteristics of Resilient Ecosystems

High Biodiversity: Ecosystems with high biodiversity tend to be more resilient because they have a variety of species that can fill different ecological roles. If one species is lost, another species can take over its role.; Complex Trophic Structure: A complex trophic structure, with many interconnected food chains and food webs, makes the ecosystem more stable. If one species in the food chain is disturbed, other species can still be a food source for predators; Adaptability: Species in resilient ecosystems have the ability to adapt to environmental changes, including changes caused by disasters. These adaptations can be physiological, behavioral, or genetic; Resource Availability: Resilient ecosystems have sufficient availability of resources, such as water, nutrients, and energy (Weiskopf et al., 2020). These resources are essential for ecosystem recovery after disturbance; Connectivity: Ecosystems that are connected to each other have a greater chance of recovering from disasters. Connectivity allows species to move and find new habitats if their ecosystem is disturbed (Seddon et al., 2021; Timpane-Padgham et al., 2017; Chambers et al., 2019).

The Role of Resilient Ecosystems in Environmental Disaster Resilience

Resilient ecosystems play a critical role in reducing the risk of environmental disasters and helping communities adapt to their impacts. Here are some key roles of resilient ecosystems:

Disaster Risk Reduction

Healthy ecosystems, such as forests and wetlands, can reduce the risk of flooding, landslides, and erosion. Vegetation can hold rainwater, prevent soil erosion, and stabilize slopes.

Coastal Protection

Coastal ecosystems, such as mangrove forests and coral reefs, protect coastlines from storm surges and erosion. They also provide habitat for a variety of marine life that are important for fisheries.

Climate Regulation

Forests and other ecosystems play a role in global and local climate regulation. Forests absorb carbon dioxide from the atmosphere, helping to mitigate the greenhouse effect and climate change.

Resource Provision

Healthy ecosystems provide communities with a variety of essential natural resources, such as clean water, food, medicine, and fuel. These resources can help communities survive and recover from disasters.

Ecosystem Recovery

A resilient ecosystem has the ability to recover after a disturbance, including a disaster. This recovery can help restore ecosystem function and reduce the long-term impacts of a disaster.

Examples of Resilient Ecosystems

Tropical Rainforests: Tropical rainforests have very high biodiversity and complex trophic structures, making them highly resilient; Coral Reefs: Coral reefs are highly productive and diverse ecosystems, providing coastal protection and habitat for many marine species; Wetlands: Wetlands, such as marshes and lakes, serve as natural water reservoirs and help reduce the risk of flooding (Angeler et al., 2023).

Efforts to Build Resilient Ecosystems

Building resilient ecosystems is key to increasing resilience to environmental disasters. Here are some efforts that can be made:

Biodiversity Conservation

Protecting biodiversity is essential to building resilient ecosystems. This can be done by creating conservation areas, reducing deforestation, and controlling invasive species.

Ecosystem Restoration

Restoring damaged ecosystems can improve the overall resilience of the ecosystem. Restoration can be done by replanting forests, rehabilitating wetlands, and cleaning up pollution.

Sustainable Resource Management

Sustainably managing natural resources, such as water, land, and forests, can help maintain the health of ecosystems and increase their resilience.

Greenhouse Gas Emission Reduction

Reducing greenhouse gas emissions is essential to mitigate the impacts of climate change, which can exacerbate the risk of environmental disasters.

Public Awareness Building

Raising public awareness about the importance of resilient ecosystems and how to build them is key to achieving resilience to environmental disasters. Efficiency in logistics means conducting logistics activities in the most effective and efficient manner, with the aim of reducing costs, increasing speed, and improving service quality (Li et al., 2023; Mittal et al., 2018). Logistics efficiency can be achieved in a variety of ways, such as (Jiang et al., 2023; Wang et al., 2025; Slam et al., 2023): Transportation Optimization: Choosing the most appropriate mode of transportation, planning efficient routes, and utilizing technology to track shipments; Effective Inventory Management: Managing inventory carefully to avoid shortages or excesses. This can be done by using sophisticated inventory management systems and forecasting customer demand; Use of Technology: Leverage technology such as logistics management information systems, route planning software, and shipment tracking systems to improve efficiency; Third-Party Partnerships: Partner with third-party logistics (3PL) providers to leverage their expertise and resources; Lean Processes: Design simple, efficient logistics processes, eliminating unnecessary steps; Performance Measurement: Measure logistics performance regularly to identify areas for improvement (Govindan et al., 2022; Lam et al., 2024).

Figure 2. Victim information and logistics interviews from BNPB

Benefits of Logistics Efficiency

Logistics efficiency can provide a variety of benefits to a company, including (Abbasi et al., 2024; Trivellas et al., 2020): Cost Reduction: Reduce transportation, storage, and other operational costs; Increased Speed: Speed up delivery times and reduce customer wait times; Improved Service Quality: Improve delivery accuracy, reduce damage to goods, and increase customer satisfaction; Increased Competitiveness: Increase the company's competitiveness by offering more competitive prices and better service.

Conclusion

The conclusion obtained in this study is that the Ecosystem has various functions that are very important for life on Earth. These functions include the provision of natural resources, regulation of environmental balance, protection, and various other ecological processes. Understanding the function of the ecosystem is very important for maintaining environmental sustainability and the sustainability of life on Earth; Resilient ecosystems are the key to resilience to environmental disasters. By building and maintaining resilient ecosystems, we can reduce the risk of disasters, protect communities, and ensure the sustainability of life on Earth; Logistics efficiency is the key to business success in the era of globalization. By improving logistics efficiency, companies can reduce costs, increase speed, improve service quality, and increase their competitiveness.

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Author Contributions

D. contributed to research, product development, data analysis, and article writing; D. J., as a supervisor in research activities until article writing.

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Conflicts of Interest

The author declares that he has no conflict of interest.

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