Assessment of airport conditions in resilience efforts: A review

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Abstract. Airports, as one of the important transportation infrastructures in a country or region, play a role in the distribution of goods and people. This study aims to compile variables from a literature review to assess the condition of airport natural disaster preparedness. Airports have good resilience when facing natural disasters. This study compiles literature by collecting references from various sources, including journal articles, proceedings articles, and textbooks. So, there are nine factors, such as safety, infrastructure, passenger facilities, availability and performance, operational efficiency, service quality, and environmental sustainability. and thirty subfactors in assessing airport conditions in resilience efforts.

1 Introduction

The climate change that is happening in various parts of the world also has an impact on Indonesia, especially on transportation infrastructure, and has the potential to cause phenomena that cause natural disasters. Airports, as part of the transportation infrastructure, play an important role in moving people and goods by aeroplane. Airports have risks in their operations, and to maintain the performance of airports and their activities, it is expected to have resilience in dealing with natural disasters. Airport resilience has an important role. These important roles include security from acts of terrorism, preparedness in dealing with disasters, the availability and reliability of infrastructure, strong infrastructure, and supporting infrastructure. The role of the airport is to ensure that air transportation remains safe, efficient, and reliable for passengers and other airport users. Airport resilience can be started by assessing the condition of the airport and the risk of natural disasters through the history of their occurrence in the area. The condition of the airport must be known as a measure in assessing how the airport can be known for its adaptation value to natural disaster risks. This research begins by collecting relevant references to support the strength of the literature on the formulation of a thinking framework. From the existing references, it will be known the supporting variables as a basis for measuring an airport condition. The importance of airport conditions is an important point to consider when determining a rating value. The rating values that will be given from these measurements can be letter grades, such as A, B, C, D, and E. These rating values reflect the level of quality, readiness, and reliability of the infrastructure. From the existing conditions at the airport, the results of measuring the condition of the airport will reflect the level of quality, readiness, and reliability of the airport.

1.1 Research purposes

The purpose of this study is to collect the results of a literature study in the form of factors to measure the condition of airports in preparation for natural disasters as well as mitigation actions that need to be taken to increase airport resilience in the future to ensure the continuity of airport operations in disaster-prone areas and increase the resilience of critical infrastructure, which are presented in supporting reference form.

1.2 Research benefits

This research has several benefits that can be obtained: first, knowing the factors in assessing airport conditions; second, knowing the potential disaster risk factors that hit airports; knowing the factors that are suitable to be applied at the airport; and contributing to our knowledge and understanding of airport resilience in the face of natural disasters.

1.3 limitations of the problem in research

The limitations of the problem in this study are focused on the literature and the results of a review of airport resilience to natural disasters. In addition, the scope of the study is limited to airport transportation infrastructure and does not extend to other modes of transportation infrastructure. The study also did not include an analysis of the economic or social impact of airport disruptions caused by natural disasters.

2 Theoretical

Airports are critical infrastructure that plays a crucial role in regional transportation and economic development [1]. However, they are also highly

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vulnerable to natural disasters and other extreme weather events [2]. These disasters can significantly impact airport operations, cause damage to critical infrastructure, and disrupt regional connectivity and economic activity [3]. Therefore, it is essential to assess the resilience of airports against natural disasters to ensure the continuity of airport operations during and after such events[4].

Resilience is the ability of a system to withstand and recover from disruption and continue its critical functions [5]. In the context of airports, resilience refers to the ability of the airport system to maintain critical functions and performance after being affected by natural disasters [6]. Evaluating the resilience of airports requires a comprehensive understanding of the interdependent components that make up the airport system and their vulnerabilities to natural disasters [7].

To assess the resilience of airports against natural disasters, various methods and tools have been developed [8]. One such tool is the Infrastructure Rating Tool (IRT), which assesses the physical condition and performance of critical infrastructure systems [9].

Assessing the resilience of airports against natural disasters is essential to ensure the continuity of airport operations and regional connectivity [10]. The proposed model in this study can contribute to enhancing the resilience of airports against natural disasters, which is critical for regional development. Moreover, the proposed model can be applied to other airports located in disaster-prone areas to improve critical infrastructure resilience.

2.1 Resilience infrastructure

Resilience Infrastructure refers to the design and construction of infrastructure systems that are able to withstand and recover from disruptions caused by natural disasters, climate change, and other types of shocks and stresses [11]. This involves building infrastructure that is adaptable, flexible, and resistant to damage, as well as developing strategies for rapid recovery and restoration of critical functions [12]. The importance of resilience infrastructure lies in its ability to ensure the continuity of essential services and functions during and after disruptive events, which is critical for preserving public safety, supporting economic activity, and maintaining social stability [13]. In the context of the research on the assessment of airport resilience in Tarakan City, developing resilience infrastructure for the airport can help mitigate the impacts of natural disasters and ensure the airport's ability to continue critical functions and operations [14].

Resilience infrastructure aims to ensure that the systems and infrastructure in place are able to resist and recover from any potential disruptions or shocks caused by natural or man-made disasters [15]. The concept of resilience infrastructure emphasizes the importance of not only building new infrastructure but also maintaining and upgrading existing infrastructure to withstand potential risks and be more sustainable over the long term [16]. In the context of this research, resilience infrastructure for airports includes physical structures such as runways, terminals, and other critical facilities, as well as communication systems, backup power sources, and emergency response plans [17]. By implementing resilience infrastructure measures, airports can better prepare for and respond to disasters and minimize their impact on airport operations and the surrounding community[18]. This is especially important in disaster-prone areas like Tarakan City, where the airport plays a critical role in regional connectivity and economic development [19].

Resilience infrastructure refers to the ability of infrastructure systems to withstand and recover from disruptive events, such as natural disasters or man-made disturbances [20]. The concept of resilience infrastructure emphasizes the importance of building and maintaining infrastructure systems that can continue to function during and after such events [21]. This requires a holistic approach to infrastructure design and management, taking into account factors such as the physical robustness of the infrastructure, its ability to adapt to changing circumstances, and the resilience of its supporting systems and networks [22]. In the context of the research on assessing the resilience of airports against natural disasters, resilient infrastructure plays a crucial role in ensuring the continuity of airport operations and regional connectivity in the face of disruptive events [23]. By identifying and addressing vulnerabilities in the airport's infrastructure and supporting systems, decision-makers can take proactive steps to improve airport resilience and mitigate the impacts of natural disasters [24].

2.2 Disaster resilience

Disaster resilience refers to the ability of a system or community to withstand, adapt, and recover from the impacts of natural or human-made disasters [25]. It encompasses preparedness, response, and recovery actions taken to reduce the effects of disasters and minimize their impact on people, the environment, and the economy[26]. In the context of this research, disaster resilience is crucial for the airport in Tarakan City, as it is vulnerable to various natural disasters such as floods, landslides, and earthquakes. Evaluating the disaster resilience of the airport system is essential to ensure its continuity of operation and prevent significant economic and social losses caused by natural disasters [27]. This research aims to develop a model for assessing the disaster resilience of the airport in Tarakan City against various natural disasters, which can be used as a guide to prioritize mitigation actions to enhance the airport's disaster resilience.

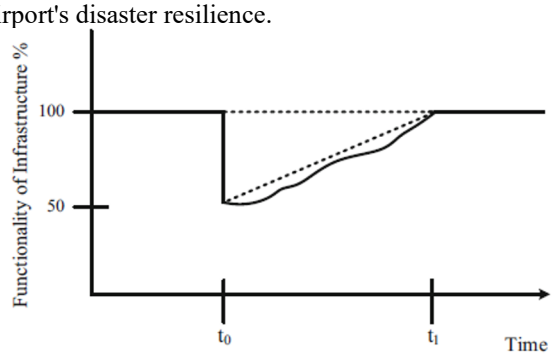

Fig. 1. Resilience triangle [28-29].

Fig. 1 shows the function of infrastructure when a hazard or disturbance occurs, the time needed to survive, and the time needed for recovery.Disaster resilience is the ability of a system to absorb and recover from the impacts of disasters, while still being able to maintain its essential functions [27]. It involves the capacity to prepare for, respond to, and recover from disasters, including natural hazards and human-made crises [30]. Disaster resilience is critical for ensuring the continuity of critical infrastructure systems, such as airports, and for safeguarding public health and safety[31]. In the context of this research, disaster resilience is essential for ensuring that the airport in Tarakan City can continue to operate effectively and provide critical services, even after a natural disaster. By assessing the resilience of the airport against natural disasters, this research can help decision-makers prioritize mitigation efforts and allocate resources effectively to enhance the airport's resilience and improve the continuity of airport operations.

Disaster resilience is an important aspect to consider in this research as it focuses on evaluating the resilience of airports in Tarakan City against natural disasters. In the face of climate change, the frequency and intensity of natural disasters are expected to increase, and it is crucial to ensure the continuity of critical infrastructure such as airports during and after these events [32]. The proposed model aims to assess the airport's ability to maintain critical functions and performance after being affected by natural disasters [33]. By integrating various factors that affect airport resilience through a multi-criteria analysis method, the model can help decision-makers prioritize mitigation actions to improve airport resilience in the future [34]. The significance of this study lies in its contribution to enhancing the resilience of airports against natural disasters, which is critical for ensuring the continuity of airport operations and regional connectivity. Furthermore, the proposed model can be applied to other airports located in disaster-prone areas to improve critical infrastructure resilience.

2.3 Understanding risk

Understanding Risk is a framework that helps decision-makers and stakeholders identify, assess, and manage disaster risk [35]. It is a concept that emphasizes the importance of proactive measures to mitigate the impact of disasters rather than relying solely on reactive responses [36]. Understanding Risk aims to provide a comprehensive approach to disaster risk management by considering various aspects such as hazard identification, vulnerability assessment, risk analysis, and mitigation measures [37]. It also involves stakeholder engagement, risk communication, and capacity building to ensure that decision-making is informed and effective [38].

In the context of this research, Understanding Risk is critical for identifying and assessing the risk of natural disasters on the airport infrastructure in Tarakan City. By utilizing the Understanding Risk framework, the research can identify the hazards that may affect the airport, assess the vulnerabilities of critical infrastructure, and analyze the risk of disasters. It also enables the research to develop mitigation measures that can reduce the impact of disasters and improve the airport's resilience [39]. The involvement of stakeholders and effective risk communication are also essential components of Understanding Risk, ensuring that decision-making is informed and aligned with the needs of the community [40]. Overall, Understanding Risk is crucial for enhancing disaster resilience and ensuring the continuity of critical infrastructure like airports in disaster-prone areas.

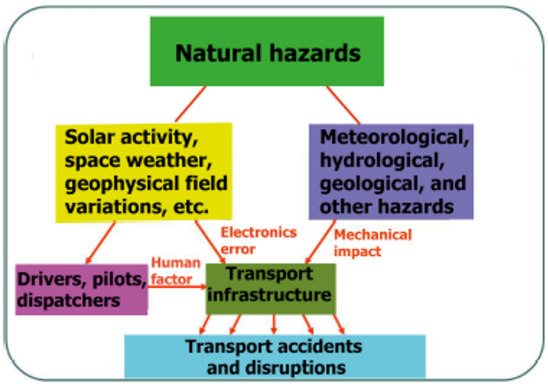

Fig. 2. Grouping of natural hazards based on their genesis and impacts on transport infrastructure [41].

Fig. 2 shows that transport infrastructure and disruptions require a risk management process to create a framework by requiring variables for components in research. Understanding the risk is an essential component of disaster risk management, and this research builds on previous studies that have highlighted the importance of risk assessment and mitigation in disaster-prone areas [42]. For example, a study conducted by the United Nations Development Program (UNDP) emphasized the need for proactive measures to mitigate the impact of natural disasters and enhance resilience in vulnerable communities [43]. The study highlighted that risk assessment and mitigation should be a critical component of disaster management plans to ensure that communities and infrastructure can withstand the impact of disasters. Similarly, a study by the World Bank Group emphasized the importance of understanding disaster risk to enable decision-makers to develop effective mitigation strategies that address the root causes of vulnerability[44] .

In the context of this research, understanding the risk is critical for enhancing the resilience of the airport infrastructure in Tarakan City. By identifying and assessing the hazards and vulnerabilities of the airport infrastructure, the research can develop mitigation strategies that address the root causes of vulnerability and reduce the impact of disasters [45]. The involvement of stakeholders in the risk assessment and mitigation process is also critical, as it ensures that decision-making is informed and aligned with the needs of the community[46]. it is not enough to only conduct community participation just as a formal procedure after the decision has been made [47].

Moreover, the understanding of risk is also important in the context of climate change, which has increased the frequency and intensity of natural disasters. The Intergovernmental Panel on Climate

Change (IPCC) has highlighted that climate change has led to an increase in the frequency and severity of extreme weather events, such as floods, storms, and heat waves [48]. These events have a significant impact on critical infrastructure, including airports, which can disrupt transportation networks and have economic consequences. Therefore, understanding the risk and developing effective mitigation strategies is critical for ensuring the continuity of critical infrastructure and reducing the impact of natural disasters on communities and economies [49].

2.4 Frameworks for assessing resilience

Resilience frameworks provide a structured approach for assessing and improving the resilience of critical infrastructure to disasters [50]. These frameworks aim to identify vulnerabilities, analyze risks, and develop mitigation strategies to enhance the resilience of infrastructure. They also provide a comprehensive view of the different aspects that affect resilience, including physical, social, and economic factors [51]. There are various resilience frameworks used in different contexts, including the urban environment, transportation, and critical infrastructure [52]. One of the most commonly used resilience frameworks is the 100 Resilient Cities framework, which focuses on building urban resilience by considering various factors such as infrastructure, governance, and social cohesion [53].

In the context of this research, using resilience frameworks is essential for assessing the resilience of the airport infrastructure [54] in Tarakan City. By utilizing these frameworks, the research can identify the different factors that affect the resilience of the airport and develop strategies to enhance its resilience [55]. This includes identifying physical vulnerabilities such as the susceptibility to flooding or earthquakes, as well as social and economic vulnerabilities such as the impact of the airport's closure on the local economy. By considering these different factors, resilience frameworks can help to develop a more comprehensive and effective approach to enhancing resilience [56].

Fig. 3. Eleven aspects of resilience [57-58].

From Fig. 3 eleven aspects of resilience are a series of dimensions, properties, and outcomes that form one of the frameworks. Previous research has shown the importance of using resilience frameworks for disaster risk management [59]. For example, research has demonstrated that using resilience frameworks can help to improve the resilience of urban areas to disasters and reduce the impact of disasters on critical infrastructure [60]. It has also shown that using resilience frameworks can help to identify vulnerabilities and develop effective mitigation strategies [61]. Therefore, using resilience frameworks is critical for enhancing the resilience of critical infrastructure, including airports, to disasters.

Frameworks for assessing resilience have become increasingly important in recent years, as communities and organizations seek to better understand and prepare for the impacts of natural disasters and other disruptions [62]. There are a variety of different frameworks available, each with its own strengths and weaknesses [63]. Some frameworks focus on physical infrastructure and engineering solutions, while others take a more holistic approach that incorporates social, economic, and environmental factors [64]. Ultimately, the most effective framework will depend on the specific context and goals of the assessment.

In the context of this research, the framework for assessing resilience is critical for understanding the airport's ability to withstand and recover from natural disasters [65]. By using a comprehensive framework that considers a range of factors, such as physical infrastructure, supply chains, and workforce capacity, the research can identify areas of vulnerability and develop targeted mitigation strategies [66]. The framework can also help to prioritize investments and resources based on the relative importance and risk of different assets and operations [67]. Importantly, the framework should be designed with the input and participation of key stakeholders to ensure that the assessment reflects the needs and priorities of the community. A good framework could connect the benchmarking concept with practical applications, because the framework could guide organizations in adopting and implementing benchmarking activities more systematically, comprehensively, and in a timely manner [68].

While frameworks for assessing resilience have many benefits, there are also challenges and limitations to consider [69]. One common challenge is the availability and quality of data, particularly in developing countries or areas with limited resources[70]. Additionally, there may be competing priorities or conflicting interests among stakeholders, which can make it difficult to reach consensus and implement effective solutions [71]. Despite these challenges, however, frameworks for assessing resilience offer a valuable tool for communities and organizations seeking to prepare for and respond to natural disasters and other disruptions.

3 Factors in the assessment of airport conditions

Airports are an important infrastructure of the air transportation system, playing a vital role in connecting and serving people around the world. To ensure optimal performance and sustainability of the airport, it is important to carry out a comprehensive assessment.

There are a number of factors that need to be considered when assessing the condition of the airport, which will be discussed. These factors provide a holistic view of the airport's condition and performance and assist in a holistic assessment of the airport's resilience, security, efficiency, and sustainability. The factors and

variables can be seen in Table 1, along with the references.

Table 1. Factors and Variables

Factors in the assessment of airport conditions		Source
A. Security		
1.	Level of compliance with aviation security rules	[72-73]
2.	Success in passenger inspection and supervision	[72, 74]
3.	The quality of the hazardous substance detection system	[75-77]
4.	Efektivitas program pelatihan keamanan bagi personel bandara	[78-79]
5.	Degree of compliance with international security regulations	[75, 80]
B. Infrastructure		
1.	Runway physical condition (length, width, strength)	[81-82]
2.	Passenger terminal conditions (waiting room facilities, immigration area, baggage check area)	[83-84]
3.	Supporting facilities (aircraft refueling stations, baggage handling facilities, cargo warehouses)	[85-88]
4.	Air navigation systems (radar, radio navigation, and landing guidance equipment)	[73, 89-90]
C. Passenger Facilities		
1.	The quality and convenience of the check-in area, waiting area, and departure gate	[72, 74, 91]
2.	Toilet facilities and cleanliness of public areas	[92-94]
3.	Availability of restaurants, shops, and other commercial areas	[84, 95]
4.	Wi-Fi quality and internet connectivity	[96-97]
5.	Special facilities for passengers with special needs (e.g., lifts, lactation rooms)	[92, 98]
D. Availability and Performance		
1.	Number of gates and terminals available	[75, 91, 99]
2.	Passenger handling capacity and capability (e.g., number of check-in desks, baggage conveyors)	[100-101]
3.	Availability of flight time slots	[74, 102]
4.	The level of timeliness and reliability of flight schedules	[7, 72, 102]
5.	Ability to cope with air traffic spikes during busy periods	[75, 94, 103]
E. Operational efficiency		
1.	Passenger waiting time at the security and inspection process	[74, 91, 104]
2.	Speed of baggage handling (for example, the time between check-in and passengers receiving the luggage at the destination)	[33, 72, 74, 92]
3.	Efficient use of resources (e.g., fuel use, energy use)	[33, 97, 105]
4.	Reduction of delays and compliance with flight schedules	[7, 102]
5.	The optimum level of use of facility capacity (e.g., use of runways and terminals)	[2, 10, 81]
F. Quality of service		
1.	Cleanliness and comfort of airport facilities	[84, 92, 106]
2.	Airport staff service quality	[33, 72]
3.	Availability and quality of information provided to passengers (e.g., flight information, directions)	[72, 74, 91]
4.	Availability of transportation services to and from the airport	[33, 72]
5.	Passenger satisfaction level and feedback from passengers	[72, 74, 91]
G. Environmental sustainability		
1.	Waste management	[1, 81, 107]

The potential that can be considered a threat to airport conditions will be considered in the risk calculation so that a response can be given to the risk. In several works of literature, many have examined this, but with a different focus. This is done because the research on airports has a variety of objects that are also different.

The developments carried out in airport research have led to an assessment as a basis for compiling further research, which will be formed in a table based on reference sources and factors.

In the process of preparing airport condition measurements, a basic study is needed to strengthen the basis for this research. As for each of these measurements, they will continue in risk research to complement resilience research at the next opportunity.

From the discussion presented by the researchers, the factors composition in preparing the airport's infrastructure assessment was obtained. This shows that research on airports was carried out by looking at several factors based on objects at the airport. on the assessment of airport infrastructure itself as a start in obtaining a real picture of the condition of the airport in terms of the physical condition of existing buildings.

The use of these factors later as the basis for airport research to obtain ratings that can be used in further research. Further research can be developed on natural disasters and how to respond. can be completely simulated on the model to obtain a simulation that can describe the situation and actions to be taken in the future.

4 Discussion

In assessing airport conditions, there are several important factors that need to be evaluated. The first factor is Security. Relevant variables in the airport

security assessment include the level of compliance with aviation security rules, the effectiveness of the hazardous substance detection system, and the quality of the security training program for airport personnel.

Furthermore, the infrastructure factor is also an important consideration. Variables that must be considered include the physical condition of the runway, passenger terminal, and supporting facilities such as aircraft refuelling stations and air navigation systems.

Factors of passenger facilities also need to be considered. Variables that are relevant in this case include the quality and convenience of check-in areas, waiting rooms, toilet facilities, and the availability of restaurants and shops at the airport. Availability of special facilities for passengers with special needs is also an important variable.

Furthermore, availability and performance factors include variables such as the number of available gates and terminals, capacity and passenger handling capabilities, as well as the level of timeliness and reliability of flight schedules.

The factor of operational efficiency is also a consideration in assessing airport conditions. Variables that are relevant in this case include passenger waiting time at security and inspection processes, baggage handling speed, efficient use of resources, and optimal level of facility capacity utilization.

The quality of service factor involves variables such as cleanliness and comfort of airport facilities, service quality of airport staff, availability of information provided to passengers, as well as transportation services to and from the airport.

Finally, the environmental sustainability factor involves the variables of waste management, efficient use of energy, and efforts to reduce negative environmental impacts.

By paying attention to and evaluating these factors, an airport condition assessment can provide a more comprehensive picture of the airport's quality and readiness in meeting passenger needs and maintaining operational sustainability in the long term.

5 Conclusions

In conclusion, airport condition assessment involves various factors that must be considered holistically. Important factors in the assessment include safety, infrastructure, passenger facilities, availability and performance, operational efficiency, service quality, and environmental sustainability. where seven factors and thirty sub-factors are obtained that are relevant to measuring airport conditions in resilience efforts.

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