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The strategy implementing IoT-based land transportation for sustainable transportation

Maudhy Satyadharma[a], AdrisAde Putra[a,b], Hasmina Tari Mokui[a,c]

[a,b] Engineering Management Study Program, Postgraduate Program, Halu Oleo University, Indonesia 93232
[b] Department of Civil Engineering, Faculty of Engineering, Halu Oleo University,Indonesia 93232
[c] Department of Electrical Engineering, Faculty of Engineering, Halu Oleo University, Indonesia 93232
E-mail: maudhymaudhy@gmail.com, hasmina.mokui@uho.ac.id*, putra_adris@yahoo.com

Abstract

The development carried out by the government requires the availability of infrastructure including transportation infrastructure. Today's transportation sector planning is greatly influenced by technological advances. In encouraging the realization of sustainable transportation, the application of the Internet of Things (IoT) is very much needed. This encourages the need for a strategy in analyzing the identification of problems in the implementation of sustainable transportation based on the Internet of Things (IoT) in Southeast Sulawesi Province. This study applies a qualitative method where informants are selected purposively, namely using the consideration that they understand the problems in the implementation of land transportation in the Southeast Sulawesi Province especially supporting sustainable transportation. Based on the results of this study, it was found that the strategies that need to be carried out by the Southeast Sulawesi Provincial Government in implementing Land Transportation in realizing sustainable transportation by utilizing the Internet of Things (IoT) include multi-sector collaboration, improving digital infrastructure, socialization and education, and strong regulations.

Key words: Internet of Things (IoT), Sustainable Transport, SWOT Method, Transport Digitalization, Transport Management.

INTRODUCTION

The development carried out by the government is strongly supported by the availability of infrastructure. Infrastructure is believed to have an influence in improving the quality of life and human welfare [1]. The availability of infrastructure also greatly determines the level of efficiency and effectiveness of economic activities and is a requirement for the economy to run well.

One of the infrastructures that plays a very important role in accelerating development is transportation infrastructure. Transportation infrastructure consists of land transportation, river/sea transportation and air transportation. Development of transportation infrastructure plays an important role in urban development and economic growth in most national economies, mainly consisting of highways, railways, ports and airports, which enable most social and commercial activities [2].

Fig. 1. Baruga terminal condition

Southeast Sulawesi Province is in great need of reliable transportation networks and infrastructure to improve accessibility and connectivity and encourage regional development and regional economic growth [3]. The current conditions regarding the problems in the land transportation sector in the Southeast Sulawesi Province are that the Type B passenger terminal which is under the authority of the Provincial Government is not yet optimal, there are still many shadow terminals, the problem of data on the number of vehicles does not reflect the actual number of conditions and data and information cannot yet be accessed by the public [4].

Today's transportation aspect planning is also greatly influenced by the development and progress of technology. This has also been expressed by several studies that believe that technological advances also have an impact on the transportation aspect and have given birth to several terms such as transportation digitalization and the application of the internet of things (IoT) to the transportation aspect. In recent years, the concept of the Internet of Things (IoT) has emerged as a potential solution to the challenges of problems faced by humans including in the transportation and traffic management aspects [5], [6], [7], [8], [9], [10]. The urgency of implementing the Internet of Things in the world of transportation is due to several problems currently being faced, such as traffic jams, increasingly long travel times, and increasing pollution due to population growth and the increasing number of vehicles today [11], [12], [13].

Sustainable transportation can be defined as an effort to meet current transportation mobility needs without reducing the ability of future generations to meet their mobility needs. [14] stated that the need to implement a sustainable strategy is due to several factors, including: a) so far government policy is still oriented towards developing road infrastructure, b) lack of comprehensive transportation studies, c) rapid growth in the global economic era demands more diverse transportation services, both in quality and quantity, and d) concerns about the threat of declining environmental quality.

The implementation of today's transportation in realizing sustainable transportation is an obligation that must be carried out by the government in order to realize the implementation of safe, comfortable, secure and regulatory-compliant transportation.

The importance of this research is to encourage a stronger government role in optimizing passenger terminals that have lost their role and function in the eyes of the public. In this case, it is necessary to conduct a problem analysis in terms of identifying problems from both the internal and external environment so that it can be a solution to the problems raised.

One method that can be used to identify internal and external environmental factors is by using Strength, Weakness, Opportunities and Threats (SWOT) analysis [15], [16], [17]. believes in the need to use SWOT analysis because this analysis will help organizations understand the situation and conditions as a whole because of the identification of internal and external environmental factors. Of course, with a good understanding of strengths, weaknesses, opportunities and threats, an organization or agency will be able to develop a much more appropriate strategy both in utilizing opportunities and overcoming existing challenges.

The novelty of the research conducted is trying to identify several factors both from a review of the use of IoT-based technology that can be used in aspects of land transportation, efficiency and effectiveness in the transportation system so that it can provide a complete picture in realizing sustainable transportation that is more adaptive but remains economical in the transportation sector. This research is based on the results of identifying why many terminals have not been functioning optimally so far. And for the region like Southeast Sulawesi Province, the need to optimize the role of important terminals in increasing accessibility and connectivity of island and mainland areas, as well as increasing regional income.

MATERIAL AND METHODS

This study uses a type of research with a qualitative approach, where it is stated that qualitative research is a research method that describes problems regarding data programs/or experiences experienced by researchers. This research has been carried out at the Southeast Sulawesi Transportation Agency as the focus of the study. Data collection techniques in this study are by conducting in-depth interviews, observations and document studies.

In this research, triangulation and thematic analysis techniques to increase the validity and reliability of research results. Triangulation refers to the use of multiple data sources, data collection techniques, or researcher perspectives to check and ensure the accuracy of findings. Meanwhile, thematic analysis is a method used to find, analyze, and understand patterns or themes that emerge from qualitative data that has been collected.

And then after the data had been analyzed, the researcher uses SWOT analysis in analyzing the strategy of organizing land transportation in realizing aspects of sustainable transportation based on the application of the Internet of Things (IoT) in Southeast Sulawesi Province.

SWOT analysis is used to evaluate the strengths, weaknesses, opportunities, and threats in the implementation of IoT-based land transportation in Southeast Sulawesi. This method helps identify optimal strategies to improve efficiency, sustainability, and technological adaptation in the transportation system, thus creating smarter and more integrated services.

RESULT AND DISCUSSION

Land transportation connecting between districts and cities in one province is the authority of the Provincial Government (Transportation Agency). Currently, observations conducted by researchers have found that the implementation of land transportation is still not optimal, especially in supporting aspects of sustainable transportation. Land transportation infrastructure managed by the Southeast Sulawesi Provincial Transportation Agency has also not been managed properly, so it is necessary to encourage the optimization of terminal utilization.

It is necessary to conduct a SWOT analysis in producing the right strategy in realizing sustainable transportation by implementing the use of the Internet of Things (IoT). Based on the results of the study, both interviews with research informants and long observations conducted by researchers will be categorized based on internal analysis and external analysis which will be described in the following table. In positive aspects such as strength and opportunity, the rating value for the strongest element in the strength and/or opportunity aspect is worth 4 and then will be worth 3, 2 and 1 for the strength element that is considered to have a lower value. And vice versa for negative aspects such as weaknesses or challenges, the rating assessment is the opposite of the assessment of positive aspects such as strength and/or opportunity [18]. While the weight assessment is the subjective assessment of the researcher towards the conditions found either through interviews or field observations. Table 2 will describe the identification of the external environment in analyzing the implementation of land transportation in realizing sustainable transportation with the use of the Internet of Things (IoT).

From the results of identifying these factors, it can be depicted in the SWOT diagram in the following image (Fig. 2). From image, it can be seen that the Implementation of Land Transportation in realizing sustainable transportation by utilizing the Internet of Things (IoT) is on the right track to continuously carry out development strategies (Growth).

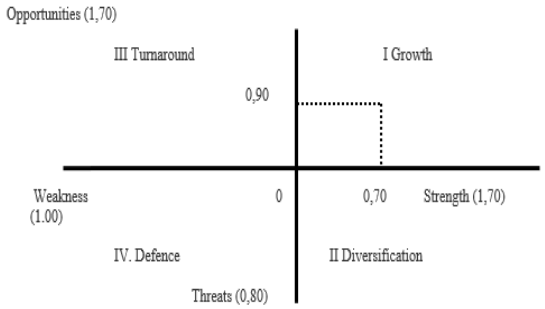

Fig. 2. SWOT diagram (Source : Data Processing, 2025)

Based on Table 3, several strategies formulated in this research can be described as follows:

a. Multi-sector Collaboration

Optimal transportation implementation today can no longer be done partially and alone but involves multi-sector participation and collaboration, especially in realizing sustainable transportation based on the application of the Internet of Things (IoT). Multi-sector collaboration is the key to success in realizing it [19], [20]. Both studies emphasized the importance of implementing collaboration in organizing transportation in order to achieve the expected results.

b. Increasing Digital Infrastructure Investment

Digital infrastructure investment in land transportation plays a crucial role in improving transportation efficiency, safety, and sustainability. Digital infrastructure includes all technologies and systems that support data-based transportation management and operations, such as the Internet of Things (IoT), artificial intelligence (AI), big data, and communication networks that connect transportation devices and systems [21], [22], [23], [24], [25], [26], [27], [28], [29]. Investment in digital infrastructure in the transportation sector is essential to realizing a sustainable transportation system. In many areas in Indonesia, strengthening digital infrastructure is an important foundation for optimizing transportation services, expanding reach, and increasing public trust in environmentally friendly public transportation.

c. Socialization and education

Socialization and education to the community in the implementation of land transportation is an important aspect to ensure that the community can adapt, participate, and utilize the transportation system optimally. In the context of the development of increasingly complex and digital land transportation, socialization and education help increase public understanding of the importance of safety, efficiency, sustainability, and technological innovation used in transportation [30], [31], [32], [33]. The research finds that through proper education, the public can understand the importance of driving safety, the use of efficient and environmentally friendly modes of transportation, and the benefits of implementing digital technology, such as navigation systems, cashless payments, and online bookings.

d. Strong regulation

Strong regulation in the application of IoT in land transportation is essential to ensure an efficient, safe and sustainable transportation system. This regulation includes laws, regulations and standards that govern various aspects of the land transportation system based on the application of the Internet of Things (IoT), from infrastructure and operations to safety and the environment [34], [35]. With strong regulations, the role of the transportation sector in regional development will be encouraged and this will have implications for improving community welfare [36], [37], [38], [39], [40], [41], [42], [43]. The results of the proposed study conclude that strong and clear regulations in the transportation sector play an important role in creating an orderly, safe, and efficient transportation system. When government policies are able to direct the development of structured, sustainable, and inclusive transportation, the impact will be directly felt by the community. Good infrastructure and affordable transportation services will facilitate the mobility of people and goods, encourage local economic growth, and open access to basic services such as education and health. Thus, effective regulations not only strengthen the transportation sector, but also become a major driver in improving the welfare and quality of life of people in the regions.

Table 1. Internal strategic factor analysis summary (IFAS) implementation of land transportation in realizing sustainable transportation by utilizing the internet of things (IOT)

Internal Strategy Factors	Weight (0,0 s.d 1,0)	Rating (1 s/d 4)	Value (2 x 3)	Comments
1	2	3	4	5
Strength				
1. IoT encourages increased data transparency for stakeholders	0.15	4	0.60	IoT will increase data transparency for regulators (government)

Internal Strategy Factors	Weight (0,0 s.d 1,0)	Rating (1 s/d 4)	Value (2 x 3)	Comments
2. IoT can encourage increased community participation	0.10	3	0.30	The public will be more involved with data transparency
3. IOT based real-time data can encourage data-based decision making	0.15	4	0.60	Government policy-making will be much more precise with more accurate data
4. Become one of the sources in encouraging further environmental impact monitoring	0.10	2	0.20	In the future, IoT data will be an important source in calculating emissions released by vehicles on the road
Total of Strengths	0.50		1.70	
Weakness				
1. The cost of implementing IoT-based technology is very high	0.20	1	0.20	The higher budget for implementing IoT technology
2. Limited human resources in implementing IoT	0.15	2	0.30	Human resources is not ready for supporting the implementation IoT in transportation aspect
3. Data Security and Privacy	0.05	4	0.20	Security and privacy aspects are also major weaknesses
4. Limited internet infrastructure network	0.10	3	0.30	Not all areas in land transportation infrastructure have good network quality
Total of weakness	0.50		1,00	

Source : Data Processing (2025)

Tabel 2. extenal strategic factor analysis summary (EFAS) implementation of land transportation in realizing sustainable transportation by utilizing the internet of things (IoT)

External Strategy Factors	Weight (0,0 s.d 1,0)	Rating (1 s/d 4)	Value (2 x 3)	Comments
1	2	3	4	5
Opportunity				
.Central government support and policies in adopting IoT in all sectors	0.05	2	0.10	Government policies and support for local governments in adopting technology for various sectors including the transportation sector
.Implementation of IoT will encourage quality of life, comfort and efficiency in transportation aspects	0.25	4	1.00	There are so many examples of IoT applications encouraging convenience, efficiency in transportation aspects and improving the quality of life of the community
.Opportunities for the private sector to collaborate in building IoT-based land transportation infrastructure	0.10	3	0.30	With a large land area, the private sector has great opportunities in developing IoT-based transportation infrastructure

External Strategy Factors	Weight (0,0 s.d 1,0)	Rating (1 s/d 4)	Value (2 x 3)	Comments
1	2	3	4	5
4. Opportunities for developing more environmentally friendly technological innovations in transportation	0.10	3	0.30	IoT implementation will encourage more environmentally friendly transportation sector technological innovations
Total of opportunities	0.50		1.70	
Threat				
. Awareness and understanding of drivers and service users in the application of IoT technology	0.25	1	0.25	Drivers' minimal awareness of IoT implementation in the transportation aspect
2. Disruption of IoT technology infrastructure	0.05	3	0.15	Disruptions in IoT implementation which become obstacles
3. Very rapid technological developments that cannot be kept up with human resources	0.10	2	0.20	Technological developments are sometimes not able to be balanced by existing human resources
4. Regulations and policies for the application of IoT, especially in the transportation sector, are not yet strong	0.10	2	0.20	It must be admitted that specific regulations related to IoT implementation in the transportation aspect are not yet strong to support implementation in the field
Total of threats	0.50		0,80	

Source : Data Processing (2025)

Table 3. SWOT matrix for implementing land transportation in realizing sustainable transportation using the internet of things (IoT)

IFAS Internal Strategy Analysis Factor EFAS External Strategy Analysis Factor	STRENGTH(S) 1. Encouraging increased data transparency for stakeholders 2. Encouraging community participation 3. IOT based real-time data can encourage data-based decision making . Become one of the sources in encouraging further environmental impact monitoring	WEAKNESS (W) 1.The cost implementation 2.Limited human resources 3.Data security and privacy 4.Limited internet infrastructure network
Opportunities (O) . Central government support . Encouraging quality of life, comfort and efficiency in transportation aspects . Opportunities for private sector for collaboration . Opportunities for developing more environmentally friendly technological innovations in transportation	SO Strategy Multi-Sector Collaboration. This strategy encourages the involvement of government, private sector and also academics in the development of IoT that focuses on sustainable transportation.	WO Strategy Digital Infrastructure Enhancement. This strategy encourages increased investment by engaging the private sector in overcoming the high cost of investment and limited human resources, thus ensuring sustainability in the transportation system.

THREATH (T) Lack of awareness from driver and public Disruption of IoT technology infrastructure Very rapid technological developments that cannot be kept up with human resources Regulations and policies for the application of IoT are not yet strong	ST Strategy Socialization and Education. It is undeniable that society is the actor of development so that socialization and education need to be carried out in increasing awareness and understanding of society (users and drivers) in adopting the application of IoT in the transportation aspect.	WT Strategy Strong regulation. Need to be done to encourage central and regional governments to create specific regulations to facilitate IoT adoption in the transportation sector.

Source : Data Processing (2025)

CONCLUSION

Based on the results of the research and discussion conducted, it can be concluded that the strategies that need to be carried out by the Southeast Sulawesi Provincial Government in organizing Land Transportation in realizing sustainable transportation by utilizing the Internet of Things (IoT) include multi-sector collaboration, improving digital infrastructure, socialization and education, and strong regulations.

This research recommendation is expected to encourage the need for research related to the design of IoT-based applications in the land transportation aspect that encourages transparency and data management where further studies are needed to design a system that is not only technologically innovative, but also able to answer challenges in terms of security, data privacy, and integration with existing policies and infrastructure, research or study on the use of big data in encouraging the optimization of sustainable transportation, where with real-time big data, decision-making becomes more targeted, thereby reducing emissions, increasing energy efficiency, and encouraging the integration of environmentally friendly transportation modes as a whole or encouraging research related to IoT-based government transportation regulations and policies.

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