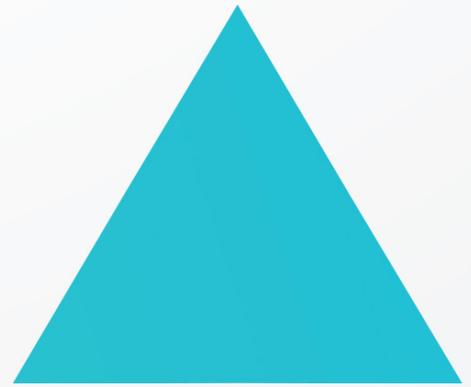


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Preference of Female Passengers Towards Public Transportation Services in Makassar City

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Keywords:

Service; Women; Satisfaction; Public Transportation

Abstract

Passenger preferences, particularly those of women, are crucial for enhancing the quality of public transportation services in Makassar, where women constitute the majority of users. This study examines female passengers' preferences and satisfaction with public transportation services in Makassar, focusing on whether these services meet the Minimum Service Standards (SPM). Secondary data were obtained through a literature review of urban transportation SPMs and comparative studies, while primary data were collected via online questionnaires, interviews, and field observations. The sample was selected using non-probability sampling, and the data were analyzed using Importance-Performance Analysis (IPA) and comparative analysis. The study identified 7 criteria and 19 service indicators across areas such as service capacity, security, and comfort. The findings revealed that the *pete-pete* transportation system fell short in quality service indicators, whereas the Bus Rapid Transit (BRT) system had two high-quality indicators: first aid facilities and air circulation/temperature control. The study highlights the need for improvement in 11 service indicators for *pete-pete* and 6 for BRT, as perceived by female passengers.

1. INTRODUCTION

Makassar is one of the cities located in South Sulawesi Province. This city is a metropolitan area that serves as a center for government, trade, education, services, and more. With an increasing population growth rate and rising mobility needs, the public requires public transportation facilities that facilitate movement from one place to another. However, the needs of passengers, especially women, in public transportation are not met with service quality that aligns with the minimum service standards.

Public transportation is a facility provided by the government to meet the community's mobility needs. However, in reality, there is a lack of public interest in using public transportation in Makassar. The low usage of public transportation is based on the low level of user confidence in the ease of service and the uncertainty of travel times (Launtu et al., 2021). Female public transportation users often experience poor behavior from drivers and other passengers, leading to reluctance to use public transportation due to feelings of insecurity and discomfort (Sumbal, 2022). According to CATAHU Komnas Perempuan 2020, 58% of the 3,062 cases of sexual violence against women occurred in public spaces. The 2019 survey by the Safe Public Space Coalition (KRPA) also showed that sexual harassment on public transportation reached 15.77%. This phenomenon indicates that aspects of security and equality in public transportation have not received special attention from the government. This can be seen from the urban design and infrastructure that do not consider the needs of women, such as terminals and other public transportation services.

In Makassar, several critical issues with public transportation significantly impact female passengers and highlight the need for focused research. The high incidence of sexual harassment on public transportation, as indicated by KRPA data, creates a pervasive sense of insecurity for women, deterring them from using public transit and limiting their mobility. Additionally, the lack of female-friendly facilities—such as comfortable waiting areas, adequate lighting, and accessible emergency buttons—further exacerbates these safety concerns.

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The inconsistency in service quality, with some routes being notably better than others, adds to the unpredictability and discomfort experienced by female passengers. Furthermore, inadequate information and communication regarding schedules, routes, and fares, combined with limited public transportation options, force many women to choose between expensive private transport or risky public transit. These interconnected problems create a vicious cycle where low usage due to safety concerns leads to less investment in improving services, perpetuating the cycle of inadequate transportation. Addressing these issues through targeted research is essential to developing more inclusive and safer public transportation systems for women in Makassar.

According to Law Number 22 of 2009 concerning Road Traffic and Transportation, Article 141 paragraph (1) states that public transportation companies must meet the minimum service standards for urban transportation, which include: safety, security, comfort, affordability, equality, and regularity. In major cities like Jakarta and Surabaya, the proportion of female passengers is 55%, while male passengers account for 45%. According to Murdiono (2006), this is because women prefer to use public transportation as a means to get to work or other destinations. Female passenger satisfaction is important to consider because transportation is considered good for all gender groups if it is rated well by both women and men (Maffi et al., 2015). It is known that the service needs of each passenger differ, including between men and women. Therefore, it is necessary to identify the preferences of female public transportation users regarding the quality of public transportation services in Makassar. This study aims to determine (1) the criteria and indicators of public transportation services for women based on literature review, (2) the opinions and expectations of female passengers regarding public transportation services in Makassar, and (3) the priority directions for improving public transportation services based on the perceptions of female passengers.

Comparison Study 1: Bus Rapid Transit (BRT) TransJakarta

TransJakarta is a mass transportation service operated by PT Transportasi Jakarta. On April 21, 2016, PT Transportasi Jakarta launched a special bus for women. The bus is white and pink and operates only on Corridor 1. As the name suggests, this bus can only be used by female passengers, and it is driven by female drivers for added security. The bus features vehicle identification, an emergency number, CCTV to prevent criminal activities, and an emergency door. The existence of this special TransJakarta bus for women meets the needs of female users when using mass public transportation.

Comparison Study 2: "Pink" Public Transportation, Mexico City

Women-only public transportation in Mexico City has existed since 2002. The Mexico City government introduced a program with two systems: all female-only transportation is colored pink, and monitoring stations are established throughout the subway to encourage female passengers to report any form of harassment. This women-only public transportation gives special attention to female users to ensure their safety and equal rights to mobility, especially when using public transportation. Additionally, there are billboards, posters, stickers, and an emergency number that can be contacted 24 hours a day. The success of women-only public transportation in Mexico City is due in part to the role of the community, the government, and especially the opinions of female public transportation users.

2. METHODS

2.1 Research Method

This research is a descriptive quantitative study using a Likert scale with a questionnaire technique approach. The sampling method used in this context is a non-probability sampling technique. This sampling technique relies on the presence of subjects who happen to meet the researcher and are deemed suitable as data sources. If the subject is considered appropriate, then the subject will be taken as a sample (Etikan, 2017). According to Sugiyono (2015), Incidental/Accidental Sampling is a sampling method based on incidental events, meaning that respondents are anyone who happens to meet the researcher, fulfills the respondent criteria, and is deemed suitable as a research sample. In this case, the respondent criteria are female residents aged 17-65 years living

in Makassar City who have used public transportation in Makassar City. The population in this study includes female residents in Makassar City, which totals 742,002 (BPS Makassar City, 2024). The sample calculation method used is according to Isaac & Michael (1995), as shown in the table below:

Table 1. Sample Size Estimation at Error Levels of 1%, 5%, and 10% (Isaac and Michael, 1995)

N	S		
	1%	5%	10%
10	10	10	10
15	15	14	14
20	19
25	24	23	23
30	29	28	27
...
50000	655	346	269
75000	658	346	270
150000	661	347	270
...			
1000000	663	348	271
∞	663	349	272

With a female population of 742,002 in Makassar City and using the sample calculation method by Isaac & Michael (1995) with a 10% margin of error, the sample size obtained is 97, rounded up to 100 respondents. The sample obtained can already represent the population. This study will include a diverse range of female public transport users from different neighborhoods and demographic backgrounds in Makassar. This approach helps in capturing a variety of perspectives and experiences relating to public transport services, thereby increasing the generalizability and validity of the research findings.

2.2 Data Analysis Methods

The methods used in data analysis include literature review analysis and comparative analysis to determine the criteria and indicators of public transportation services for women. Importance Performance Analysis (IPA) is used to score the performance level and the expectation level of public transportation services based on female passengers' perceptions to obtain quadrant analysis results. The responses for performance level and expectation level can be seen in tables 1 and 2.

Table 2. Performance Level Scores

Performance Level (X)	Score
Very Good	5
Good	4
Fair	3
Poor	2
Very Poor	1

Table 3. Expectation Level Scores

Expectation Level (Y)	Score
Very Important	5
Important	4
Fair	3
Less Important	2
Not Important	1

Next, the scores from the performance level (X) and expectation level (Y) are tabulated into IBM SPSS Statistics 22. The results from SPSS will determine the indicators whose services need to be improved. In IPA analysis, the SPSS results are divided into four quadrants: quadrant I (high priority), quadrant II (maintain performance), quadrant III (low priority), and quadrant IV (excessive).

3. RESULT AND DISCUSSION

3.1 Criteria and Indicators of Public Transportation Services for Women

Based on the results of literature review analysis and comparative analysis by comparing SPM, previous research, and benchmarking, criteria and indicators of public transportation services for women were obtained. The analysis of criteria and indicators of services for women can be seen in Table 3.

Table 4. Results of Literature Review and Comparative Analysis of Public Transportation Services for Women

No.	Literature Review	Variable and Indicators
Minimum Service Standards		
1.	Standar Pelayanan Minimal Angkutan Orang Dengan Kendaraan Bermotor Umum Dalam Trayek (Peraturan Menteri Perhubungan RI Nomor PM 98 Years 2013)	<ul style="list-style-type: none"> • Security (Vehicle identity, crew identity, public transport lighting facilities) • Safety (Driver's physical condition, driver competence, traffic discipline, health facilities (first aid kit), smoking ban in public transport, travel disruption information) • Comfort (Passenger density, seating conditions, temperature inside the transport, cleanliness inside the transport) • Affordability (Accessibility of public transport, transport fares) • Equality (Priority seating for disabled, elderly, and pregnant women, wheelchair storage space) • Regularity (Service information)
Previous Research		
1.	Desain Layanan Kendaraan Umum untuk Wanita Berbasis <i>Fuzzy-Kano Quality Function Deployment</i> (QFD) (Prihono, 2012)	<ul style="list-style-type: none"> • Emergency contact information • Service information • No smoking policy on public transport • Reserved seats for women
2.	Kota Surabaya: Pelayanan transportasi umum bus damri khusus wanita di Kota Surabaya (Dinny Octaviane Wasistya, 2013)	<ul style="list-style-type: none"> • Security • Safety • Comfort • Affordability • Equality • Regularity
3.	Model Kebutuhan Angkutan Umum Khusus Perempuan (<i>The 17th FSTPT International symposium 2014, Jember University</i>) (Atik Wahyuni, Achmad Wicaksono, Ludfi Djakfar, Harnen Sulistio)	<ul style="list-style-type: none"> • Fare • Special seating for women, mothers, children, and elderly • Security personnel

No.	Literature Review	Variable and Indicators
4.	<i>Gender in Public Transportation. A perspective of Women Users of Public Transportation.</i> (Sahar Aloul, dkk. 2018)	<ul style="list-style-type: none"> • Accessibility • Harassment and security • Travel patterns • Routes taken • Friendliness of staff
6.	Layanan Bus Rapid Transit Purwokerto-Purbalingga pada Pengguna Wanita Menuju Kesiapan Dimensi <i>Smart Mobility</i> (Fauzan Ramadlon, 2021) Warta penelitian perhubungan	<ul style="list-style-type: none"> • Timeliness of BRT arrival at destination • Affordable BRT ticket prices • BRT being a safe and comfortable mass transit option • Good integration of BRT with other modes of transportation
5.	Pengembangan model pengukuran tingkat pelayanan transportasi umum yang ramah gender, anak, dan kelompok berkebutuhan khusus (Bayu Kania dan Linda Aisyah, 2021)	<ul style="list-style-type: none"> • Tingkat keamanan dalam angkutan • Keselamatan (Kompetensi supir, ketertiban lalu lintas) • Kenyamanan (kebersihan dalam angkutan, kepadatan penumpang, kondisi tempat duduk) • Ketersediaan fasilitas penunjang (toilet khusus wanita, musholla yang dapat diakses difabel, fasilitas penerangan, ruang menyusui) • Perilaku pengemudi • Ketertiban pengemudi di jalan • Sikap pengemudi ramah dan sopan • Petugas tanggap dalam membantu • Tempat duduk prioritas
Studi Banding		
1.	Kota Meksiko: Women-Only Transportation: How “Pink” Public Transportation Changes Public Perception of Women’s Mobility (Amy Dunckel-Graglia, 2013)	<ul style="list-style-type: none"> • Security level within transportation • Safety (Driver competence, traffic discipline) • Comfort (Cleanliness inside the transport, passenger density, seat conditions) • Availability of supporting facilities (Women’s dedicated toilets, accessible prayer rooms for people with disabilities, lighting facilities, nursing rooms) • Driver behavior • Driver discipline on the road • Friendly and courteous driver attitude • Responsive personnel in assisting • Priority seating
2.	Kota Jakarta: BRT Trans Jakarta Khusus Perempuan (PT. Transportasi Jakarta, 2016)	<ul style="list-style-type: none"> • Affordability (Fare) • Service Capacity (Availability of seats for women on mixed transportation) • Safety (Travel disruption information) • Regularity (Service information)

From the results of literature review analysis and comparative analysis in the table above, criteria and indicators of public transportation services for women were identified, namely 6 criteria and 20 indicators. These include safety, security, comfort, affordability, equality, and safety.

Table 5. Variables and Indicators of Public Transportation Services for Women

No	Variable	Indicator
1.	Service Capacity	<ul style="list-style-type: none"> • Special seats for women • Service at crowded points for potential female passengers

		<ul style="list-style-type: none"> • Storage area for belongings inside the transportation
2.	Security	<ul style="list-style-type: none"> • Vehicle identification • Lighting facilities • Security against criminal acts
3.	Safety	<ul style="list-style-type: none"> • Physical condition, driver competence, and discipline • First aid facilities • Emergency contact information
4.	Comfort	<ul style="list-style-type: none"> • Passenger density • Seat condition • Air circulation/ room temperature facilities • Cleanliness facilities • No smoking signs
5.	Accessibility	<ul style="list-style-type: none"> • Accessibility of transportation • Transportation fares
6.	Equality	<ul style="list-style-type: none"> • Priority seating for disabilities, elderly, and pregnant women • Wheelchair storage space
7.	Regularity	<ul style="list-style-type: none"> • Service information

3.2 Characteristics of Female Public Transportation Users in Makassar City

a. Socio-Economic Characteristics of Female Pete-pete Public Transportation Users in Makassar City. Socio-economic characteristics based on age, education, occupation, and income levels in Makassar City, as shown in the following table:

Table 6. Socio-Economic Characteristics of Female Pete-pete Public Transportation Users

Social Economic Characteristics	Item	Frequency
Age	=< 17 Years	3
	18– 65 Years	96
	>65 Years	1
Education	Elementary School	0
	Junior/Senior High School	3
	College/University	97
Type of Work	Occupation Student	77
	Entrepreneur	10
	Housewife	6
	Civil Servant	7
Income Level	<Rp. 1.000.000	63
	Rp. 1.000.000 – Rp. 1.500.000	16

Social Economic Characteristics	Item	Frequency
	Rp. 1.500.000 – Rp. 2.000.000	5
	Rp. 2.000.000 – Rp. 2.500.000	4
	>Rp. 2.500.000	12

b. Socio-Economic Characteristics of Female BRT Users in Makassar City. Socio-economic characteristics based on age, education, occupation, and income levels in Makassar City, as shown in the following table:

Table 7. Socio-Economic Characteristics of Female BRT Users

Social Economic Characteristics	Item	Frequency
Age	=< 17 Years	7
	18– 65 Years	93
	>65 Years	0
Education	Elementary School	0
	Junior/Senior High School	5
	College/University	95
Type of Work	Occupation Student	76
	Entrepreneur	10
	Housewife	12
	Civil Servant	2
Income Level	<Rp. 1.000.000	51
	Rp. 1.000.000 – Rp. 1.500.000	20
	Rp. 1.500.000 – Rp. 2.000.000	8
	Rp. 2.000.000 – Rp. 2.500.000	12
	>Rp. 2.500.000	9

3.3 Preferences of Female Passengers Towards Public Transportation Services in Makassar City

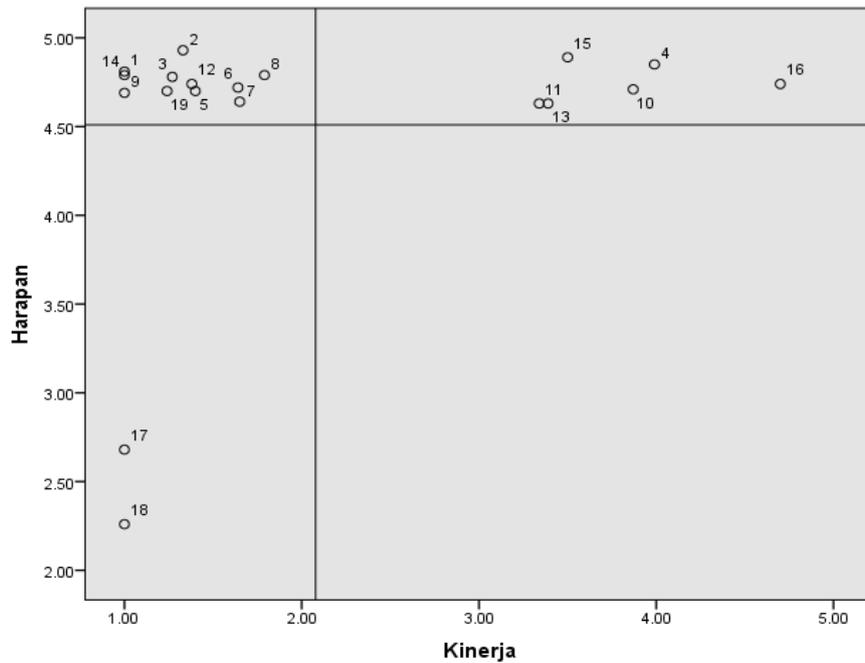
This analysis aims to determine the assessment of female passengers towards public transportation services in Makassar City. This study involves a sample of 100 female respondents who have used public transportation. The perceptions of female passengers are evaluated based on 19 questions regarding the services provided by

public transportation for women. The average performance and expectation levels of pete-pete public transportation can be seen in Table 8.

Table 8. Performance Score and Expectation Level of Pete-Pete Public Transportation Services

Indicator	Performance Level (X)	Expectation Level (Y)
1	1.00	4.81
2	1.33	4.93
3	1.27	4.78
4	3.99	4.85
5	1.4	4.7
6	1.64	4.72
7	1.65	4.64
8	1.79	4.79
9	1.00	4.69
10	3.87	4.71
11	3.34	4.63
12	1.38	4.74
13	3.39	4.63
14	1.00	4.79
15	3.5	4.89
16	4.7	4.74
17	1.00	2.68
18	1.00	2.26
19	1.24	4.7

Based on the performance score and expectation level data from female passengers towards pete-pete public transportation services, it is found that according to the perceptions of female passengers, there are no quality indicators for pete-pete public transportation services. In contrast, for BRT, there are 2 indicators that are of very high quality (>100%), namely first aid facilities (P3K) and air circulation/room temperature facilities, and 1 indicator of quality (=100%), which is the presence of no-smoking signs in the vehicles. Subsequently, quadrant analysis was conducted using IBM SPSS Statistics 22, divided into 4 quadrants, as shown in the following Picture.



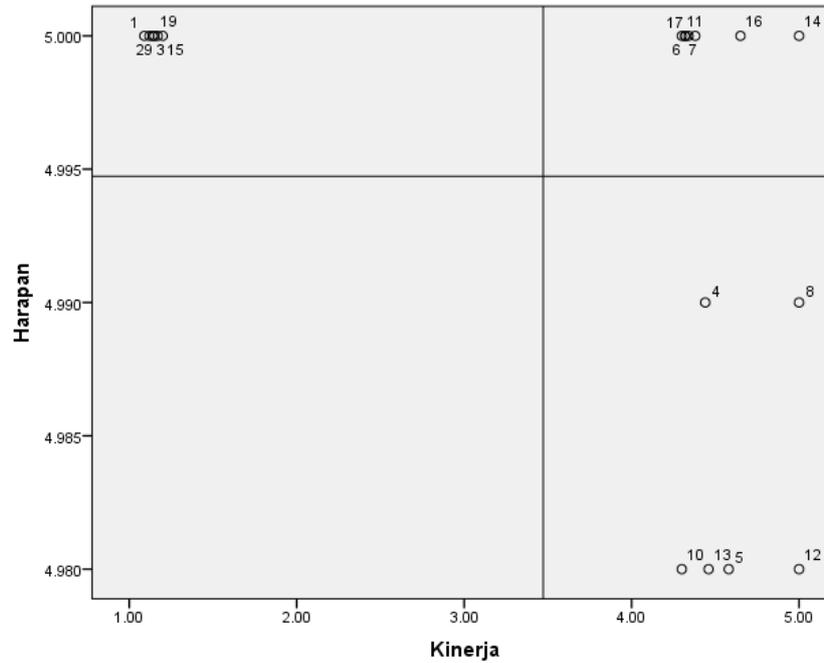
Picture 7. Quadrant of Importance Performance Analysis for Pete-pete Public Transportation
Source: Results of IBM SPSS Statistics 22 application analysis

The average performance score and expectation level of Bus Rapid Transit services based on female passengers' perceptions can be seen in the following table.

Table 9. Performance Score and Expectation Level of BRT Services

Indicator	Performance Level (X)	Expectation Level (Y)
1	1.09	5.00
2	1.12	5.00
3	1.14	5.00
4	4.44	4.99
5	4.58	4.98
6	4.32	5.00
7	4.32	5.00
8	5.00	4.99
9	1.17	5.00
10	4.3	4.98
11	4.3	5.00
12	5.00	4.98
13	4.46	4.98
14	5.00	5.00
15	1.2	5.00
16	4.65	5.00
17	4.34	5.00
18	4.38	5.00
19	1.15	5.00

Based on the data of performance scores and expectation levels from female passengers regarding Bus Rapid Transit services, the quadrant analysis results were obtained using IBM SPSS Statistics 22, which are divided into 4 quadrants.



Picture 8. Importance Performance Analysis Quadrants for BRT
 Source: Analysis results from IBM SPSS Statistics 22 application

3.4 Recommendations for Improving Public Transportation Services for Women in Makassar City

To enhance public transportation services for women in Makassar City, improvements should be focused on items that have low performance but high expectations, identified in quadrant I.

The pete-pete public transportation system has 11 items in quadrant I, namely: designated seats for women in mixed transport, service at crowded points for prospective female passengers, storage areas for belongings in the transport, interior lighting facilities, security against criminal activities, driver's physical condition, competence, and discipline, first aid facilities (P3K), emergency contact information, air circulation/room temperature facilities, no-smoking signs on the transport, and service information. Meanwhile, Bus Rapid Transit (BRT) has 6 items in quadrant I, namely: designated seats for women in mixed transport, service at crowded points for prospective female passengers, storage areas for belongings in the transport, emergency contact information, transport affordability, and service information. The indicators listed for both the pete-pete and Bus Rapid Transit (BRT) systems are crucial for addressing the specific needs and safety concerns of female passengers, thereby influencing their overall satisfaction with public transportation, namely:

1. Designated Seats for Women: Providing reserved seats for women in mixed transport enhances comfort and safety, helping to prevent unwanted interactions and ensuring that women have a safe space, especially in crowded conditions.
2. Service at Crowded Points: Ensuring that there is adequate service at points where female passengers gather helps manage crowd flow and reduces the risk of harassment or discomfort during boarding and alighting.
3. Storage Areas for Belongings: Safe and accessible storage areas prevent overcrowding and protect personal belongings, contributing to a more organized and comfortable travel experience.
4. Interior Lighting Facilities: Proper lighting within transport vehicles improves visibility and enhances safety, making passengers feel more secure and less vulnerable to theft or harassment.

5. Security Against Criminal Activities: Measures such as surveillance or on-board security personnel are essential for deterring and addressing criminal activities, thus reducing safety concerns for female passengers.
6. Driver's Physical Condition, Competence, and Discipline: A driver's fitness and professionalism impact the overall safety and quality of the ride. Well-trained and disciplined drivers contribute to a safer and more reliable service.
7. First Aid Facilities (P3K): Availability of first aid facilities ensures that immediate medical assistance can be provided in case of accidents or health issues, enhancing the safety and reliability of the service.
8. Emergency Contact Information: Clear and accessible emergency contact information allows passengers to quickly report incidents or seek help, improving overall security and response efficiency.
9. Air Circulation/Room Temperature Facilities: Adequate air circulation and comfortable temperature settings contribute to a pleasant travel experience, reducing discomfort and making the journey more enjoyable.
10. No-Smoking Signs: Enforcing no-smoking policies helps maintain a clean and healthy environment, which is particularly important for passengers sensitive to smoke or with respiratory conditions.
11. Service Information: Providing clear and up-to-date service information, including schedules and route details, helps passengers plan their journeys better and reduces uncertainty, leading to increased satisfaction.

Addressing these indicators effectively can significantly improve the quality of public transportation for female passengers, leading to higher satisfaction levels and increased use of public transport systems.

4. CONCLUSIONS

From the above description, it can be concluded that there are 7 criteria and 19 indicators of public transportation services for women, namely service capacity, security, safety, affordability, regularity, comfort, and equality. Based on the perceptions of female passengers, it was found that there are no high-quality indicators for pete-pete public transportation, while for BRT, there are 2 indicators with very high quality (>100%), namely first aid facilities (P3K) and air circulation/room temperature facilities, and 1 indicator with high quality (=100%), which is the presence of no-smoking signs on the transport. The main priority directions for improving public transportation services based on the perceptions of female passengers identified 11 service indicators for pete-pete public transportation and 6 service indicators for Bus Rapid Transit based on quadrant analysis from the Importance Performance Analysis assessment.

This study faces several limitations that need to be considered. First, the relatively small sample size may make the results of the study not fully representative for the entire population of women public transportation users in Makassar. In addition, this study only focuses on women's perceptions without considering the perspectives of other user groups, such as men or people with disabilities, who may provide different views on service quality. The research instruments used have also not been empirically tested before, so there is a possibility of bias in the measurement of research variables. Finally, public transportation conditions in Makassar may change over time, which means the results of this study may not remain relevant in the long term.

5. ACKNOWLEDGMENTS

Thank you to all parties who have supported or been involved in this research.

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Risk Management Analysis Based on ISO 31000:2018 at Andi Djemma Masamba Airport, Luwu Regency

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Airports, Risk Management, risks, ISO 31000:2018

Abstract

The density of activities that take place around the operating facilities at Andi Djemma Masamba Airport so that the Management of the Andi Jemma Airport Operator Unit Office has launched the development of Andi Djemma Masamba Airport as an aviation company so that it continues to carry out various facility improvements, especially in risk prevention with potential activities with high losses, therefore it is necessary to conduct research to find out how to map, risk assessment and design a risk control and mitigation system at the Operations facility at Andi Djemma Masamba Airport caused by activities that have the potential to cause risk. The stages of the risk management process refer to ISO 31000: 2018 including risk identification, risk analysis and risk evaluation. Risk analysis aims to assess risks from a list of confirmed risks. This is done by multiplying the magnitude of the risk impact by the probability of its occurrence, to determine the severity of the risk. The input for this stage is a list of confirmed risks. Expected impact and likelihood of occurrence are mapped through the risk matrix from the Federation Aviation Administration (FAA). The results showed that at the andi djemma masamba airport there were 6 events that fell into the red category, namely Aircraft accidents during take off/landing, Aircraft accidents in the apron area, Escape of dangerous goods into the aircraft, Fuel Spills on the Apron/Taxiway, Lack of building maintenance, The security inspection process is less than optimal.

1. INTRODUCTION

Each airport can address risks based on its location, size, and operational environment. Therefore, it is important to carry out a comprehensive and specific risk analysis according to the situation of each airport, so that the development of a Safety Management System is formed following these characteristics. To anticipate all existing risks, it is necessary to carry out risk management so that work accidents and their potential impacts can be avoided. This will not hinder the smooth running of the work (Rahajaan et al., 2019).

The dense activity that takes place around the operational facilities at the airport can create risks. It is important to implement risk management, or efforts to deal with risks that will arise so that it is hoped that workers will be able to handle emergencies to avoid work accidents and be able to resume operational activities. (Dayu et al., 2022).

Good risk management in companies is very important for the sustainability of projects and departments themselves, especially in management bureaus (Debrina et al., 2016). The ISO 31000 approach aims to help resolve problems related to all forms of risk in a structured manner and various scopes and contexts of problems (Anita et al., 2021). The aim of ISO 31000 is to help organizations identify, assess, and manage risks in a systematic, structured, and integrated manner.

Andi Jemma Airport plays an important role as an air transportation place and a driver of economic progress, considering the needs of the community, especially the people of Masamba, Seko and Rampi for transportation access in the area. Andi Jemma Masamba Airport is a technical implementing unit within the

Directorate General of Civil Aviation which of course administratively and operationally is under the Directorate General of Civil Aviation, Ministry of Transportation

The condition of Andi Jemma Airport is currently operating from Monday to Saturday, with an average of 4 to 6 flights a day and the services provided are passenger and cargo services. The high flow of passenger and cargo services means that the Management of the Andi Jemma Airport Management Unit has launched the development of Andi Djemma Masamba Airport as an aviation company so that it continues to make various improvements to facilities, especially in preventing risks with potential activities with high losses and overcoming them in order to support airport services. Air to the maximum, safety aspects are a high priority which must be prioritized for the sake of sustainable air transportation activities (Cahayani et al., 2022). Therefore, it is necessary to carry out research to find out how to carry out mapping, risk assessment and design of control and risk management systems at operational facilities at Andi Djemma Masamba Airport caused by activities that have the potential to cause risk.

Based on this background, the researcher carried out research with the title "Iso 31000: 2018 Based Risk Management Study at Andi Djemma Masamba Airport, North Luwu Regency". With this research, it is hoped that benefits will be obtained in the form of a good understanding of risk management, risk assessment using the ISO 31000:2018 standard, mapping risks into the *Federal Aviation Administration* (FAA) risk matrix, designing risk controls, and providing clear direction, boundaries and responsibilities for the implementation of Risk Management. The aim of this research is to analyze the mapping and risk assessment of operational facilities at airports and determine a list of potential risks, risk assessment of operating facilities at airports based on ISO 31000 standards and determine risk control against potentially dangerous risks at operating facilities. The Federal Aviation Administration (FAA) uses the risk matrix as a tool to evaluate and assess the risks associated with various aviation activities and operations. A risk matrix is a visual representation that helps identify the likelihood and severity of a risk that may occur.

2. METHODS

2.1 Types Of Research

Judging from the type of data, the research approach used in this research is qualitative. Based on the problems studied, this research from the sampling aspect is included in the survey research category. Respondents in this study were employees who had experience operating facilities to obtain subjective answers. Then the qualitative data will be processed into quantitative data based on categories.

The population that will be used in this study is officers within the technical scope of the airport consisting of:

Population	Position	Sum
Head of class III airport office	Head of Airport Management Andi Djemma Masamba	1
Aviation Security and Safety Sub-Section	Head of Aviation Security and Safety Subsection Petugas senior AVSEC Senior PKP-PK officer Petugas junior AVSEC Petugas junior PKP-PK Apron attendant Hygiene and sanitation officer Airport mechanic level 1	25
Aviation technician functional position group	Supervisory flight technician Advanced executing flight technician Executing flight technician	5
Administrative affairs	Head of Administrative Affairs Financial manager Personnel manager	9

	General administration	
	Overall total	40

Of the total population, there are 40 people, so according to the opinion above and considering the number of samples for this study, there are only 22 employees who are directly related to activities that can pose risks

2.2 Data Analysis Technique

The risk management research method is carried out referring to ISO 31000. The stages start from risk identification, risk analysis and risk evaluation. All identified risks take into account their impact on the goals the company wants to achieve. Risk identification is the process of identifying all possible risks that may occur in a project or organization. Risks can come from a variety of sources, such as government policy, industry competition, market changes, or internal problems such as system failure or data loss.

Risk analysis aims to assess risks from a list of confirmed risks. This is done by multiplying the magnitude of the risk impact by the probability of its occurrence, to determine the severity of the risk. The input for this stage is a list of confirmed risks. Risk mapping is carried out between the impact value and the probability value of the event using the risk matrix provided. From the risks mapped, the types of risks can be seen from the most potential or dangerous to those that are normal or tolerable.

Control systems are created to assist in making decisions. The control system takes the form of preventing risk events that have not yet occurred and handling risks that have occurred, through a risk control plan. At the risk control planning stage, a validation process and ongoing discussion with the company is required. This aims to ensure that the control and mitigation plans designed are relevant and possible for the company to implement.

The research instrument is a questionnaire with a questionnaire method and the score results are carried out using the Likert Scale. All results of the respondent questionnaire were then tabulated to become import data for *software programs*. A research instrument is a tool that uses a scale to measure the value of the variables being researched with the aim of producing accurate qualitative data. By using the questionnaire method as a data collection tool with the Likert Scale and in order to make the coverage of information more complete and on the target, before the preparation of the instrument grid includes the variable instrument of possible risk on the *runway*, the variable instrument of possible risk around the apron and the variable instrument of possible risk in the terminal building.

3. RESULT AND DISCUSSION

3.1 Respondent Profile

The respondents in this study were officers at Andi Djemma Masamba Airport who worked at airport operations facilities and based on the existing population, the sample used was 22 people. The 22 respondents who participated in this research were further grouped based on gender, age, education, length of work and experience with risk management at Andi Djemma airport.

Table 1. Respondents by Gender

No	Gender Category	Amount	Percentage (%)
1	Male	10	46
2	Female	12	54
	Total	22	100

Table 2 Respondents Based on Age

No	Age Category	Amount	Percentage (%)
1	20 – 24 years old	13	59
2	25 – 30 years old	5	23
3	> 30 years old	4	18
	Total	22	100

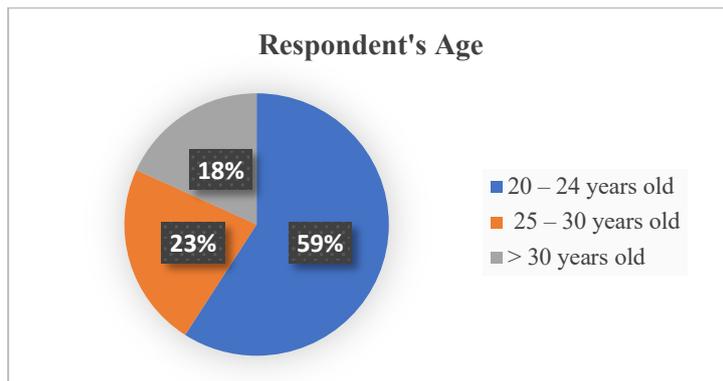


Figure 1. Percentage of Respondents by Age

Table 3 Respondents Based on Education

No	Education Category	Amount	Percentage (%)
1	Senior High School	7	32
2	Diploma Level	7	32
3	Undergraduate Level	8	36
	Total	22	100

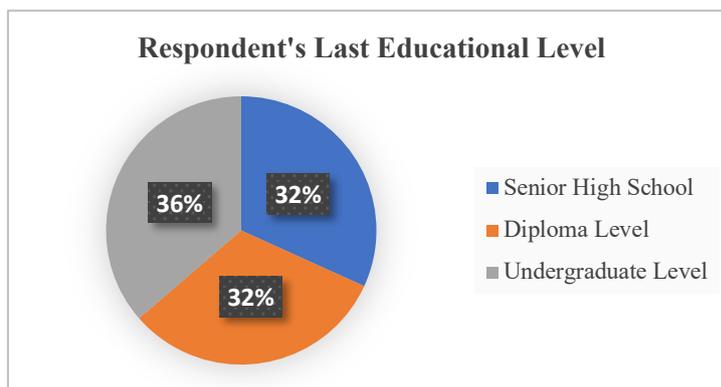


Figure 2. Percentage of Respondents Based on Education

Table 4 Respondent Based on Length of Work

No	Length of Work Category	Amount	Percentage (%)
1	1 – 3 years	12	55
2	4 – 6 years	4	18
3	6- 10 years	6	27
	Total	22	100

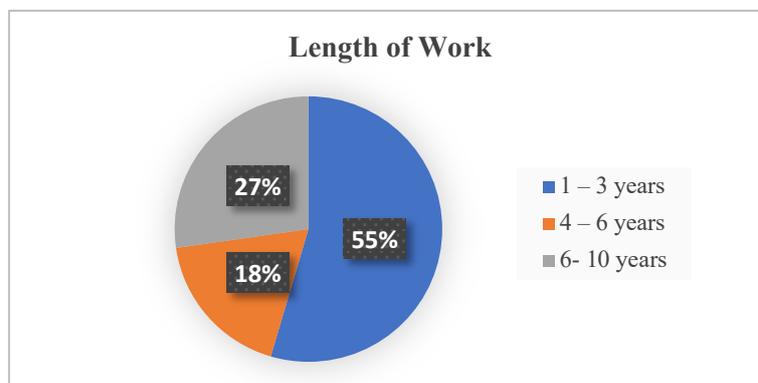


Figure 3. Percentage of Based on Length of Work

Table 5 Respondents Based on Experience with Risk Management at Andi Djemma Airport

No	Risk Management Experience Category	Amount	Percentage (%)
1	1 – 3 years	15	68
2	4 – 5 years	4	18
3	5- 10 years	3	14
	Total	22	100

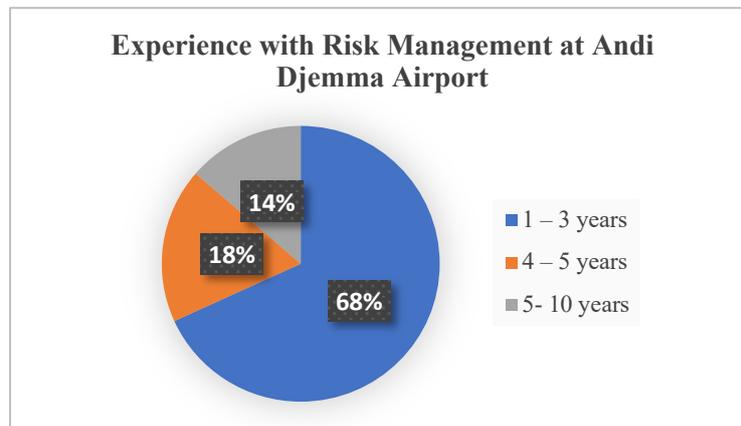


Figure 4. Percentage of Respondents Based on experience with risk management

3.2 Instrument Testing

3.2.1 Validity Test

The validity test is used to measure whether the questionnaire used is valid or not. The analytical tool used to measure the validity of the data is the correlation coefficient depicting $\alpha = 5\%$ with the condition that it is said to be valid if the calculated $r > r_{table}$ and the significant value is > 0.5 .

Table 6 Results of Runaway Variable Statement Item Validity Test (X1)

Indicator	$r_{count} (KK)$	$r_{count} (D)$	r_{table}	Significance Value	Information
X1.1 = Runway Surface Breaks	0.747	0.502		0.000	Valid
X1.2 = Occurrence of Obstacles on the Runway	0.839	0.554	0.404	0.000	Valid
X1.3 = Plane Crash During Take Off or Landing	0.816	0.559		0.000	valid

Table 7 Results of the Validity Test of Variable Statement Items of the Passenger Terminal (X3)

Indicator	$r_{count} (KK)$	$r_{count} (D)$	r_{table}	Significance Value	Information
X3.1 = Operational disruption and terminal services	0.786	0.598		0.000	Valid
X3.2 = Stacking of goods in cargo	0.694	0.582	0.404	0.000	Valid
X3.3 = The security check process is not optimal	0.613	0.537		0.002	Valid
X3.4 = Slipping of dangerous goods into the plane	0.715	0.615		0.001	Valid

X3.5 = Shortage of employees	0.601	0.806	0.003	Valid
X3.6 = Lack of building maintenance	0.650	0.578	0.001	Valid
X3.7 = Passenger density at the terminal	0.669	0.738	0.003	Valid

Based on the table above which is the result of the validity test, it can be seen that all statement items have a correlation coefficient value ($r_{count} > r_{table}$) and a significance value below 0.050 so that it indicates that the data obtained is valid.

3.2.2 Reability Test

Reliability is a tool used to measure a questionnaire which is an indicator of a variable. A questionnaire is said to be reliable or reliable when the respondent's answers to statements are consistent or stable over time. To measure reliability with the Cronbach Alpha (α) statistical test, a construct or variable is said to be reliable if it provides a Cronbach Alpha value > 0.60 (Ghozali, 2011: 48). The results of reliability testing in this research are as follows:

Tabel 8 Reability Statistics

Variabel	Cronbach's Alpha	N Of Items
X	0.832	12
Y	0.898	3

The results of the reliability test show that the Cronbach's Alpha value (0.832 & 0.898) > 0.60 , thus it can be concluded that all reliable X and Y measurements in the questionnaire are reliable

3.3 Risk Mapping

According to Darmawi (2008) "Risk identification is a process that is systematically and continuously carried out to identify the possibility of risk arising." The risk identification method is an interview with the head of aviation security and safety, who is considered competent in understanding the sources of risk, events, causes and potential consequences.

According to Darmawi (2008) "Risk identification is a process that is systematically and continuously carried out to identify the possibility of risk". The risk identification method is an interview with the head of the aviation security and safety section, who is considered qualified in understanding the source of risk, events, causes and potential consequences. Data on all possible negative risk events can be seen as follows:

Table 9 List of Risk Events and Causes and Its Impact

NO	LIST OF EVENTS	CAUSES OF RISK	RISK IMPACT
1.	Runway surface breaks	<ul style="list-style-type: none"> · Increase in traffic · Declining groundwater level · Dummy joint missed · Technical Age 	<ul style="list-style-type: none"> · Loss of company assets · Declining service levels · Loss of property and human life · <i>Runway</i> closed
2.	Obstacles on the <i>runway</i>	<ul style="list-style-type: none"> · Less than optimal supervision from airport officers · Barriers to coordination with related institutions · Socialization to the community is not good 	<ul style="list-style-type: none"> · There was a plane accident
3.	Plane crash during take-off/landing	<ul style="list-style-type: none"> · FOD · <i>Runway</i> Incursion · Bird Strike · Kite · Standing water 	<ul style="list-style-type: none"> · Loss of property and human life · Disruption of corporate image

4.	Plane accident in the apron/taxiway area	<ul style="list-style-type: none"> · Miscommunication about the movement of aircraft and vehicles in the apron area · Marking and sign are not clear · Inadequate groundhandling facilities · Limited area of the Apron 	<ul style="list-style-type: none"> · Loss of property and human life · Complaints from airlines · Disruption of corporate image
5.	There is a fuel spill on the apron/taxiway	<ul style="list-style-type: none"> · Negligence of the refueling officer · Problematic fuel hose · Aircraft fuel tank leaks 	<ul style="list-style-type: none"> · Loss of property and human life · Flight delays due to control
6.	Operational and service disruptions at the terminal	<ul style="list-style-type: none"> · Limited number of competent human resources · The development of airport facilities is not balanced with the growth of airport service users 	<ul style="list-style-type: none"> · Complaints from airlines · Disruption of corporate image
7.	Stacking of goods in cargo	<ul style="list-style-type: none"> · The number of X-rays is only 1 unit · Cargolast minute freight forwarding culture · The condition of the X-Ray is old · Insufficient warehouse area 	<ul style="list-style-type: none"> · Declining service levels · Disruption of corporate image
8.	Inspection process Security is not optimal	<ul style="list-style-type: none"> · The number of human resources is inadequate · The performance of security facilities declined · The quality of officer service is inadequate 	<ul style="list-style-type: none"> · Disruption of corporate image · There was a queue of passengers
9.	Slipping of dangerous goods into the plane	<ul style="list-style-type: none"> · X-ray technology cannot detect DG · Agent doesn't understand DG handling · Limited number of DG-certified AVSEC HR 	<ul style="list-style-type: none"> · Loss of property and human life · Complaints from airlines
10.	Shortage of employees	<ul style="list-style-type: none"> · Changes in organizational structure · The employee needs map has not been implemented optimally · The recruitment pattern has not been balanced with the formation 	<ul style="list-style-type: none"> · Work results are not optimal
11.	Lack of building maintenance	<ul style="list-style-type: none"> · Unpredictable weather · Lack of optimal performance of maintenance staff 	<ul style="list-style-type: none"> · Loss of company assets · Disruption of corporate image
12.	Passenger density at the terminal	<ul style="list-style-type: none"> · Limited check-in counter facilities · Airline demand during golden time · Inadequate security equipment 	<ul style="list-style-type: none"> · Disruption of corporate image

3.3.1 Risk Evaluation

Risk evaluation aims to select the most potential risks from the list of existing risks. The way to do this is by mapping the list of risks resulting from the risk analysis into the FAA risk matrix. Risk mapping is carried out between the impact value and the probability value of the event using the risk matrix provided. From the risks mapped, the types of risks can be seen from the most potential or dangerous to those that are normal or tolerable.

The value of each respondent's answer to the event that has been obtained is then calculated by calculating the median, mode, standard deviation, highest value and lowest value using Microsoft Excel worksheet software. This attribute value is obtained from subjectivity through the process of filling out a questionnaire with the calculation results as shown in Tables 7 and 8 below:

Table 7 Calculation of Probability Statistics

Event No.	Possible Event
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	Median	Mode	ST Dev	maximum	minimum	Mode Values Are Rounded
1	3	4.0	0.9258	2	4	4
2	3	3.5	1.0538	1	4	3
3	2.5	3.0	0.9351	1	4	3
4	2	2.5	1.0022	1	4	2
5	2.5	2.0	1.0075	1	4	2
6	3	2.0	1.4111	1	5	2
7	2	2.0	1.2792	1	5	2
8	2.5	2.0	1.4683	1	5	2
9	2	2.0	1.1010	1	4	2
10	2	2.5	1.1406	1	4	2
11	2	2.0	0.8985	1	4	2
12	2	3.0	1.1358	1	5	3

Table 8 Calculation of Impact Statistic

Event No.	Impact					
	Median	Mode	ST Dev	maximum	minimum	Mode Values Are Rounded
1	3	3.0	0.7516	4	2	4
2	2	3.5	0.9989	5	2	3
3	5	4.5	0.9069	5	3	3
4	5	5.0	0.945	5	3	2
5	4	4.0	0.7025	5	1	2
6	2	2.0	0.7327	3	1	2
7	2	2.0	0.5284	3	1	2
8	3.5	3.0	0.7854	4	2	2
9	3	4.0	0.8985	5	3	2
10	1	2.5	0.9715	4	1	2
11	3	3.0	1.0414	4	1	2
12	3	3.0	0.9946	4	1	3

3.3.2 Risk Matrix From the Federation Aviation Administration (FAA)

The FAA risk matrix is used because the FAA already has good experience in aviation matters. The scale criteria refer to the FAA, namely 1-5 as in Table below:

Table 9 Scale of Probable Events and Impact

No.	Possibility	Score	Impact
1	Often	5	Big Disaster
2	Possible	4	Dangerous
3	Small possibility	3	Big
4	The possibility is very small	2	Small
5	Very Impossible	1	There is No Serious Impact

Table 10 Risk Level

No	Risk Level	Information
1	HIGH RISK	Risks that really need to be handled as quickly as possible, and the impact is very large
2	MEDIUM RISK	Risks that require handling and their impact are large
3	LOW RISK	Risks that can be avoided and can be overcome

Table 11 Risk Mapping uses the FAA Risk Matrix

		IMPACT				
		1	2	3	4	5
POSSIBLE EVENT	1					
	2	10	6,7	8,9,11	5	4
	3		2	12		3
	4			1		
	5					

Based on table 11, it was found that there were 6 risk events that fell into the red category, while 3 were in the yellow category, and 1 was in the green category. All risks in the red zone receive special treatment, namely in the form of further treatment. All risks in the red zone are then recorded in the list of potential risks. The following is a table listing the potential risks that have been obtained:

Tabel 12 List of Potential Risk

No	Name of The Risk Event	Possibility	Impact
1	The security inspection process is less than optimal	2	3
2	Passage of dangerous goods into the aircraft	2	3
3	Minimal building maintenance	2	3
4	There is a fuel spill on the apron/taxiway	2	4
5	Plane accident in the apron/taxiway	2	5
6	Plane accident during take off/landing	3	5

3.3.3. Operating Planning

The operating system is made to assist in decision-making. The control system is in the form of prevention of risk events that have not yet occurred and the handling of risks that have occurred, risk control plans. At the risk control planning stage, a validation process and continuous discussion are needed with the company. This is so that the control and mitigation plan designed can be relevant and possible for the company to implement. Here are the control systems created for all six types of potential risk events that have been detected:

a. Plane accident during take off/landing

Some of the causes of the risk of airplane accidents during take off/landing are: foreign object debris (FOD), runway incursion, bird strikes, kites and standing water. Some efforts to prevent the risk of accidents are: regular supervision, coordination of related units and facility maintenance SOPs. Based on these causes, control is carried out by making chronological reports, coordinating related units, and improving facilities.

b. Plane Crash in the Apron Area

Some of the causes of aircraft accidents in the apron area are: inadequate competence of ground handling officers, officers lacking order in arranging work facilities after use, miscommunication regarding the movement of aircraft and vehicles in the apron area, limited number of AMC officers, unclear markings and signs, ground vehicle facilities inadequate handling, and limited apron area. Several efforts to prevent aircraft

accidents in the apron area are: training and education for officers in the apron area, increasing inspections, increasing the number of personnel, socializing markings and signs with officers, repainting markings and signs, replacing vehicles with adequate ones, maintaining vehicles, expanding apron area, and layout settings. Meanwhile, the controls are: accident investigation, coordination with related units, coordination with public relations and making a chronological report

c. Passage of dangerous goods into the aircraft

Some of the causes that cause dangerous goods to escape into aircraft are: X-ray technology cannot detect dangerous goods (DG), there are other doors that are not guarded, the number of DG-certified AVSEC (aviation security) human resources is limited, officer training and education. Some efforts to prevent the passage of dangerous goods into aircraft are: X-ray calibration, manual inspection by officers, purchasing the latest X-ray models, placing personnel, coordinating goods through X-ray, increasing overtime working hours, and checking X-rays one by one. Meanwhile, the controls are: coordinating with public relations, securing dangerous goods, making chronological reports, and coordinating with related units.

d. There is a fuel spill on the apron/taxiway

Several causes that cause fuel spills on the apron/taxiway are: a leak in the fuel loading device to the aircraft, incorrect estimation of the amount of refueling. Several efforts to prevent fuel spills on aprons/taxiways are: manual inspection by officers, placing personnel, coordinating filling personnel. Meanwhile, the control is: securing the affected area, making a chronological report, and coordinating with related units.

e. Minimal building maintenance

Some of the causes of minimal building maintenance are: lack of inspection of the building, maintenance only focuses on a small part of the building. Some efforts to prevent minimal building maintenance are: manual inspection by officers, providing employees with an understanding of how to always look after the building, such as keeping it clean. Meanwhile, the controls are: coordinating with section heads, making chronological reports, and coordinating with related units, immediately carrying out maintenance, especially on vital airport buildings.

f. The security inspection process is less than optimal

Some of the causes that make the security inspection process less than optimal are: the presence of other doors that are not guarded, the number of DG-certified AVSEC (aviation security) human resources is limited, training and education of officers. Some preventative measures for the security inspection process are less than optimal, namely: manual inspection by officers, placing personnel always on standby. Meanwhile, the controls are: training and education of officers, making daily reports, and coordinating with related units.

Control only reaches the planning stage and is not continued into the implementation stage so its durability cannot be tested but is good enough for current risk control. Each control has a strength value against risk. This research does not involve an assessment of the control system, but ends with the registration of the control system, because this assessment can be carried out if the control system has been implemented for a long time. Further research needs to be developed to the implementation stage so that an assessment of the control system can be carried out. The results of this study are also in accordance with the initial hypothesis that risk management is important to be applied in the context of Andi Djemma Airport because it has potential risks.

4. CONCLUSIONS

1. Based on mapping and risk assessment using the FAA risk matrix and statistical calculations of the probability of occurrence and impact of events, the mode value obtained from respondents' answers to 12 lists of events was obtained, then it was found that there were 6 risk events that were in the red category (high risk level), while 3 is for the yellow category (medium risk level), and 3 is for the green category (low risk level).
2. After obtaining 6 risk events that are included in the list of potential risks, namely, 1) Plane accident during take off/landing, 2) Plane accident in the apron area, 3) The escape of dangerous goods on board the plane, 4) There is a fuel spill on Apron/Taxiway, 5) Minimal building maintenance, 6) The security inspection process is less than optimal. Major events that fall into the dangerous category and require special treatment

have been provided with a control and prevention system. The design of the risk control system has been well made, because it has been subjectively validated by the relevant fields.

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Identification of MSMEs' Decision in Using Digital Payment as Part of the Smart City Concept Implementation in Lhokseumawe City

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Abstract

Keywords:

Digital payment,
Structural Equation
Modeling Partial Least
Square (SEM-PLS),
Smart City, Theory
Acceptance Model
(TAM)

In today's digital era, many people are using various digital payment products. Digital payments make transactions faster, safer, and more efficient, especially for Micro, Small, and Medium Enterprises (MSMEs). This is particularly relevant in the effort to develop the smart city concept, which emphasizes the use of technology to improve the quality of life in urban areas. This research was conducted to determine the most preferred type of digital payment and the factors that influence the decision of MSMEs in Lhokseumawe to use digital payments as a non-cash transaction medium. The research used a questionnaire for data collection. The sample consists of MSMEs in Lhokseumawe that use digital payments, with 100 samples analyzed using Structural Equation Modeling Partial Least Square (SEM-PLS). The results show that of the 100 MSME respondents using digital payment in Lhokseumawe, the most preferred digital payment types are BSI Mobile (44%), QRIS (38%), DANA (14%), and ShopeePay (4%). The factors influencing the decision of MSMEs in Lhokseumawe to use digital payments include social influence perception, ease of use perception, and risk perception

1. INTRODUCTION

In today's digital era, where technology is developing without limits, many industries must adapt and use technology in every aspect of their business. One of the growing technological implementations is the use of digital payments in daily transactions. Digital payments make it easier for people, especially Micro, Small, and Medium Enterprises (MSMEs), to conduct transactions more quickly, securely, and efficiently (Merdeka.com, 2017).

Based on the results of the Visa Consumer Payment Attitudes Study, the use of digital wallets continues to increase, with the highest payment reaching 92% among Indonesians, the same figure as the previous year. On the other hand, the use of cash has decreased to 80% from 84% in 2022. With digital payments, many people who previously used cash payments have now switched to non-cash payments for various transactions (Saputra, 2024). This becomes very relevant in efforts to develop the concept of a smart city that prioritizes the use of technology to improve the quality of life for urban communities (Anisa et al., 2022).

Lhokseumawe, as one of the developing cities in Aceh, is trying to adopt the smart city concept in order to increase the effectiveness and efficiency of various public services and strengthen local economic competitiveness. One important aspect of smart city development is the use of digital technology, including in economic transactions through digital payments. However, the adoption of digital payment technology by MSMEs in Lhokseumawe still faces various challenges and obstacles (Kurniawati et al., 2017). The varying levels of adoption indicate that there are several factors influencing MSMEs' decisions to use this technology.

Based on preliminary data, digital payment platforms such as BSI Mobile, QRIS, DANA, and ShopeePay have begun to be used by several MSMEs in Lhokseumawe, although with different levels of adoption. This shows the need for more in-depth research on the factors that influence MSMEs' decisions in using digital payments as part of efforts to realize a smart city in Lhokseumawe.

One theory that can be used to understand these factors is the Theory of Acceptance Model (TAM). TAM is a tool to analyze factors that influence the acceptance of a system or information (Rizky Wicaksono, 2022). According to TAM, a person's use of technology is influenced by two main things: perceived usefulness (how useful the technology is) and perceived ease of use (how easy the technology is to use) (Faizani1 & Indriyanti, 2021). In addition to these two factors, trust, risk, and social influence can also affect a person's interest in using the technology (Farrasari & Amaliah, 2023)

This research was conducted to determine the types of digital payments that are most in demand and what factors influence the decisions of MSMEs in Lhokseumawe city in using digital payments as a non-cash transaction medium. The research results are expected to identify the main factors that influence MSMEs' decisions in adopting digital payments (Pangaribuan et al., 2019). The findings of this study are also expected to provide input for local governments and related parties in designing more effective strategies to increase the adoption of digital payment technology, which will ultimately support the success of the smart city concept in Lhokseumawe City. Therefore, the researchers conducted a study entitled "Identification of MSME Decisions in Using Digital Payments in Lhokseumawe City".

2. LITERATURE REVIEW

2.1 Digital Payments and MSMEs

Digital payments have become one of the main pillars in supporting business efficiency, especially in the Micro, Small and Medium Enterprises (MSME) sector. According to research from Thakur and Srivastava (2014), digital payments can improve the operational efficiency of MSMEs by enabling faster and safer transactions. Research conducted by (Nurhayani et al., 2024) shows that the adoption of digital payments among MSMEs helps improve market access, as many customers prefer practical cashless payment methods. However, some MSMEs are still reluctant to switch due to limited understanding of the technology and security concerns (Yanurida & Istantia, 2023)

In Indonesia, the use of digital payments in MSMEs is still mixed, especially in less developed areas such as Lhokseumawe. Research from found that in some areas, MSMEs still rely heavily on cash payments due to limited access and understanding of digital technology. On the other hand, research by (Setyaningtyas, 2024) shows that in more developed urban areas, digital payments are starting to be more widely adopted by MSMEs, especially after the COVID-19 pandemic which accelerated the use of this technology.

2.2 Factors Influencing Digital Payment Adoption

Based on the Theory Acceptance Model (TAM), the use of technology by individuals or organizations is influenced by two main factors: perceived usefulness and perceived ease of use (Davis, 2018). Perceived usefulness refers to the extent to which a person believes that technology will improve their performance, while perceived ease of use refers to how easy the technology is to learn and apply. In the context of MSMEs, research by (Tirtana et al., 2022) shows that perceived ease of use and benefits strongly influence the decision to adopt digital payment technology.

Previous research has also identified various factors that influence MSME decisions to adopt digital payments. According to (Rithmaya et al., 2024), factors such as trust in technology, perceived risks (related to security and privacy), as well as government support and social environment are the main factors that influence adoption decisions. Other factors that influence MSME decisions to use digital payments are perceived risk, trust in technology, and social influence (Purwantini & Anisa, 2021). (Melianthi & Darma, 2024) found that many MSMEs are reluctant to use digital payments due to concerns about data security and the risk of invalid transactions. On the other hand, social influence, such as recommendations from peers or the business community, also plays an important role in accelerating technology adoption (Gunawan et al., 2023).

2.3 Smart City

The smart city concept has become an important agenda in the development of cities in Indonesia. Smart cities integrate information and communication technology (ICT) to improve the quality of public services, operational efficiency, and quality of life. According to (Hutama & Djunaedi, 2019), Indonesia has started smart city initiatives in several major cities such as Jakarta, Surabaya, and Bandung. In these cities, digital technology is used to monitor traffic, health systems, and public services more efficiently. One crucial aspect in smart city development is the digital payment system that enables economic transactions to run faster, more efficiently, and safely.

The Indonesian government, through several programs such as the National Non-Cash Movement (GNNT) and the adoption of QRIS, continues to encourage the implementation of digital payment technology as part of smart city initiatives in various cities in Indonesia, including Lhokseumawe. However, some challenges in implementing smart cities, especially in small cities like Lhokseumawe, still need attention. According to research by (Agustian, 2023), inadequate infrastructure, limited internet access, and low digital literacy are the main obstacles in developing smart cities in Indonesia. Therefore, a focused strategy is needed to increase understanding and access to technology for communities and small businesses so that smart city goals can be achieved.

3. METHODS

The method in this research is quantitative, using primary data collected through questionnaires and distributed directly with random sampling techniques.

3.1 Population and Sample

This research was conducted in the city of Lhokseumawe, Aceh Province. The study began in April 2024 and will continue until its completion. The objects of this research are MSMEs that use digital payment systems. The primary data obtained in this study include the types of digital payments used, as well as information on MSMEs' preferences, experiences, and perceptions of digital payments. The secondary data needed in this research include the number of MSMEs in Lhokseumawe, literature studies from academic books, journals, and other sources of information.

3.2 Analysis Method

Analysis was conducted on 100 respondents to identify MSME decisions to use digital payments in Lhokseumawe city. In this study, to analyze the data using PLS-SEM by considering a relatively small sample and not normally distributed. So that structural equation modeling, or SEM, combines factor analysis and path analysis into a more comprehensive statistical method (Haryono, 2016).. The stages used in PLS - SEM analysis include:

1. Model Specification
2. Model Estimation
3. Outer Model Evaluation
 - a. Convergent Validity Test
 - b. Discriminant Validity Test
 - c. Composite Reliability (CR)
4. Inner Model Evaluation
 - a. Model Fit Test
 - b. Collinearity Test
 - c. R-Square Test
 - d. Effect Size
 - e. Path Coefficients

4. RESULT AND DISCUSSION

4.1 Population and Sample

This research begins with the data collection process, which involves gathering facts and figures related to the issue being studied.

The population (N) in this study includes 5,739 Micro, Small, and Medium Enterprises (MSMEs) located in the city of Lhokseumawe. To determine the number of participants in the study with a margin of error (α) of 10%, the Slovin formula is used, with the following calculation :

$$n = \frac{N}{1 + N \alpha^2}$$

$$n = \frac{5.739}{1 + 5.739 (0,1)^2}$$

$$n = 98,29 \approx \text{rounded up to } 100$$

Thus, the sample size taken is 100 people. Therefore, in this study, data must be collected from at least 100 respondents.

4.2 MSMEs That Use Digital Payments

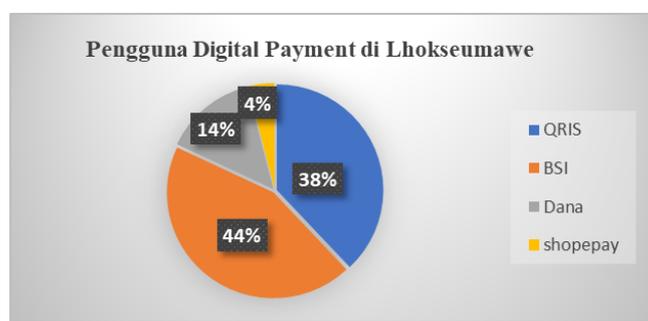


Figure 1. MSMEs Using Digital Payments in the City of Lhokseumawe.

From Figure 1 above, it is known that the total number of respondents is 100 people, with 44% using BSI Mobile, 38% using QRIS, 14% using DANA, and 4% using ShopeePay. From these results, it can be concluded that BSI Mobile is the most preferred type of digital payment among the respondents.

The next stage is data processing, which is carried out through the following steps:

4.3 Structural Equation Modeling (SEM) Analysis

In PLS-SEM analysis, there are several stages, including model specification, parameter estimation, structural model testing, and measurement model testing.

1. Model Specification

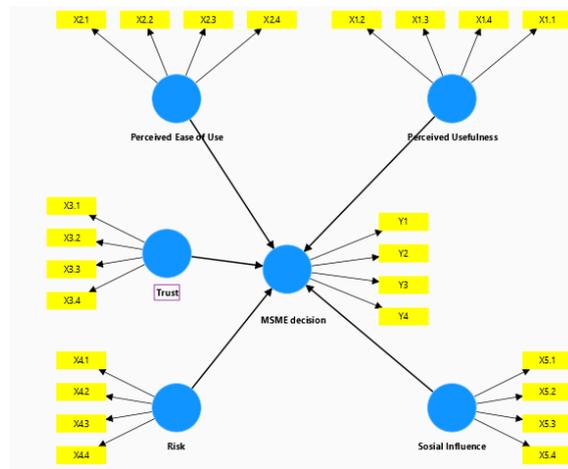


Figure 2. Model Specification

At this stage, a model is developed to illustrate the relationships between one latent variable and another latent variable. The model specification can be seen in Figure 2 as follows.

2. Model Estimation

Analysis at this stage involves the PLS algorithm, which includes iterative procedures to produce latent variable scores. The model estimation can be seen in Figure 3.

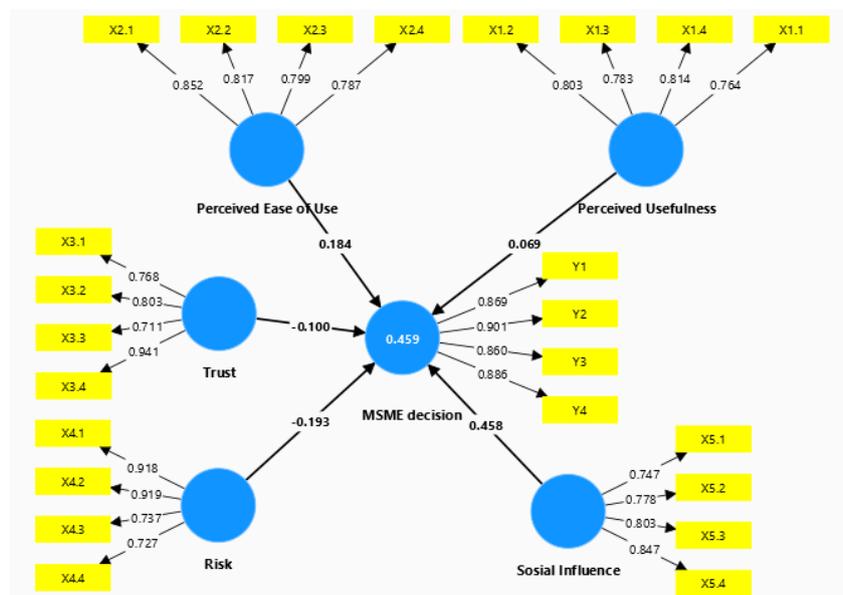


Figure 3. Model Estimation

3. Measurement Model Evaluation (Outer Model)

The evaluation of the measurement model is conducted to verify indicators and latent variables that can be further tested. In the measurement model, the evaluation is carried out using convergent validity, discriminant validity, and composite reliability.

a. Convergent Validity Test

The Convergent Validity Test is used to determine the validity of each relationship between indicators and their constructs or latent variables. The results of the Outer Loading can be seen in Table 1 below.

Table 1. Nilai *Outer Convergent Validity*

Variable	Indicator	Outer Loading	Description
Perceived Usefulness	X1.1	0.764	Valid
	X1.2	0.803	Valid
	X1.3	0.783	Valid
	X1.4	0.814	Valid
Perceived Ease of Use	X2.1	0.852	Valid
	X2.2	0.817	Valid
	X2.3	0.799	Valid
	X2.4	0.787	Valid
Trust	X3.1	0.768	Valid
	X3.2	0.803	Valid
	X3.3	0.711	Valid
	X3.4	0.941	Valid
Risk	X4.1	0.918	Valid
	X4.2	0.919	Valid
	X4.3	0.737	Valid
	X4.4	0.727	Valid
Social Influence	X5.1	0.747	Valid
	X5.2	0.778	Valid
	X5.3	0.803	Valid
	X5.4	0.847	Valid

Based on Table 1, the results of the validity test show that the outer loading or factor loading values for each research variable exceed > 0.7 . This indicates that the variables used, namely: perceived usefulness, perceived ease of use, trust, risk, and social influence, are valid and can be used as benchmarks in measuring the decision of MSMEs to use digital payments in the city of Lhokseumawe.

b. Discriminant Validity Test

Discriminant validity shows whether a test designed to measure a specific construct does not correlate with tests that measure different constructs. The results of the validity test can be seen in Figure 2 below.

Table 2. Discriminant Validity Test Results

Variable	Average Variance Extracted (AVE)
Perceived Ease of Use	0.663
Trust	0.657
MSME decision	0.773
Risk	0.626
Social Influence	0.631
Perceived Usefulness	0.690

From Table 2 above, it shows that each variable has an Average Variance Extracted (AVE) value > 0.5 , so it can be concluded that the indicators used have good discriminant validity.

c. Composite Reliability

Composite Reliability is used to measure how well the underlying variables of a construct are represented in structural equation modeling. The values of Cronbach's Alpha and Composite Reliability can be seen in Table 3 below.

Table 3. Cronbach's Alpha and Composite Reliability Values

Variable	Cronbach's alpha	Composite reliability
Perceived Ease of Use	0.832	0.851
Trust	0.843	0.986
MSME decision	0.902	0.904
Risk	0.807	0.828
Social Influence	0.805	0.812
Perceived Usefulness	0.855	0.957

Based on Table 3 above, it shows that the composite reliability value is > 0.7 and the Cronbach's alpha value is > 0.7 , indicating good reliability. It can be concluded that all variables are reliable.

4. Structural Model (Inner Model)

After evaluating the measurement model for constructs/variables, the next step is to evaluate the structural model or Inner Model. The evaluation of the inner model can be carried out through the model fit test, collinearity assumption test, R-Square test, effect size, and path coefficients.

a. Model Fit Test

The Model Fit Test is used to assess the fit between the observed correlations. If the Standardized Root Mean Square (SRMR) value is less than 0.10 or 0.08, the model is considered to be a good fit. Additionally, the model is said to fit if the Normal Fit Index (NFI) value is between 0 and 1, with values closer to 1 indicating a better fit. The results of the Model Fit Test can be seen in Table 4 below.

Table 4. Model Fit Test Results

Parameter	Saturated model	Estimated model
SRMR	0.080	0.080
d_ ULS	1.933	1.933
d_ G	0.671	0.671
Chi-square	378.008	378.008
NFI	0.723	0.723

Based on Table 4 above, the NFI value is close to 1, and the SRMR value is < 0.08 , so it can be concluded that the model is considered good and well-fitted.

b. Collinearity Test

Collinearity occurs when there is a correlation between indicators in a latent variable within a model, making its predictive power unreliable and unstable. Collinearity can be indicated by the VIF (Variance Inflation Factor) value, where if it is < 5 , collinearity does not occur. The VIF (Variance Inflation Factor) values can be seen in Table 5 below.

Table 5. Collinearity Test Result

Indicator	VIF
X1.1	1.886
X1.2	1.452
X1.3	1.687
X1.4	1.726
X2.1	1.822
X2.2	1.977
X2.3	1.680
X2.4	1.807
X3.1	1.875

X3.2	1.738
X3.3	1.897
X3.4	2.650
X4.1	2.774
X4.2	2.849
X4.3	1.662
X4.4	1.676
X5.1	1.528
X5.2	1.732
X5.3	1.641
X5.4	2.006
Y1	2.606
Y2	2.982
Y3	2.286
Y4	2.645

Based on Table 5 above, if the VIF (Variance Inflation Factor) value is < 5 , the level of multicollinearity is low. This result strengthens the estimation results in SEM PLS, indicating that they are robust (not biased)

c. R-Square

R-Square (R^2) is a statistical measure used to determine the proportion of variance in the dependent variable that can be predicted or explained by the independent variables. An R-Square value close to 0.67 is considered strong, 0.33 as moderate, and 0.19 as weak. The R-Square values can be seen in Table 6 below.

Table 6. R-Square Values

	R-square	R-square adjusted
MSME decision	0.459	0.430

Based on Table 6, the R-Square value for the MSME decision variable is 0.459, which indicates that the variables of perceived usefulness, perceived ease of use, trust, risk, and social influence collectively explain 45.9% of the variation in the MSME decision to use digital payments in the city of Lhokseumawe. Thus, the R^2 value (0.459) indicates a moderate relationship between the latent variables and the dependent variable.

d. Effect Size

Effect Size is used to measure the magnitude of the influence of an independent variable on a dependent variable in the model. Recommended effect sizes (f^2) are 0.02, 0.15, and 0.35, where exogenous latent variables have small, moderate, and large effects at the structural level. The effect size values can be seen in Table 7 below.

Tabel 7. effect size Values

Criteria	f-square
Perceived Usefulness	0.009
Perceived Ease of Use	0.051
Trust	0.018
Risk	0.063
Social Influence	0.299

Based on Table 7 above, the effect sizes on the MSME decision to use digital payments in the city of Lhokseumawe are as follows:

- a). Perceived Usefulness has a weak effect on the MSME decision to use digital payments in Lhokseumawe (0.009).
- b). Perceived Ease of Use has a weak effect on the MSME decision to use digital payments in Lhokseumawe (0.051).

- c). Trust has a weak effect on the MSME decision to use digital payments in Lhokseumawe (0.018).
 - d). Risk has a weak effect on the MSME decision to use digital payments in Lhokseumawe (0.063).
 - e). Social Influence has a strong effect on the MSME decision to use digital payments in Lhokseumawe (0.299).
- e. Path Coefficients

Hypothesis testing involves making specific statements or hypotheses about population parameters, and sample statistics are used to assess the likelihood that the hypothesis is true. The criteria for evaluating the structural model (inner model) is significance. The significance values used are (two-tailed): t-value 1.65 (significance level = 10%), 1.96 (significance level = 5%), and 2.58 (significance level = 1%). The Path Coefficient values can be seen in Table 8 below.

Table 8. Coefficient Patch

Variable	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P-values
Perceived Usefulness	0.069	0.075	0.107	0.643	0.260
Perceived Ease of Use	0.184	0.188	0.087	2.120	0.017
Trust	-0.100	-0.105	0.087	1.160	0.123
Risk	-0.193	-0.199	0.100	1.935	0.027
Social Influence	0.458	0.453	0.106	4.320	0.000

Based on Table 8 above, the results of the hypothesis testing are as follows:

- a). The Perceived Usefulness variable has a T-statistic value of $0.643 < 1.96$ and a p-value of $0.260 > 0.05$. This result indicates that perceived usefulness does not influence the decision of MSMEs to use digital payments in Lhokseumawe.
- b). The Perceived Ease of Use variable has a T-statistic value of $2.120 > 1.96$ and a p-value of $0.017 < 0.05$. This result indicates that perceived ease of use influences the decision of MSMEs to use digital payments in Lhokseumawe.
- c). The Trust variable has a T-statistic value of $1.160 < 1.96$ and a p-value of $0.123 > 0.05$. This result indicates that trust does not influence the decision of MSMEs to use digital payments in Lhokseumawe.
- d). The Risk variable has a T-statistic value of $1.935 < 1.96$ and a p-value of $0.027 < 0.05$, but it has an original sample value (O) of -193. This result indicates that risk negatively influences the decision of MSMEs to use digital payments in Lhokseumawe.
- e). The Social Influence variable has a T-statistic value of $4.320 > 1.96$ and a p-value of $0.000 < 0.05$. This result indicates that social influence significantly affects the decision of MSMEs to use digital payments in Lhokseumawe.

4.4 Discussion

The analysis results show the influence of five independent variables: perceived usefulness, perceived ease of use, trust, risk, and social influence on MSME (Micro, Small, and Medium Enterprises) decisions to adopt digital payments in Lhokseumawe City. The discussion of each variable is as follows:

- a. The influence of perceived usefulness shows a T-statistic value of 0.643, which is smaller than the critical value of 1.96, and a p-value of 0.260, which is greater than 0.05. This indicates that perceived usefulness does not have a significant influence on the decision of MSMEs to use digital payments in Lhokseumawe City. This is due to the low digital literacy in the area, where business owners focus more on factors related to ease of use, cost implications, and user security of the payment system. This study is not in line with the research conducted by (Farid & Laksmi, 2023), which stated that perceived usefulness has a positive and significant effect on the interest in using electronic wallets, where when the electronic wallet is perceived to be useful, more people tend to use it. In terms of electronic wallet usage, the intended benefits are to increase the effectiveness and efficiency of its use.

- b. The variable of perceived ease of use shows significant results with a T-statistic value of 2.120, which is greater than 1.96, and a p-value of 0.017, which is less than 0.05. This indicates that perceived ease of use has a significant positive influence on the decision of SMEs to use digital payment in Lhokseumawe City. In other words, the easier SMEs perceive the use of digital payment, the more likely they are to adopt it. This aligns with the research findings of (Rodiah & Melati, 2020) as well as (Muthia Kesuma Hayati & Fauzi, 2022), which also concluded that Perceived Ease of Use influences the use of digital wallets for Financial Management. The results of this study are consistent with the Technology Acceptance Model (TAM) theory, which defines perceived ease of use of a technology as a measure of an individual's belief that using the technology can be easily understood and utilized (Davis, 2018).
- c. Trust as a variable has a T-statistic value of 1.160, which is less than 1.96, and a p-value of 0.123, which is greater than 0.05. These results indicate that trust does not have a significant influence on the decision of SMEs to use digital payment. In this case, trust may not be a primary factor considered by SMEs in Lhokseumawe City when adopting digital payment. SMEs feel that security has already become a standard feature provided by digital payment service providers, so the trust factor is no longer a main concern in adoption decisions. The results of this study are also in line with research conducted by (Rismalia & Sugiyanto, 2022), who examined perceived ease of use, perceived usefulness, and trust in relation to the decision to use Dana at Esa Unggul University. They found that trust, which consists of factors such as the presence of transaction evidence, transaction history, provision of responsibility, compensation, and confidence in security when transacting using Dana, can be interpreted as a positive attitude towards using Dana.
- d. Risk: The risk variable shows an interesting result with a T-statistic value of 1.935, which is close to 1.96 but slightly smaller, and a p-value of 0.027, which is smaller than 0.05. Although statistically close to significant, this result is accompanied by an original sample (O) value of -0.193, indicating a negative influence. This means that the higher the perceived risk by MSMEs, the lower the likelihood they will adopt digital payments. The perceived risks include potential fraud or security vulnerabilities. Many MSMEs are uncertain about the security of their data, particularly regarding financial and personal information, making them reluctant to switch to non-cash payment methods.
- e. The influence variable shows highly significant results with a T-statistic value of 4.320, far greater than 1.96, and a p-value of 0.000, which is well below 0.05. These results indicate that social influence plays a crucial role in SMEs' decision to use digital payment. This means that SMEs' decisions to adopt digital payment are heavily influenced by the perceptions and actions of people around them, including colleagues, customers, or the business community. Many business owners also stated that they feel compelled to follow digital trends because their business partners have already adopted them. This research finding is also supported by a study conducted by (Sastra, 2024), which showed that Social Influence has a significant effect on the use of QRIS digital payment among SME actors in Bukittinggi city. This demonstrates that the influence of the surrounding environment pressures individuals to take certain actions. The local government of Bukittinggi has announced and socialized that SME actors in Bukittinggi city are required to have a QRIS account. The Bukittinggi city government is collaborating with several parties, such as banking institutions, to accelerate the adoption of QRIS.

5. CONCLUSIONS

Based on the analysis conducted in this study, the following conclusions can be drawn: The most preferred digital payment types in Lhokseumawe City are BSI Mobile (44%), QRIS (38%), DANA (14%), and Shopepay (4%). The factors influencing the decision of MSMEs to use digital payment in Lhokseumawe City include perceived social influence, perceived ease of use, and perceived risk. For future researchers, it is recommended

to expand the number of respondents and include additional variables that may influence MSMEs' decisions to use digital payment. This will provide new perspectives on the use of digital payment

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Model for Determining Sustainable Food Agricultural Land through a Spatial Optimization Approach in Bantul Regency

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Optimization Model;
Linear Programming;

Abstract

Land use is a characteristic of the arrangements, activities, and contributions made by humans to either effect changes or maintain a certain type of land cover (Gregorio and Jansen, 1998). Agricultural land is a crucial resource for sustainability and food security. In an effort to control and anticipate the conversion of agricultural land, the Bantul Regency Government has issued Regional Regulation No. 10 of 2023 on the Protection of Sustainable Food Agricultural Land, with a total area of 12,831 hectares. However, the area designated for protection according to the 2021 study recommendations is 14,407.50 hectares. This represents a reduction of 1,576 hectares due to agricultural land in Sewon and Kasihan Districts being planned for non-agricultural use. Therefore, the objective of this study is to identify the modeling of sustainable food agricultural land designation in Bantul Regency, using a linear programming optimization approach with the aid of Microsoft Excel Solver. The linear programming model, with the objective function to minimize the area designated in the regional regulation, determined the need for 11,356.52 hectares of agricultural land to maintain food security in Bantul Regency over a period of 20 years.

1. INTRODUCTION

Land use is a characteristic of the arrangements, activities, and contributions made by humans to produce a change or maintain a particular type of land cover (Gregorio and Jansen, 1998). Land use includes how humans can utilize and manage land for various purposes, such as agriculture, settlement, industry, and conservation. However, the phenomenon of high urbanization rates is a problem in current land use where urbanization is one of the drivers of land use change (Grimm et al. 2008; McDonald et al. 2008). Rapid urbanization rates often come at the expense of losing agricultural land to meet the needs of urban activities. On the other hand, the continuous decline of agricultural land not only limits the potential for increasing land productivity but also affects national food security. Agricultural land is a critical resource for sustainability and food security. Farmland provides the majority of food supply and guarantees a large number of ecosystem services, such as providing food ingredients (Pereira et al., 2018; Scown et al., 2019; Stephens et al., 2018). Therefore, preserving and protecting agricultural land for now and the future is something that must be addressed immediately (Hertel, 2011; Caldwell et al., 2017; FAO, 2021), because the preservation and protection of agricultural land can provide many benefits such as maintaining local and national food security, environmental sustainability, and can control urban growth.

To address the challenges posed by rapid urbanization and agricultural land loss, innovative models for determining sustainable food agricultural land are essential. Spatial optimization techniques can be employed to identify the most suitable areas for agricultural use while considering urban encroachment and ecosystem preservation (Landis, 2001). By integrating geographic information systems (GIS) with land-use planning, stakeholders can visualize potential impacts of development and make informed decisions about land allocation (Batty et al., 2012). Moreover, using spatial analysis tools allows for the evaluation of agricultural land quality, enabling the prioritization of areas that contribute significantly to food security (Meyer et al.,

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2017). The importance of incorporating local knowledge and stakeholder engagement into land-use planning cannot be overstated. Participatory approaches ensure that the perspectives of farmers, urban planners, and community members are included, ultimately leading to more sustainable outcomes (Reed, 2008). By fostering collaboration among various stakeholders, it is possible to create a shared vision for land use that balances agricultural needs with urban development (Mastrorillo et al., 2016). Furthermore, public awareness campaigns can enhance community understanding of the value of agricultural land, promoting its conservation (López et al., 2013).

In addition, the application of environmental and economic assessment tools can support policy-making processes related to agricultural land protection (Kirkpatrick et al., 2010). Such assessments provide evidence to justify maintaining agricultural land amidst competing urban pressures, ultimately contributing to national food security goals (Bai et al., 2019). It is crucial to adopt an evidence-based approach to land-use planning that incorporates ecological and socio-economic factors (Zhang et al., 2015). This multifaceted analysis enables the creation of adaptive strategies that are resilient to changing conditions and urban dynamics (Fischer et al., 2018). Lastly, the integration of technology in agriculture, such as precision farming and sustainable practices, can enhance productivity on existing agricultural lands (Liakos et al., 2018). By optimizing the use of resources, farmers can increase yields while minimizing environmental impacts (Kumar et al., 2019). Supporting research and development in sustainable agricultural technologies is vital for ensuring the long-term viability of food systems (Godfray et al., 2010). Ultimately, a comprehensive model that combines spatial optimization, stakeholder engagement, environmental assessments, and technological integration can pave the way for sustainable food agricultural land management (Moran et al., 2020). As such, it is imperative to continue exploring innovative frameworks that support both agricultural productivity and urban sustainability (Pérez et al., 2021).

Efforts to protect agricultural land in Indonesia are stipulated in Law No. 41 of 2009 concerning the protection of sustainable food agricultural land (LP2B), and Presidential Regulation No. 59 of 2019 concerning Control of Paddy Field Conversion, or often abbreviated as the Protected Paddy Field (LSD) regulation. These regulations aim to maintain the sustainability of national food production by protecting agricultural land from conversion to non-agricultural land. Thus, the existence of this regulation becomes the basis for the government in setting policies and supervising the use and conversion of agricultural land, especially paddy fields, in order to maintain sustainable food availability and production. However, in its implementation, there is often ineffectiveness in the implementation of laws and regulations due to the unclear objects of protected agricultural land, and the lack of public knowledge and awareness about the importance of protecting food agricultural land (Irawan, 2014; Rachmanto, 2014) [21]. This situation is evident in Sewon District, which has the largest rice harvest area in Bantul Regency, covering 2,468.6 hectares (BPS Bantul, 2021). As a result, Sewon District has been designated as the largest LP2B area in Bantul Regency. However, on the other hand, based on Bantul Regency Regional Regulation No. 8 of 2018 concerning the Detailed Spatial Plan and the Zoning Regulation for the Urban Area of Sewon for the years 2018 to 2038, all villages in Sewon District have been classified as part of the urban area. Additionally, monitoring and evaluation results of spatial utilization control activities in Sewon District for 2022-2023 indicate that there are still constructions being established in agricultural zones.

Bantul Regency is one of the four regencies in the Special Region of Yogyakarta. The land area of Bantul Regency is 50,685 ha, which is dominated by built-up land at 36.85%, irrigated rice fields 27.17% and non-irrigated rice fields 26.77%. As a result of the massive development of the city of Yogyakarta which has an impact on Bantul Regency itself, every year agricultural land shrinks, due to land conversion. Based on data from the Department of Land and Spatial Planning, agricultural land in Bantul Regency decreases by an average of 50 hectares per year, especially in the buffer zone of the city, such as Kapanewon Banguntapan, Sewon, Kasihan, and Sedayu (Lugas Subarkah, 2023, October 10). The objective of this research is to identify the extent of LP2B through a spatial optimization modeling approach in determining sustainable food agricultural land in Bantul Regency. This approach enables more integrated planning by considering both

potential and needs, allowing for a more effective and sustainable balance between agricultural land requirements and urban development.

There has been extensive research identifying sustainable agricultural land for food production. Intan Agnes Manullang et al. (2023) identified existing rice fields and analyzed the suitability of rice field areas for LP2B (Sustainable Food Agricultural Land) designation using visual/digital interpretation methods from SPOT 7 imagery in 2020. The results were then overlaid to analyze the suitability of the existing rice fields with LP2B areas. Rachman Andriawan et al. (2020) assessed the potential suitability of LP2B with the Regional Spatial Plan (RTRW). They used a spatial approach to key variables determining LP2B potential based on technical guidelines for land suitability for food crop commodities, assigning weights and scores to these criteria. However, research discussing spatial optimization modeling for determining sustainable rice field protection is still limited

2. METHODS

This research uses a quantitative approach. Quantitative research can be interpreted as research that uses a lot of numbers, starting from the data collection process, data analysis and data display (Siyoto and Sodik, 2015). This research will be more emphasized on numerical data which is then analyzed with appropriate methods. Starting from the process of identifying the minimum agricultural land area requirements in accordance with population pressure for the future, which will then be identified based on the distribution of agricultural land based on the quality of land that supports agricultural activities, to be able to formulate an optimal model for determining agricultural land protection.

This secondary data is in the form of spatial and aspatial data obtained through authorized local government agencies and other sources. Secondary data needs are Administrative Map, Land Use Map, Agricultural Land Distribution Map, LP2B Distribution Map, Food Agricultural Land Productivity of Bantul Regency, and Population of Bantul Regency.

The analysis methods used in this research are land carrying capacity analysis, land evaluation and optimization modeling through Linear Programming. The following are the stages of analysis used in this research.

- a. Land carrying capacity analysis is an environmental carrying capacity analysis that serves to calculate the availability of paddy agricultural land in supporting the population needs in a certain area, using the following formula :

$$\sigma = \frac{Lp/Pd}{KFM/Pr} \quad (1)$$

where:

σ = Carrying capacity of agricultural area

Lp = Harvest area (ha)

Pd = Total population (people)

KFM = Food demand (kg/capita/year)

Pr = Average land production per hectare (kg/ha)

- b. Land evaluation is a process in estimating the class of land suitability and land potential for certain uses, both for agriculture and non-agriculture. To determine the level of land suitability, the required data includes slope gradient, elevation, rainfall, geology, land use, and soil type. Each of these data points will be assigned a value according to its classification based on the Ministry of Public Works Regulation No. 20/PRT/M/2007 on Technical Guidelines for the Analysis of Physical and Environmental, Economic, and Socio-Cultural Aspects.
- c. Analysis of the area of agricultural land needs in accordance with food needs for 20 years. To calculate the required land area, the following calculation is used:

$$KLP2B = \left(\frac{Kp \times \Sigma Pt}{P} \right) \times \frac{1}{IP} \quad (2)$$

where:

Kp = standard food requirement based on rice consumption (tons/capita/year)

ΣPt = population in year t (people)

P = productivity level in paddy fields (tons/ha)

IP = rice paddy cropping index (%)

- d. Land demand optimization model with Linear Programming approach through simplex method, with the assistance of Microsoft Excel Solver software. Linear programming is well-suited for problems involving the allocation of limited resources, such as land, while satisfying multiple constraints. In spatial optimization, it helps determine the most efficient way to use land, balancing agricultural, urban, and environmental needs.

3. RESULT AND DISCUSSION

3.1 Land Support Capacity

Agricultural land carrying capacity is an important concept in maintaining the food security of a region. Agricultural land carrying capacity is an area's ability to provide land that can support agricultural activities (Moniaga, 2011). An area is able to provide a decent life for its population depending on food crops that can meet the needs of the population at a decent level, which is equivalent to 265 kilograms of rice/person/year or 2.466 times the FKM. In the last 5 years, the harvest area in Bantul Regency has experienced an increasing trend, reaching its peak in 2022, followed by a decline in 2023. Despite the fluctuations, the overall harvested area shows a positive trend until 2022 before decreasing in 2023, which is caused by the impact of land conversion in Bantul Regency.

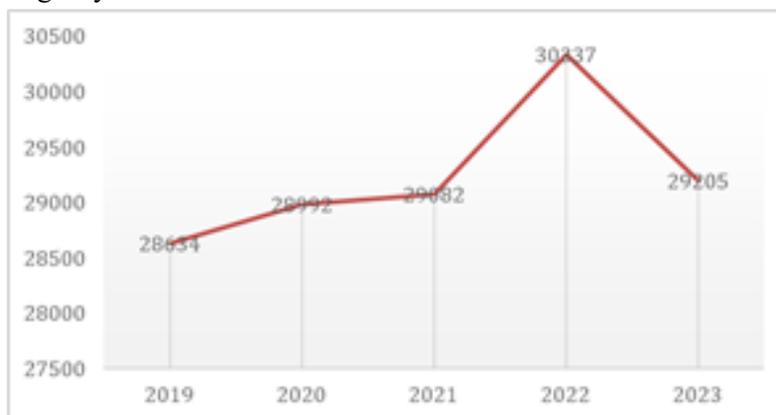


Figure 1. Figure/Diagram Illustration placement.

Based on the figure above, the average harvest area of Bantul Regency is 29,250 hectares with an average production level of 187,981 tons. The population in 2023 reached 971,161 people, it is known that currently, Bantul Regency is included in the category of areas capable of food self-sufficiency for its population in meeting their rice needs, with an σ value of 3.49 obtained from the formula calculation:

So that Bantul Regency has a high level of agricultural carrying capacity which is able to achieve self-sufficiency in terms of rice production.

Table 1. Self-sufficiency carrying capacity level of Bantul Regency

Production (tons)	Average production (kg)	Population 2023 (people)	Rata-rata Average KFM* (kg)	Agricultural Support Capacity (σ)
183.964	106.456	972.161	81,4	3,49

Efforts to ensure the sustainability and stability of food supply for the population in Bantul Regency without damaging the environment are to consider the ability of land to support food needs for the local population in Bantul Regency. The population of Bantul Regency in 2023 reached 971,161 people. By projecting over a 20 year period with an increasing population growth scenario, it is predicted that by the year 2043, the population of Bantul Regency will reach 1,116,612 people.

Table 2. Population Projections for 2023 - 2043 Bantul Regency

Total Population (people)				
2023	2028	2033	2038	2043
971.161	1.006.549	1.042.068	1.078.839	1.116.612

To calculate the food demand in Bantul Regency, a calculation based on Odum's theory was used, which stipulates that an area capable of meeting food needs is an area that can provide the minimum physical needs of the population of 1600 calories/person/day, or the equivalent of 100 kg/rice/person/year (Soehardjo and Tukiran, 1990). Thus, the food demand in 2043 in Bantul Regency is 112,661 tons. With an average cropping index of 1.6, the standard food requirement for grains according to the food agency of 100.4 kg/cap/year, a farmland area of 11,357 ha is required. This represents the minimum area of agricultural land that must be protected to avoid land conversion to non-agricultural use in order to maintain food security in Bantul Regency.

3.2 Land Evaluation

The land evaluation of Bantul Regency in this study was carried out to assess the level of land suitability based on the physical aspects of agricultural land potential and the existing conditions of agricultural land in Bantul Regency. To be able to determine the level of land suitability, the data required includes slope, altitude, rainfall, geology, land use and soil type. Each of these data will be given a value according to its class in accordance with the Regulation of the Minister of Public Works No.20/PRT/M/2007 on Technical Guidelines for Analysis of Physical and Environmental, Economic and Socio-Cultural Aspects. After all the data is given a value, an overlay process will be carried out with the aim of more in-depth analysis of different spatial information, which will produce 10 thematic maps of Land Capability Units, namely Morphological SKL, Ease of Working SKL, Slope Stability SKL, Foundation Stability SKL, Water Availability SKL, Drainage SKL, Erosion SKL, Waste Disposal SKL, and Disaster Prone SKL. The land suitability analysis process is the combined result of thematic SKLs that are overlaid and then weighted with the help of ArcGIS software. The results of the weighting will produce a level of land suitability for agricultural spatial direction with 5 categories, namely Very Low (Class A), Low (Class B), Medium (Class C), Somewhat High (Class D) and Very High (Class E).

Based on the results of the analysis of the level of land suitability based on physical aspects there are 40,503 Ha in the rather high and very high development categories. While with the current amount of agricultural land use of 14,861.03 ha, which is included in the class of agricultural land suitability high and very high amounted to 13,858 ha. While the remaining 1,000 ha is in the very low to medium development class.

Table 3. Existing Agricultural Land Suitability of Bantul Regency

Land Capability	Irrigated Rice Field	Tidal Rice Field	Rainfed Rice Field	Total (Ha)
High	4.020,35	6,36	710,41	4.737,12
Very High	7.824,21	105,10	1.192,27	9.121,57
Total	11.844,56	111,46	1.902,68	13.858,69

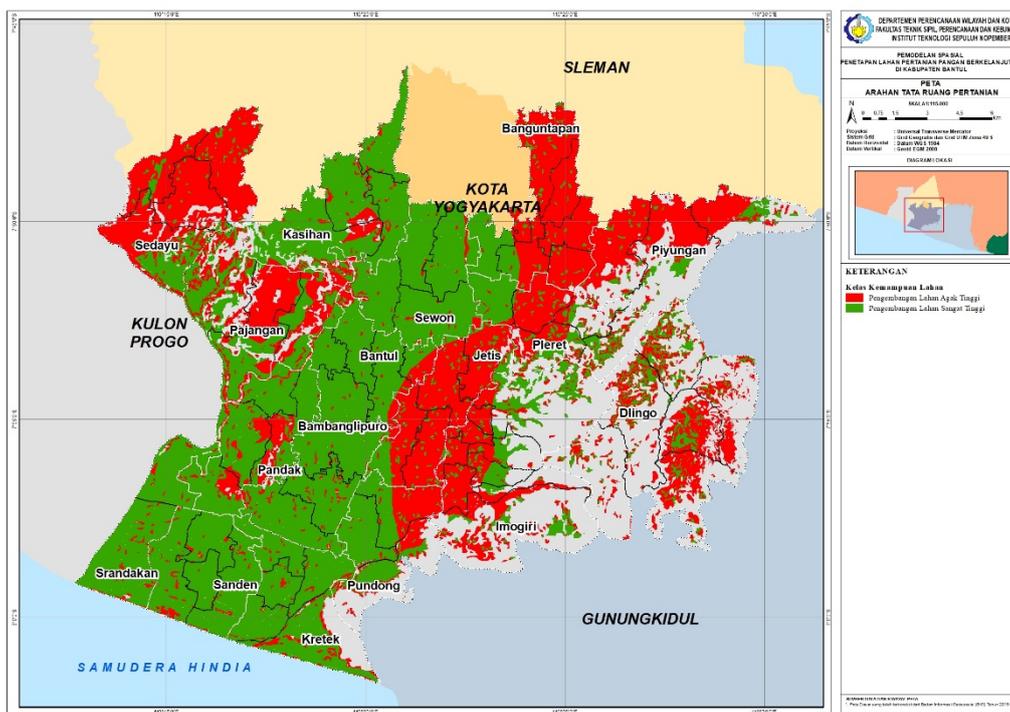


Figure 2. Land suitability map of Bantul Regency

3.3 Suitability of Sustainable Agricultural Land

Bantul Regency Regional Regulation No.10 of 2023 concerning the Protection of LP2B, that Bantul Regency has determined an area of Sustainable Food Agricultural Land of 12,831 ha. The land area that has been designated as LP2B, based on the results of the analysis, 90% is in the category of suitability for agricultural spatial direction with a rather high (Class D) and very high (Class E) development capability class, amounting to 11,666 ha, while the remaining 1,164 ha is in the very low to medium development class category.

Table 4. Land Suitability of LP2B

No	Development Direction Class	Area (ha)
1	Very Low	163,111
2	Low	226,115
3	Medium	774,875
4	High	4.111,583
5	Very High	7.555,319
	Total	12.831,003

The high composition of existing agricultural land, which in terms of land suitability is in the high capability category for agricultural development, indicates that the LP2B location has been determined in accordance with the physical potential of the region. Most of the agricultural land is located in the moderately high and very high development capability classes, which means that the land has good potential for agriculture. Although around 10% of agricultural land is in the less high development category, this is still acceptable as the land can be used as a reserve or developed gradually according to the needs and conditions of the field.

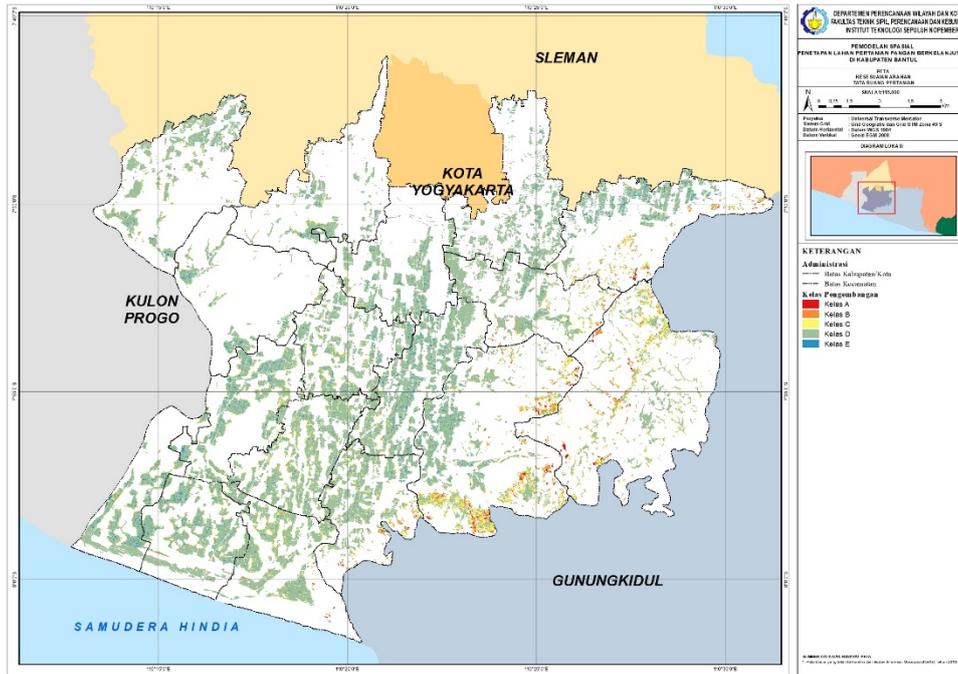


Figure 2. Land suitability class map of LP2B Bantul Regency

3.4 Optimization Model for Sustainable Food Agricultural Land Designation

Spatial Optimization Model is a mathematical tool or method used to solve problems related to space or geographic location, by utilizing spatial data and optimization techniques to find the most effective solution (Faiz and Krichen 2012; Tong and Murray 2012). In optimization modeling, there are systematic steps to find the optimal solution. Starting from object identification, objective function and determining constraints or limiters. The function of the object to be optimized in this study is to minimize the sustainable food agricultural land that has been determined by local regulations in order to meet food needs in Bantul Regency for 20 years with a land requirement of 11,356 ha.

The objective function, namely minimizing the area of agricultural land that has been determined, in order to meet food needs in Bantul Regency in the amount of 112,107 tons, so that the objective function is as in the following equation

$$\text{Min } Z = \sum_{i=1}^{14} x_i$$

The constraint function is a linear formula that contains decision variables that explain the limits of the decision taken. The constraint is that the land area used in each sub-district must not exceed the total available land capacity, as in the following equation

$$x_i \leq \text{Total}_i$$

The total land area needed must reach 11,356 ha from the available 12,831 ha, equation (3) and the value of x must not be negative.

$$\sum_{i=1}^{14} x_i \leq 11.356$$

After the decision variables, objective functions and constraints above are determined. The modeling process is done with Microsoft Excel software with Add-in solvers. Decision variables and constraints are entered into columns and cells in excel. As for the objective function, the equation above is entered in the cell which is the place for the optimization results. Then, the solver is activated through the Data tab, Set Objective by selecting the cell containing the objective function. By Changing Variable Cells, enter the cells that will be filled with the values to be optimized. Subject to the Constraints, add the constraints by clicking Add and entering the range of cells for the constraints and their limits. Once all parameters and constraints are added, the solver run will search for the optimal solution of the problem automatically.

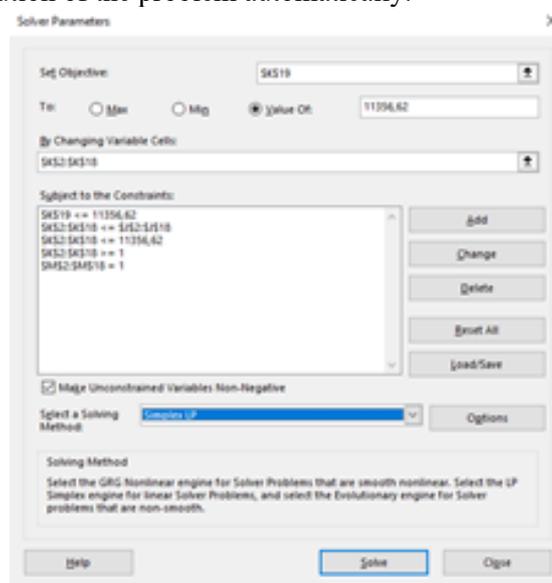


Figure 4. Solvers Add In Display

The optimal solution will be found if the solvers produce an optimal solution that meets all the constraints in the linear programming problem, this condition can be seen from the report results by giving the statement “Result: Solver found a solution. All Constraints and optimality conditions are satisfied.”

The results of modeling with solvers, found that the model to minimize the area of agricultural land in Bantul Regency found an optimal solution. With the distribution of optimal land allocation in each sub-district not exceeding the predetermined constraints.

Table 6. Results of optimization of agricultural land modeling in Bantul Regency

Sub-district	LP2B area (Ha)	Optimization land (Ha)
Bambanglipuro	1.057,63	719,41
Banguntapan	560,03	560,03
Bantul	793,08	793,08
Dlingo	728,85	728,85
Imogiri	1.350,09	984,36
Jetis	1.142,98	925,29
Kasih	341,39	341,39
Kretek	829,63	633,52
Pajangan	277,73	277,73
Pandak	800,63	800,63
Piyungan	704,95	704,95
Pleret	664,25	664,25
Pundong	786,20	666,64
Sanden	885,68	648,61
Sedayu	708,44	708,44

Sub-district	LP2B area (Ha)	Optimization land (Ha)
Sewon	625,87	625,87
Srandakan	573,56	573,56
Grand Total	12.830,99	11.356

3.5 Optimal Area of Sustainable Food Agricultural Land

The area of sustainable food agricultural land that has been designated in Bantul Regency is quite varied, ranging from 277.73 to 1,350.09 hectares. The results of optimization with solvers, it is known that the model equation (1) with the objective of minimization, can find the optimal solution and meet all the specified constraints. Of the 17 sub-districts designated as LP2B, 1,474.38 ha of agricultural land can become non-priority or reserve land from LP2B, meaning that there is agricultural land that can be removed from LP2B. Land optimization occurs in several sub-districts such as Bambanglipuro, Jetis, and Sanden which is quite significant, while most other sub-districts have reached the optimal level fully in accordance with the existing agricultural land.

Table 7. Comparison of LP2B Land Area and Optimization Results

No	Sub-district	Luas (Ha)		
		LP2B	Optimization	Non-Priority
1	Bambanglipuro	1.057,63	719,41	338,22
2	Banguntapan	560,03	560,03	0,00
3	Bantul	793,08	793,08	0,00
4	Dlingo	728,85	728,85	0,00
5	Imogiri	1.350,09	984,36	365,73
6	Jetis	1.142,98	925,29	217,69
7	Kasih	341,39	341,39	0,00
8	Kretek	829,63	633,52	196,11
9	Pajangan	277,73	277,73	0,00
10	Pandak	800,63	800,63	0,00
11	Piyungan	704,95	704,95	0,00
12	Pleret	664,25	664,25	0,00
13	Pundong	786,20	666,64	119,56
14	Sanden	885,68	648,61	237,07
15	Sedayu	708,44	708,44	0,00
16	Sewon	625,87	625,87	0,00
17	Srandakan	573,56	573,56	0,00
	Grand Total	12.830,99	11.356,62	1.474,38

The optimization results show that the proposed reduction in agricultural land allows the Bantul district government to allocate land more efficiently without sacrificing agricultural productivity. Some sub-districts, such as Bambanglipuro and Sewon, show larger land area reductions in the optimization results, while sub-districts such as Kretek and Imogiri have smaller reductions.

4. CONCLUSIONS

In assigning sustainable food agricultural land to achieve optimal results, a mathematical approach through Linear Programming can be a solution to the problem of distributing space allocation. The optimization results provide a clear picture of how agricultural land will be allocated in the future, allowing better planning to support urban growth and agricultural needs. The optimization process successfully maintains a balance

between the potential of developed land according to the direction of agricultural spatial planning, thus meeting agricultural needs by considering existing constraints.

Based on the optimization results that the Bantul Regency Government can protect its agricultural land of 11,356.62 ha, while the remaining 1,474 ha can become non-priority land or reserve land. Each sub-district shows different optimization results. Some sub-districts such as Bambanglipuro and Sewon experienced larger land reductions, while sub-districts such as Kretek and Imogiri had fewer reductions. With optimization, the Bantul Regency Regional Government is able to improve the efficiency of agricultural land use. Overall, it can be concluded that the use of linear programming with the simplex method in assigning protected agricultural land is able to provide significant results. This method not only allows the identification of optimal land allocation but also helps in maintaining a balance between agricultural land development and other needs. The implementation of linear programming with the simplex method can provide strong guidance for the government in planning and managing agricultural land use, ensuring that existing resources are used efficiently and effectively to achieve the desired results. Thus, the Bantul Regency Government can better protect its agricultural land to support sustainable regional growth and development.

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Contribution of Economic Development to The Development of The Mamminasata Region

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Abstract

Mamminasata (Makassar, Maros, Gowa, Takalar) is one of the urban or metropolitan areas in Eastern Indonesia. Mamminasata as a strategic area with economic interests has an important role in the development of its city and surrounding areas. Meanwhile, the dynamic development of the city causes demands for space needs to increase, especially the need for residential land. The objectives of this study are to 1) know economic development in the Mamminasata district/city in 2001-2021 2) know the development of built-up land in the Mamminasata district/city in 2001-2021 and 3) know the influence and contribution of economic growth to the development of the Mamminasata region. The research location is Makassar City, Maros Regency, Gowa Regency and Takalar Regency. This type of research is descriptive quantitative qualitative. The required data is collected through literature studies in the form of secondary data, namely Gross Regional Domestic Product (GRDP) at constant prices 2010, and google earth images 2001-2021. The analysis used in the research is literature study analysis, qualitative quantitative descriptive, basic statistics, LQ-DLQ, Shift Share, and multiple linear regression analysis. The result of this study is that during 2001-2021 the real income of the Mamminasata Region continued to increase. With the highest growth rate in Gowa Regency. Makassar City only has one leading sector, Maros Regency has two leading sectors, Gowa Regency has three leading sectors, and Takalar Regency has two leading sectors. Only Kabupaten Maros experienced a shift in economic structure from the tertiary sector to the primary sector in 2021 due to a significant economic decline. Spatially, sub-districts that are adjacent or directly adjacent to Makassar City have the most significant built-up land growth with developments following the main road network pattern. Based on the results of multiple linear regression analysis, it shows that there is no significant influence between the independent variables on the dependent variable either jointly or partially individually. Then the t-test was conducted again between tertiary variables and built-up land and showed a significant influence with a contribution of 33% to built-up land.

Keywords:

Leading Sectors;
Economic Structure;
Mamminasata; Built Up
Area; Contribution

1. INTRODUCTION

Indonesia's economic growth during 2023 grew by 5.05% which was lower than the previous year, 2022 with 5.31%. Spatially, Indonesia's economy continues to grow, with the largest contribution contributed by Java Island with 57.05%; followed by Sumatra 22.01%; Kalimantan 8.49%; Sulawesi 7.10%; Bali and Nusa Tenggara 2.77%; and Maluku and Papua 2.58% (Badan Pusat Statistik, 2024).

According to Wahyudi et al. (2022), regional development or the development of new urban areas can be carried out with the establishment of National Strategic Areas (KSN) which function to accelerate national economic development. One of the urban or metropolitan areas in Eastern Indonesia is Mamminasata (Makassar, Maros, Sungguminasa, Takalar). The Mamminasata area has been organically formed since the 1980s due to the rapid population growth in Makassar City and the expansion of urbanization around it (Sulmiah et al., 2019).

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The economic development of the Mamminasata region will certainly affect how the physical development of the region. Based on Firman (1996), said that the actual development of the city is a physical manifestation of economic development. The continuous development of the city causes demands for space needs to increase, especially the need for residential land. In addition, Makassar City is one of the largest cities in Indonesia, especially in the East. Making Makassar City as a hub in connecting Eastern Indonesia with other regions.

By knowing whether there is an influence between economic growth and the development of the Mamminasata region, it can provide information on how the contribution of economic sectors to land development, so that it can provide input for the government and stakeholders in focusing the direction of development for each district / city in Mamminasata according to the characteristics of the region.

This study aims to 1) determine economic development in the Mamminasata district / city in 2006-2021 2) determine the development of built-up land in the Mamminasata district / city in 2006-2021 and 3) determine the influence and contribution of economic growth to the development of the Mamminasata region.

2. METHODS

2.1 Research Method

The type of research used by the author in this research is descriptive research with a qualitative quantitative approach. This research was conducted in the Mamminasata Region which consists of 46 sub-districts, consisting of 14 sub-districts in Makassar City, 9 sub-districts in Takalar Regency, 11 sub-districts in Gowa Regency, and 12 sub-districts in Maros Regency. This research was conducted in the Mamminasata Region because Mamminasata is the only metropolitan as well as national strategic area located in Eastern Indonesia. Thus, it has the potential and important role to drive the Indonesian economy, especially in the east. The spatial research area can be seen in Figure 1.

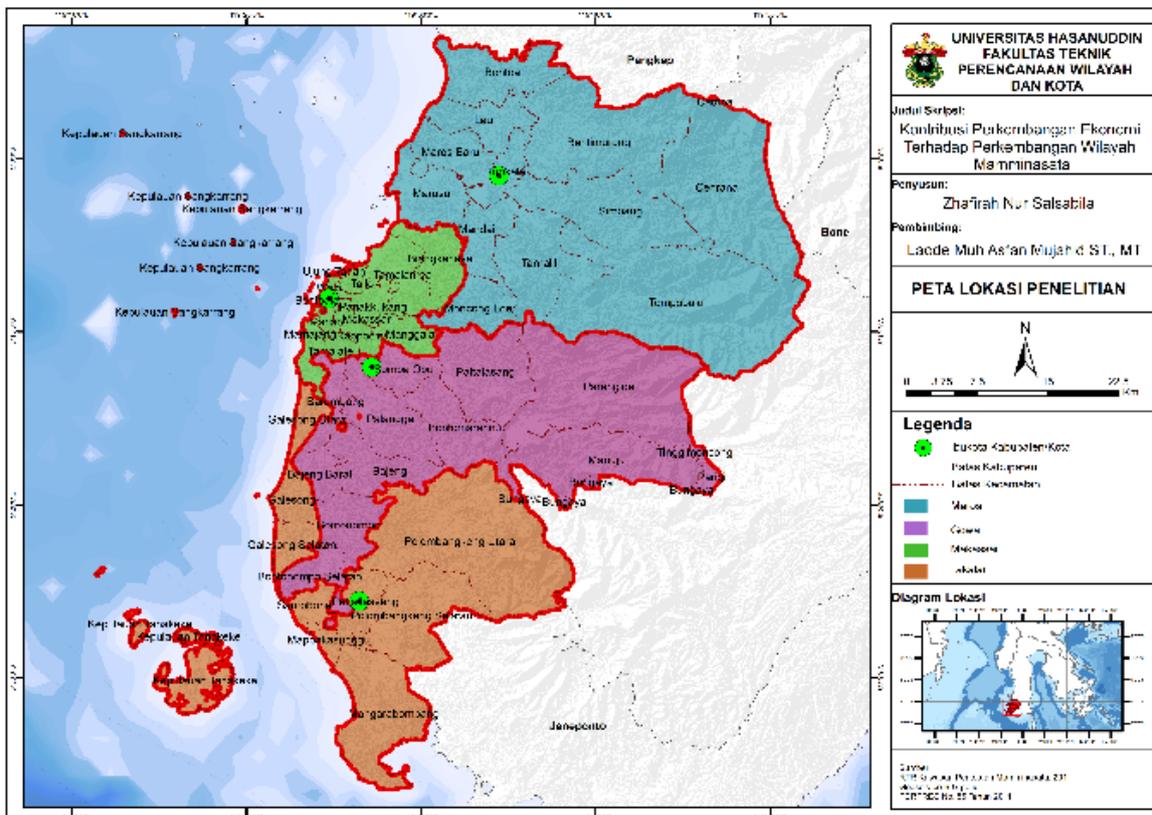


Figure 1. research location

The population in this study are districts / cities that are part of the Mamminasata KSN. The technique in determining the sample in this study is purposive sampling technique or deliberate sampling based on certain

considerations (Sugiyono, 2019). The samples in this study are sub-districts that are part of the Mamminasata Region from four districts/cities in South Sulawesi, namely Makassar City, Maros Regency, Gowa Regency, and Takalar Regency.

2.2 Data Analysis Technique

The analysis techniques to achieve the first research objective are described as follows:

1. Real income is obtained from GRDP data based on 2010 constant prices obtained through the BPS website.
2. The economic growth rate in this study uses GRDP data with the following exponential equation (Duko et al., 2018).

$$r = \text{anti log} \frac{PDRB_t - PDRB_0}{t} - 1 \dots \dots \dots (1)$$

with,

r = economic growth rate

t = period of observation

GRDP_t = GRDP in year t

GRDP₀ = GRDP in the initial year

3. Sektor basis dan non basis diperoleh dengan analisis LQ-DLQ. Berikut merupakan formula perhitungan LQ berdasarkan Sarwo dkk., (2019).

$$LQ = \frac{S_i/S}{N_i/N} \dots \dots \dots (2)$$

Description:

LQ = Location Quotient

S_i = GRDP of sector i of the city/district

S = Total GDP of district/city sector

N_i = GRDP of sector i of province/national

N = Total GRDP of provincial/national sector

If the LQ value ≥ 1 indicates that the sector is basic, while if the LQ value < 1 then the sector is categorized as non-basic (Sarwo et al., 2019). A base sector indicates a sector where goods and services can be exported outside the region, after meeting the needs within the region. Meanwhile, non-base sectors are sectors that provide goods and services needed by people within the region and cannot export.

The DLQ method emerged to overcome the weakness of the LQ method which only calculates the leading sector at one time (Nugraha, 2019). With DLQ, it can be seen whether there are changes in the basic and non-basic sectors in the future. The DLQ method formula is as follows (Pribadi & Nurbianto, 2021).

$$DLQ = \frac{(1 + g_{ij})/(1 + g_j)}{(1 + g_{ip})/(1 + g_p)} \dots \dots \dots (3)$$

where:

DLQ = Dynamic Location Quotient

g_{ij} = average GRDP growth of sector i of district j

g_j = average growth of total GRDP of district j

g_{ip} = average GDP growth of sector i at province level p

g_i = average growth of total GRDP at province level p

If the DLQ value > 1 , it indicates that the development potential of sector i of Regency/city j is faster than the sector in the reference region, while if the DLQ value < 1 , it is the opposite (Saputri & Boedi, 2018). The next step is to combine the LQ and DLQ analysis to determine whether there is a shift and repositioning and to see the prospects for the existence of regional economic sectors in the future, which can be seen in Table 1 below.

Table 1. Economic sector typology based on LQ and DLQ

Kriteria	LQ > 1	LQ < 1
DLQ > 1	Featured	Reliable
DLQ < 1	Prospective	Lagging

Sumber: Saputri dan Boedi (2018)

The results of the cross-table resulted in 4 classifications, namely:

- a. Leading sectors, having LQ and DLQ values > 1 indicate that the sector remains basic both now and in the future;
 - b. Mainstay sector, having DLQ > 1 and LQ < 1 means that the sector is not currently basic but has the potential to excel in the future;
 - c. Prospective sector, having a value of LQ > 1 and DLQ < 1 indicates the sector is currently basic but has no potential to excel in the future; and
 - d. Lagging sectors, having LQ and DLQ values < 1 indicates that the sector is not currently basic and has no potential to excel in the future.
4. Analisis struktur ekonomi digunakan untuk melihat bagaimana struktur perekonomian di suatu wilayah dan apakah telah terjadi pergeseran struktur ekonomi selama periode waktu penelitian yang dilakukan dengan analisis shift share. Formula shift share dirumuskan sebagai berikut (Pribadi & Nurbiyanto, 2021):

$$\text{Shift Share} = PN_{ij} + PP_{ij} + PPW_{ij} \dots \dots \dots (4)$$

$$PN_{ij} = (Ra)Y_{ij} \dots \dots \dots (5)$$

$$PP_{ij} = (Ri - Ra)Y_{ij} \dots \dots \dots (6)$$

$$PPW_{ij} = (ri - Ri)Y_{ij} \dots \dots \dots (7)$$

$$Ra = \frac{Y' - Y}{Y} \dots \dots \dots (8)$$

$$Ri = \frac{Y'_{ij} - Y_{ij}}{Y_{ij}} \dots \dots \dots (9)$$

$$rij = \frac{Y'_{ij} - Y_{ij}}{Y_{ij}} \dots \dots \dots (10)$$

Notes:

PN_{ij} = economic growth of the province in sector i in district j

PP_{ij} = proportional growth of sector i in district j

PPW_{ij} = regional share growth of sector i in district j

PB_{ij} = net shift of sector i in district j

Ra = ratio of GRDP in the province (reference)

Ri = ratio of GRDP of sector i in the province (reference)

rij = ratio of GRDP of sector i in district j

Y' = GDP of the province in the final year of observation

Y = GRDP of the province in the base year of observation

Y'ij = GRDP of sector i in district j in the final year of observation observation

Yij = GRDP of sector i in district j in the base year of observation base year of observation

Y'i = GRDP of sector i in the province in the final year of observation observations

Yi = GRDP of sector i in the base year province observation

The analysis technique to achieve the second research objective, namely to obtain the building area and its number by interpreting Google Earth images of Makassar City, Maros Regency, Gowa Regency and Takalar Regency in 2001, 2006, 2011, 2016, and 2021 was carried out by manual digitization.

The analysis technique used to achieve the third research objective related to the influence and contribution of economic development to the development of the Mamminasata region uses multiple linear regression analysis. Before conducting multiple linear regression analysis, a classical assumption test was previously carried out, which included four, namely.

1. Normality test, conducted to see if the data is normally distributed. If the Sig value. ≥ 0.05 then the data is concluded to be normally distributed (Putra et al., 2019).
2. Multicollinearity test, a good regression model does not occur multicollinearity. If the VIF value < 10 and the Tolerance value > 0.1 , the level of collinearity can be tolerated (Raharjo, 2008).
3. Heteroscedasticity test, conducted through the Glejser test. A good model is a model that does not occur heteroscedasticity or homoscedasticity which is indicated by the significance value must be more than 0.05 (Novianingtyas & Bagana, 2022).
4. Autocorrelation test, conducted through the Run Test. Where a good model is that there are no autocorrelation symptoms indicated by the Asymp. Sig (2-tailed) ≥ 0.05 (Mokoginta et al., 2021).

After the data has passed the classical assumption test, a multiple linear regression model can be made. To find out whether there is an influence of the independent variable on the dependent, the following test is carried out.

1. Simultaneous Test (F Test), used to see and measure whether the independent variables together have an effect on the dependent variable, which is indicated by the Sig value. ≤ 0.05 (Mokoginta et al., 2021).
2. Partial Test (t test), used to see whether the independent variable partially or individually affects the dependent variable. If the Sig value. ≤ 0.05 , it shows that there is an influence between the independent variable and the dependent variable (Mokoginta et al., 2021).

$$Y = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3 + e \dots \dots \dots (11)$$

with,

Y = Dividend Payout Ratio

α = constant

$b_1 b_2 b_3$ = coefficient value

X1 = primary sector

X2 = secondary sector

X3 = tertiary sector

E = Error Term

3. RESULT AND DISCUSSION

The Mamminasata region includes all sub-districts in Makassar City and Takalar Regency, except 2 out of 14 sub-districts in Maros Regency and 7 out of 18 sub-districts in Gowa Regency. These sub-districts are excluded due to their distance from the metropolitan area (Integrated RTR for Mamminasata Metropolitan Area, 2006). The area of Mamminasata is approximately 2,666.63 km² or 5.7% of the total area of South Sulawesi. The total population of Mamminasata in 2023 is about 2.7 million people with population concentration occurring in Makassar City. The total area and population in Mamminasata Region can be seen in the following table

Table 2. Mamminasata population, percentage, area and population density

Kabupaten/Kota	Jumlah Penduduk (jiwa)	Luas wilayah (Km ²)	Kepadatan Penduduk (jiwa/Km ²)
Kota Makassar	1,432,189	175.77	8,148
Kabupaten Gowa	627,031	1,237.84	507
Kabupaten Maros	332,245	686.51	484
Kabupaten Takalar	305,077	566.51	539
Total	2,696,542	2,666.63	1,011

Source: BPS in figures, 2023 (data processed)

The Mamminasata region is considered to have a very high density, with the largest number in Makassar City at 8,388 people/km². The population density in Maros Regency is 484 people/km², the density in Gowa Regency is 510.6 people/km², and the population density in Takalar Regency is 575.5 people/km².

3.1 Mamminasata Economic Development

In this study, it only discusses four of the various factors that mark economic growth in the Mamminasata Region, namely regional real income, economic growth rate, basic sectors and shifts in economic structure.

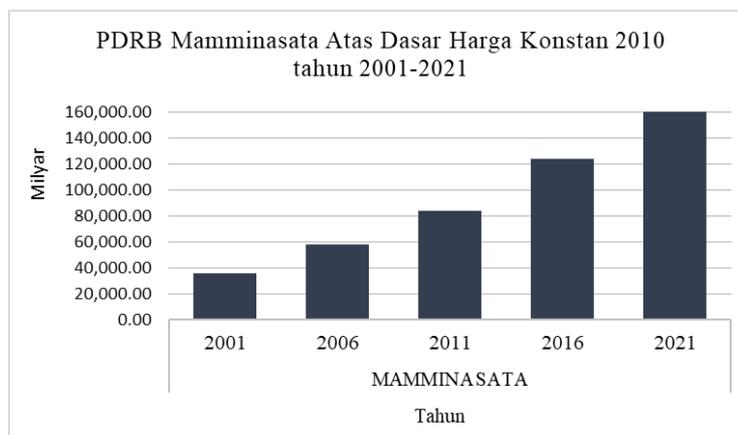


Figure 2. PDRB atas dasar harga konstan 2010, tahun 2001-2021

Real regional income in the Mamminasata Region is seen from GRDP data at constant prices in 2010 in Makassar City, Maros Regency, Gowa Regency, and Takalar Regency. From 2001 to 2021, the real income of the Mamminasata Region continued to increase, which can be seen in Figure 2. The increase can be seen that in 2001, Mamminasata's real regional income was Rp. 35,941.77 billion and continued to increase until it reached Rp. 160,665.17 billion in 2021. This shows that the increase in Mamminasata's real regional income based on the increase in the production factors of the economic sector is not affected by the element of inflation.

The increase in 2010 ADHK GRDP in Mamminasata cannot be separated from the contribution of the districts/cities in it. A comparison of the percentage contribution of GRDP in 2001 and 2021 shows that the contribution of GRDP is uneven, as shown in Table 3.

Table 3. Percentage contribution of GRDP Mamminasata ADHK 2010 per district/city

Mamminasata	Persentase PDRB Mamminasata ADHK 2010 per kabupaten/kota			
	2001	Kontribusi (%)	2021	Kontribusi (%)
Kota Makassar	27,673.91	77.08	126,312.82	78.62
Kabupaten Maros	5,011.19	13.96	12,400.61	7.72
Kabupaten Gowa	2,425.21	6.76	15,043.70	9.36
Kabupaten Takalar	790.66	2.2	6,908.04	4.3
Mamminasata	35,900.97	100	160,665.17	100

In 2001 and 2021, Makassar City dominated the contribution with a percentage of 77.08% and 78.62% respectively. Meanwhile, the rest is the percentage of contributions from 3 other districts. In 2001, the percentage of Maros Regency was 13.96%, Gowa Regency was 6.76%, and Takalar Regency was only 2.20%. In 2021, the percentage contribution of Gowa Regency's GRDP was 9.36%, which was greater than that of Maros Regency, which was 7.72%, which was smaller than the percentage contribution of Maros Regency in 2001. Meanwhile, Takalar Regency still has the smallest contribution with 4.30% but has increased compared to 2001.

The rate of economic growth is one way to determine whether the economy has grown. In general, the economic growth rate of districts and cities in Mamminasata is positive although the growth is fluctuating, which can be seen in Figure 3.

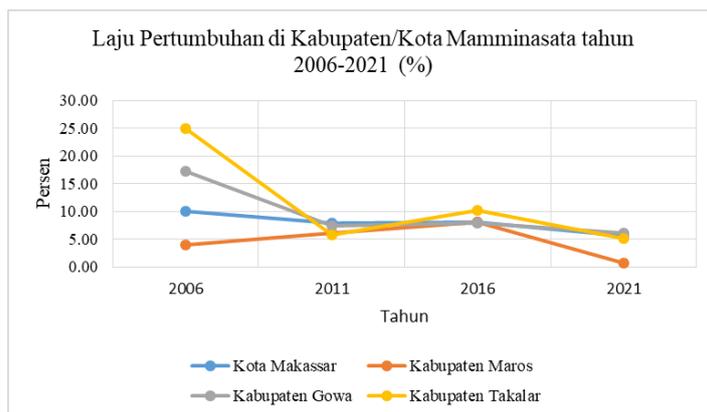


Figure 3. Economic growth rate of Mamminasata district/city in 2001-2021

The region with the highest average economic growth rate is Takalar Regency with 11.44%, followed by Gowa Regency with 9.64%, then Makassar City with 7.90%, and finally Maros Regency with 4.67%.

Table 4. The results of the average LQ value in Mamminasata Regency / City in 2001-2021

No	Sektor Ekonomi	Kabupaten/Kota			
		Makassar	Maros	Gowa	Takalar
1	Pertanian, Kehutanan, dan Perikanan	0.03	0.83	1.38	1.99
2	Pertambangan dan Penggalian	0.00	1.26	0.94	0.26
3	Industri Pengolahan	1.42	1.46	0.50	0.52
4	Listrik, Gas dan Air	1.33	0.91	1.73	1.02
5	Bangunan/konstruksi	1.41	0.56	0.85	0.75
6	Perdagangan Restoran dan Hotel	1.46	0.27	0.84	0.98
7	Angkutan dan Komunikasi	1.45	3.76	1.14	0.88
8	Keuangan, Real Estate dan Jasa perusahaan	1.45	0.39	1.19	1.23
9	Jasa-Jasa	1.48	0.49	0.95	0.52

Basic Sector

The results of the calculation of the average LQ for districts/cities in Mamminasata in 2001-2021 can be seen in Table 4. The results of the average LQ calculation in Makassar City show that there are 7 basic sectors. If sorted from highest to lowest value, they are 1) services sector 2) trade, restaurant and hotel sector 3) transportation and communication sector 4) finance, real estate and corporate services sector 5) manufacturing sector 6) building sector and 7) electricity, gas and water sector. There are three basic sectors in Maros Regency, ranked from highest to lowest value, namely 1) transportation and finance sector 2) manufacturing sector and 3) mining and quarrying sector. Gowa Regency has four basic sectors, in order from highest to lowest, namely 1) electricity, gas, and water sector 2) agriculture, forestry, and fisheries sector 3) finance, real estate, and corporate services sector and 4) transportation and communication sector. Meanwhile, Takalar Regency has three basic sectors in the highest to lowest order, namely 1) the agriculture, forestry and fisheries sector 2) the finance, real estate and corporate services sector.

Furthermore, to strengthen the results of the LQ analysis, the DLQ calculation was carried out, the results of which can be seen in Table 5.

Table 5. The results of the calculation of DLQ analysis in Mamminasata district/city in 2001-2021

No	Sektor Ekonomi	Kabupaten/Kota			
		Makassar	Maros	Gowa	Takalar
1	Pertanian, Kehutanan, dan Perikanan	0.80	1.07	1.17	1.13
2	Pertambangan dan Penggalian	0.42	1.33	0.94	1.00
3	Industri Pengolahan	1.06	1.04	0.95	0.84
4	Listrik, Gas dan Air	0.89	1.04	0.85	1.00
5	Bangunan/konstruksi	0.95	1.05	1.00	0.83
6	Perdagangan Restoran dan Hotel	0.94	0.96	1.13	0.91
7	Angkutan dan Komunikasi	0.98	0.83	1.05	0.88
8	Keuangan, Real Estate dan Jasa perusahaan	0.92	2.38	1.08	0.88
9	Jasa-Jasa	0.91	1.04	1.12	1.32

Basic Sector

Based on the results of the Makassar City DLQ calculation, there is only one basic sector in Makassar City, namely the manufacturing sector. This is due to the fact that the GDRP growth rate of Makassar City in 2021 has decreased in all sectors compared to the GDRP in 2016. For Maros Regency, there are seven basic sectors. Gowa Regency has six basic sectors. Meanwhile, Takalar Regency has four basic sectors based on DLQ analysis.

Furthermore, the LQ and DLQ analyses were combined to determine whether there was a shift and repositioning and to see the prospects for the existence of economic sectors in the future, which are described in Table 6.

Table 6. Combined results of LQ and DLQ in Mamminasata Regency/city

No	Sektor Ekonomi	Kabupaten/Kota			
		Makassar	Maros	Gowa	Takalar
1	Pertanian, Kehutanan, dan Perikanan	Tertinggal	Andalan	Unggulan	Unggulan
2	Pertambangan dan Penggalian	Tertinggal	Unggulan	Tertinggal	Andalan
3	Industri Pengolahan	Unggulan	Unggulan	Tertinggal	Tertinggal
4	Listrik, Gas dan Air	Prospektif	Andalan	Prospektif	Unggulan
5	Bangunan/konstruksi	Prospektif	Andalan	Andalan	Tertinggal
6	Perdagangan Restoran dan Hotel	Prospektif	Tertinggal	Andalan	Tertinggal
7	Angkutan dan Komunikasi	Prospektif	Prospektif	Unggulan	Tertinggal
8	Keuangan, Real Estate dan Jasa perusahaan	Prospektif	Andalan	Unggulan	Prospektif
9	Jasa-Jasa	Prospektif	Andalan	Andalan	Andalan

Based on the LQ results, there are 7 basic sectors in Makassar City, while based on the DLQ results, only the processing industry sector is basic. Thus, for the final result, only the processing industry sector is the leading sector. Maros Regency has two leading sectors, namely the mining and quarrying sector and the manufacturing sector. Gowa Regency has three leading sectors, namely the agriculture, forestry, fisheries, transportation and communication sector, and the finance, real estate, and corporate services sector. Meanwhile, Takalar Regency has two leading sectors, namely the agriculture, forestry, fisheries, and electricity, gas, and water sectors.

Changes in economic structure are a prerequisite for economic growth that supports sustainable development (Rachamn, 2019). During the calculation year, the economic structure group that had the largest role in Makassar City was in the tertiary structure, which was dominated by the trade, restaurant and hotel sector. Based on this, there has been no shift in the economic structure of Makassar City during the 2001-2021 calculation period, the economic structure of Makassar City is still dominated by the tertiary group followed by the secondary sector then the primary sector. The economy of Maros Regency is dominated by tertiary sectors. However, in 2021 the tertiary and secondary sectors experienced a significant decline, which was caused by the covid-19 pandemic which made the economy of Maros Regency decline. Meanwhile, the primary sector shows a consistent increase until it surpasses the secondary and tertiary sectors in 2021. As a result, the economy of Maros Regency in 2021 is dominated by the primary sectors.

The economic structure in Gowa Regency according to the shift share calculation shows that from 2006-2021 it has been dominated by the tertiary sector. Where this tertiary group only experienced a decline in 2011. Meanwhile, the economy of Takalar Regency based on the results of the shift share analysis shows that throughout 2006-2021, its economic structure remains dominated by the primary sector. Although, the growth of this sector is slower than the agricultural sector in South Sulawesi, it consistently shows higher competitiveness.

3.2 Perkembangan Lahan Terbangun di Kabupaten/Kota Mamminasata tahun 2001-2021

The development of built-up land in the Mamminasata Region is seen from the growth of building area and the number of building units carried out by interpreting google earth imagery during 2001, 2006, 2011, 2016 and 2021. In general, the growth rate of districts/cities in the Mamminasata Region is positive, indicating that built-up land continues to grow. Based on Table 7, Gowa Regency has the fastest growth rate among other Mamminasata regions. Makassar City has a consistent growth rate of 2% except in 2021 where it only increased by 0.10%. Maros Regency has experienced an annual increase in growth from 1% to 3%. Meanwhile, Takalar Regency has a growth rate that fluctuates every year.

Table 7. The Growth Rate of Built-Up Land in Mamminasata Cities and Regencies from 2006 to 2021 (%)

No	Kabupaten/ Kota	Tahun			
		2006	2011	2016	2021
1	Kota Makassar	2.17	2.56	2.10	0.10
2	Kabupaten Maros	1.41	2.89	2.93	3.63
3	Kabupaten Gowa	4.34	4.13	5.33	3.99
4	Kabupaten Takalar	-	1.34	3.43	2.00

Sumber: Analisis penulis, 2024

1. Makassar City

The average development of built-up land in Makassar City is 3.02 km² or 302 hectares per year, with the highest growth occurring in 2011. The largest land area is in Biringkanaya Sub-district with 809.26 hectares in 2021. The number of buildings generally increases along with the increase in building area with an average growth of 3,873 units per year.

Spatially, the development of built-up land in Makassar City is most visible in sub-districts on the outskirts of the city, such as Biringkanaya Sub-district, Tamalanrea Sub-district, Manggala Sub-district, Rappocini Sub-district, and Tamalate Sub-district, which is marked with a darker red color in Figure 4. This land growth fills the existing vacant spaces, so that the land becomes increasingly densely populated by buildings and development goes out to the suburban areas. As stated by Munawir et al. (2019) and Ashari and Maryana (2019) where the impact of high development intensity in Makassar City causes the physical development of the city to expand to other areas around it by following the road network pattern due to the ease of people to access the city center in and to Makassar City. So that it changes the function of land which was originally dominated by agricultural land or non-built land into urban land such as settlements, industry, commercial, and social culture.

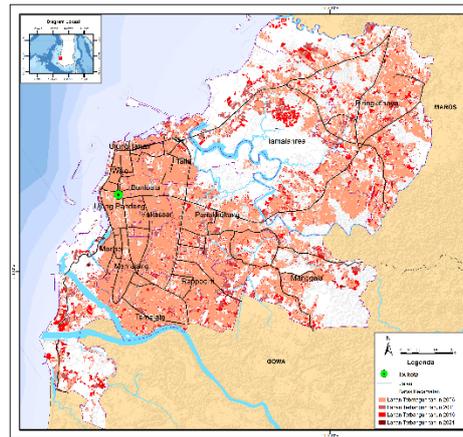
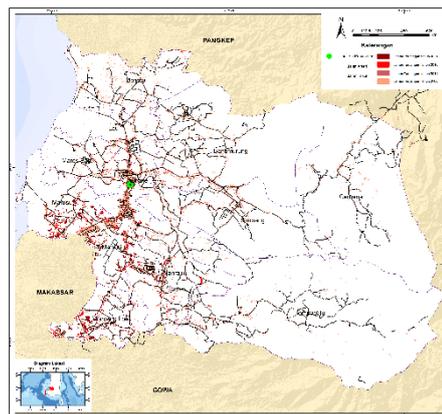


Figure 1. Map of Built-Up Land Development in Makassar City from 2006 to 2021

2. Maros Regency

The growth of built-up land in Maros Regency is considered quite slow with an average growth of 0.27 km² or only 27 hectares per year. With peak growth in 2016. The sub-districts that have the most extensive built-up land include three sub-districts, namely Mandai, Turikale and Tanralili. As the area of built-up land increases the number of buildings also increases with an average increase of 1,146 units per year.

Figure 2. Map of Built-Up Land Development in Maros Regency from 2006 to 2021



When viewed spatially in Figure 5, sub-districts that are adjacent or directly adjacent to the City of Makassar have the fastest growth of built-up land, indicated by the darker red color. Mandai sub-district, which is located directly adjacent to Makassar City and is traversed by the Makassar-Maros Axis Road, had a growth of 4.13%. In addition, Sultan Hasanuddin International Airport is located in the sub-district. Making Mandai Sub-district the center of economic activity in Maros Regency. This is also as conveyed by Latief et al. (2021) in their research that high population growth in Mandai District has an impact on the activity of undeveloped land into built-up land. This growth mainly occurs following the pattern of the main road network, especially the Makassar-Maros Axis Road and the Maros-Pangkep Axis Road.

3. Sungguminasa Regency (Gowa)

The development of built-up land in Gowa Regency is said to be quite fast and even the highest compared to other districts/cities in Mamminasata. The average growth of built-up land area is 0.69 Km² or 69 hectares per year. With the peak growth occurring from 2011 to 2016 with a growth of 4.49 Km². The development of the number of building units in Gowa Regency also continues to increase along with the increase in built-up land area. The average development of the number of buildings in Gowa Regency is 5,594 units per year.

In general, the development of built-up land in the sub-districts of Kabupaten Gowa grew significantly. Barombong sub-district has a location directly adjacent to Makassar City where the land development is quite fast with 4.84%.

Pattallassang sub-district is conceptualized as a new city area based on Presidential Regulation No. 55 of 2011 concerning the RTR of Mamminasata urban area together with Moncongloe sub-district in Maros Regency. This area is directed as a new urbanization center to accommodate population growth in Makassar City. This causes the demand for space to increase, especially for settlements, resulting in changes in the function of non-built land into built-up land, especially housing. The growth of built-up land in Pattallassang Sub-district is the highest at 8.58% per 5 years of observation during 2001-2021. As stated by Haikal et al. (2023) in their research results show that during 2002-2022 the development of built-up land in Moncongloe District consistently increased, while forest areas and agricultural land consistently decreased.

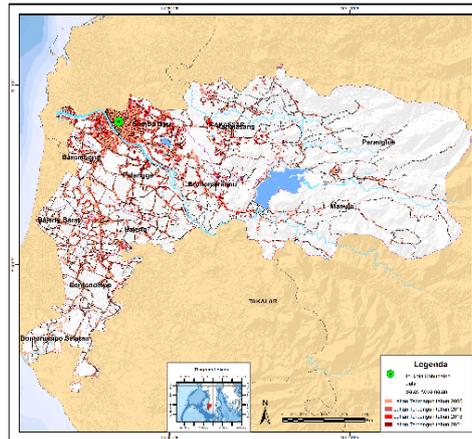


Figure 3. Map of Built-Up Land Development in Gowa Regency from 2006 to 2021

4. Takalar Regency

The development of built-up land in Takalar Regency in 2006-2021 can be said to be very slow as indicated by its average growth of 0.17 km² or only 17 hectares per year. The sub-district with the highest built-up land area from year to year is Kecamatan Palombangkeng Utara followed by Kecamatan Pattallassang and the smallest area is owned by Kecamatan Kep. Tanakeke.

The number of buildings in Takalar Regency during the research time continued to increase as the built-up land expanded. If averaged, the growth in the number of buildings in Takalar Regency is 1,114 units per year with the highest growth occurring in 2016 with 2,040 units per year.

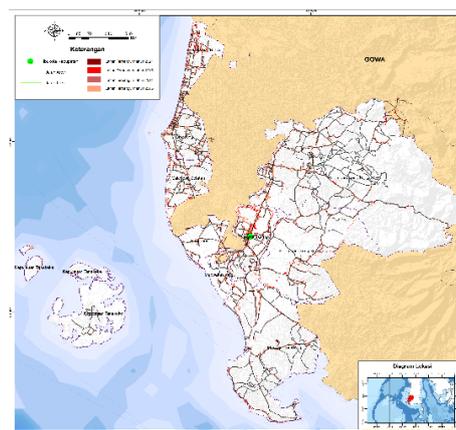


Figure 4. Map of Built-Up Land Development in Takalar Regency from 2006 to 2021

Similar to other regions in Mamminasata, the development of built-up land in Takalar Regency has transformed areas that were initially open spaces or water absorption areas into developed land (buildings). The built-up land in Takalar Regency has expanded following the road network, particularly along Jalan Diponegoro and Jalan Poros Takalar, with notable growth observed in Pattallassang and Mangara Bombang Subdistricts. Additionally, the growth of built-up land in Takalar Regency has also occurred around coastal areas, especially in Galesong Utara, Galesong, and Galesong Selatan Subdistricts. Overall, this expansion of

built-up land primarily involves the construction of factories or industrial facilities and the establishment of new residential areas on previously vacant land.

3.3 Pengaruh dan Kontribusi Perkembangan Ekonomi terhadap Perkembangan Wilayah Mamminasata

In examining the influence of various economic growth factors on regional development, a multiple linear regression analysis was employed. The results regarding the impact and contribution of economic factors to the development of built-up land are presented as follows.

1. Correlation Analysis

Correlation analysis is utilized to examine whether there is a relationship or correlation between independent and dependent variables. The results of the Pearson correlation between the variables are as follows.

Table 8. Pearson Correlation Results

	Variabel	Primer	Sekunder	Tersier	Luas Bangunan
<i>Pearson Correlation</i>	Primer	1.000	-0.158	0.182	0.433
	Sekunder	-0.158	1.000	0.492	0.382
	Tersier	0.182	0.492	1.000	0.577
	Luas Lahan	0.433	0.382	0.577	1.000
Sig. (1-tailed)	Primer	.	0.303	0.275	0.070
	Sekunder	0.303	.	0.044	0.099
	Tersier	0.275	0.044	.	0.019
	Luas Lahan	0.070	0.099	0.019	.

Source: Author's analysis, 2024

Based on Table 8 above, there is potential evidence of a relationship or correlation between the tertiary variables and the area variable, as indicated by a significance value (1-tailed) of 0.019, which is less than 0.05.

2. Simultaneous Test (F Test)

The simultaneous test, or F test, is conducted to determine whether the independent variables have a simultaneous effect on the dependent variable.

Table 9. F test results

Variabel	F	Sig.	Keterangan
Regression	2.906	0.094	Tidak berpengaruh
Residual			
Total			
a. Dependent variable: Luas lahan			
b. Predictors: (constant), Primer, Sekunder, Tersier			

Source: Author's analysis, 2024

Based on Table 9, the significance value of 0.94 is greater than 0.05, indicating that the independent variables do not collectively have an effect on the dependent variable. In other words, the development of built-up land is not influenced by the growth of economic sectors.

3. Partial Test (t Test)

The partial test, or t test, is conducted to determine whether the independent variables have a partial (individual) effect on the dependent variable.

Table 10. T test results

Variabel	t	Sig.	Keterangan
Primer	1.608	0.223	Tidak berpengaruh
Sekunder	0.918	0.142	Tidak berpengaruh
Tersier	1.308	0.383	Tidak berpengaruh
a. Dependent variable: Luas lahan			

Source: Author's analysis, 2024

Based on Table 10, the significance values for the tertiary sector (0.223), primary sector (0.142), and secondary sector (0.383) are all greater than 0.05, indicating that the independent variables do not have a partial (individual) effect on the dependent variable. In other words, the development of built-up land area is not influenced by the primary, secondary, or tertiary sectors.

Since the correlation analysis indicates a relationship between the tertiary variable and the land area variable, a simple linear regression analysis was conducted for these two variables, resulting in the following outcomes.

Table 11. Hasil uji t variabel tersier terhadap variabel luas lahan

Variabel	Unstandardized Coefficients		t	Sig.	Keterangan
	B	Std. Error			
(Constant)	-4.039	2.868	-1.408	0.187	
Tersier	7.617	3.247	.577	0.039	Signifikan

a. Dependent variable: Luas lahan

Source: Author's analysis, 2024

Based on Table 11, the significance value for the tertiary sector is 0.039, which is less than 0.05, indicating that the tertiary variable has a significant effect on the land area variable.

Tabel 12. Koefisien dan determinasi

Model	R	R Square	Adjust R Square	Std. Error of the Estimate
1	0.577	0.333	0.273	1.17110

a. Predictors: (Constant), Tersier
b. Dependent Variable: Luas lahan

Source: Author's analysis, 2024

The R value in the model indicates a correlation coefficient of 0.577, reflecting a positive correlation between land area and the tertiary sector. The R Square value represents the coefficient of determination, which indicates the independent variable's ability to explain the variation in the dependent variable. The R Square result shows a value of 0.333, meaning that the tertiary variable accounts for 33% of the variation in land area, while the remaining 67% is explained by other unexamined variables.

The linear regression equation that can be formulated is $Y = -4.039 + 7.617 X_3$. The regression coefficient of 7.617 indicates that each 1% increase in the tertiary sector will raise the built-up land area by 7.61%. The regression results demonstrate a significant influence of the tertiary sector on the development of built-up land in the Mamminasata area. The tertiary sector in the Mamminasata cities and regencies predominantly manifests in Makassar City, Maros Regency, and Gowa Regency, where the development of built-up land is particularly rapid, especially in Makassar City and Gowa Regency. Additionally, the tertiary sector continues to strengthen in Takalar Regency.

One rapidly developing tertiary sector in Makassar City is transportation and communication. This is evidenced by the conversion of land in the northern part of Makassar City into warehousing areas along Insinyur Sutami Toll Road and the Western Ring Road in Tamalanrea Subdistrict. The development of warehousing areas has accelerated with the construction of Insinyur Sutami Toll Road, which connects Makassar City to the Makassar-Maros border, linking the city with Sultan Hasanuddin Airport.

The development of the tertiary sector in Maros Regency is significantly influenced by the transportation and communication sector. This underscores the importance of Sultan Hasanuddin Airport for the economic development of Maros Regency. According to research conducted by Gusrianda and Wibowo (2024), the area of Sultan Hasanuddin Airport increased by 5.81 hectares from 2003 to 2010 and 2023. However, in 2020-2021, the transportation sector in Maros Regency experienced a significant decline in revenue due to the Covid-

19 pandemic, which restricted outdoor activities. This limitation severely affected Sultan Hasanuddin Airport's operations, resulting in decreased revenue.

Gowa Regency has experienced the fastest growth of built-up land compared to other regions in Mamminasata. The conversion of land primarily consists of residential and settlement developments. According to the Financial Services Authority (OJK), the real estate sector encompasses land and physical buildings, including all assets on the land, such as buildings and fences, used for various purposes. Somba Opu and Palangga Subdistricts exemplify areas in Gowa Regency where land development is significant. This growth is dominated by the construction of new residential units, which, based on imagery, display similar architectural designs and are developing in clusters.

Takalar Regency features several attractive tourist sites that, if developed, could enhance growth in various economic sectors, particularly trade, restaurants, and hotels. The influx of tourists contributes to local income through expenditures on services and local products. Currently, the development of built-up land in Takalar Regency remains relatively slow compared to other regions in Mamminasata.

4 CONCLUSIONS

Based on the analysis and descriptions provided earlier, the following conclusions can be drawn:

- a. **Regional Real Income:** The regional real income in the Mamminasata cities and regencies, as measured by the Gross Regional Domestic Product (GRDP) at constant 2010 prices from 2001 to 2021, has shown a continuous increase. The analysis indicates that in Makassar City, the processing industry is the only leading sector. Maros Regency has two leading sectors: mining and the processing industry. Gowa Regency has four basic sectors, two of which are leading sectors. Takalar Regency has three basic sectors, with two being leading sectors: agriculture, and electricity, gas, and water. The shift-share analysis for the Mamminasata regions reveals no significant structural economic shifts during the assessment period, except for Maros Regency, which experienced a change in sector dominance from the tertiary sector to the primary sector.
- b. **Built-Up Land Growth:** The built-up land in the Mamminasata cities and regencies has consistently grown from 2001 to 2021. Makassar City experienced a built-up land growth of 1.73%, Maros Regency 2.72%, Gowa Regency 4.45%, and Takalar Regency 2.26%. Spatially, the sub-districts adjacent to or directly bordering Makassar City exhibit the most significant growth in built-up land. This phenomenon is attributed to intense urban development in Makassar City, leading to the expansion of built-up areas into the surrounding regions, following road network patterns. This development represents the conversion of previously undeveloped land into built-up areas.
- c. **Multiple Linear Regression Analysis:** The results from the multiple linear regression analysis indicate that there is no effect of the independent variables on the dependent variable, either simultaneously (jointly) or partially (individually). However, the results from the simple linear regression between the tertiary sector and built-up land area demonstrate a significant influence, with the tertiary sector contributing 33% to the land area. The regression equation indicates that for every 1% increase in the tertiary sector, there is a corresponding 7.61% increase in built-up land area in the Mamminasata region.

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