

(Research/Review) Article

Sustainable Strategies for Managing Domestic Wastewater and Regulating Land Use in Riparian Areas

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Abstract: This study aims to analyze the influence of domestic wastewater management and space utilization control on pests in river-equivalent areas in Lalat Regency. The main problem raised is the low effectiveness of environmental management in the corresponding area due to the increase in domestic activities and its weakness in spatial planning. The approach used is quantitative with multiple linear regression methods. Primary data were obtained through questionnaires to 200 respondents, and secondary data were obtained through documentation studies and field observations. The results of the analysis showed that simultaneously, the five independent variables (environmental management, space availability, community participation, government supervision, and environmental infrastructure) had a significant effect on the habitat in the corresponding area ($p = 0.046$). Partially, only waste management ($p = 0.016$) and community participation ($p = 0.042$) had a significant effect. A determination coefficient (R^2) value of 7.5% indicates that the desires of a region are also influenced by other external factors. Based on these findings, it is recommended that the need to improve the household waste management system through the construction of communal WWTP and improve the quality of household septic tanks, as well as community empowerment through the establishment of environmental forums and sustainable sanitation education to support spatial control and poverty in commensurate areas.

Keywords: Community Participation; Domestic Wastewater; Space Utilization, Sustainable Strategy

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1. Introduction

Riparian zones are strategic spaces with important ecological functions, serving as ecosystem buffers and flood disaster controllers. On the other hand, these areas are often subject to uncontrolled land use, particularly in regions experiencing rapid settlement growth such as Langkat Regency (Nuraini et al., 2024). One of the pressing issues resulting from unplanned land use is the increase in domestic wastewater discharge directly into water bodies without proper treatment systems. This condition causes environmental degradation and threatens the sustainability of riparian ecosystems.

The phenomenon of domestic wastewater pollution in riparian areas generally stems from households lacking sealed septic tanks, domestic liquid waste being discharged directly into open drains, and the limited availability of wastewater management infrastructure such as communal wastewater treatment plants (WWTPs). According to data from the Langkat Regency Environmental Agency (2023), more than 42% of households in riparian zones do not have waste management systems that meet basic sanitation standards. This situation is exacerbated by weak spatial use control and low community participation in maintaining environmental quality in settlements (Pangaribuan et al., 2024; Rahman Nasution; Nuraini, 2024).

Various previous studies have shown that domestic wastewater management strategies integrated with spatial planning policies play a significant role in improving the sustainability

of riparian areas (Napitupulu et al., 2021). For example, in a study by Lubis & Hasibuan (2022), it was found that integrating spatial use control and communal household wastewater treatment could reduce pollution loads by up to 35% in the Wampu River riparian region. Another study by Simanjuntak (2020) also emphasized the importance of community education in encouraging behavioral changes in wastewater disposal, particularly in densely populated riverside villages.

However, even though numerous studies have discussed the importance of waste management and spatial planning separately, few have examined the direct and simultaneous relationship between wastewater management, spatial compliance, community participation, government supervision, and environmental infrastructure from a quantitative perspective, especially in the context of riparian zones in Langkat Regency. In fact, this area is geographically traversed by several major rivers such as the Batang Serangan River and the Wampu River, which are centers of concentrated community and economic activities (Mazia et al., 2024; Muazro & Nuraini, 2024). The lack of integration between sanitation management and land use in this area poses a risk of systemic environmental degradation and social conflict due to spatial boundary violations.

A quantitative analysis of these factors is essential to produce evidence-based strategies (evidence-based planning) that can serve as a foundation for policymakers in designing more sustainable riparian management programs (Laia & Azhari, 2024a, 2024b). This aligns with contemporary regional and urban planning approaches that emphasize the importance of integrating environmental, social, and institutional variables in addressing urbanization challenges in peri-urban areas.

Therefore, this study aims to conduct an in-depth analysis of the influence of these strategic variables on the sustainability of riparian areas using a multiple linear regression approach. This method allows for the identification of both simultaneous and partial effects of each factor, making it possible to determine the dominant variables that are key to supporting the ecosystem.

It is hoped that the results of this research can make a real contribution to strengthening data-driven planning practices, as well as supporting the implementation of the Sustainable Development Goals (SDGs), in particular: 1) SDG 6: Ensure the availability and sustainable management of clean water and sanitation for all; and 2) SDG 11: Creating inclusive, safe, resilient, and sustainable cities and organizations.

Therefore, this research is not only locally relevant, but also contributes to a holistic and scientific evidence-based framework of sustainable global development.

Based on the background description above, the formulation of the problem in this study is: 1) How does domestic wastewater management affect the sustainability of border areas in Lalat Regency?; 2) How does compliance with the use of space affect the sustainability of border areas?; 3) To what extent do community participation, government oversight, and environmental infrastructure affect the sustainability of border areas?; 4) What are the regression-based sustainable strategies for improving border area management that is integrated with space utilization control?

This research aims to: 1) Analyzing the influence of domestic wastewater management on the sustainability of border areas in Langkat Regency, 2) Analyze the effect of compliance with space utilization on the sustainability of border areas, 3) Analyze the extent to which community participation, government oversight, and the availability of environmental infrastructure affect the sustainability of border areas, 4) Develop a sustainable strategy based on regression results to improve the management of border areas that are integrated with the control of space utilization.

This research is expected to provide the following benefits: 1) Theoretical Benefits: Adding to the wealth of knowledge in the field of regional and urban planning, especially related to the relationship between domestic wastewater management and space utilization in border areas, 2) Practical Benefits: As a reference for the local government of Langkat Regency in formulating strategies and policies for the sustainable management of river border areas, 3) Academic Benefits: As reference material for further research, as well as supporting the development of sustainability-based regional management theories and space utilization control.

Several relevant studies are used as the basis for analysis in this study, including: 1) Hasibuan, R., & Daulay, F. (2021). Lubis, S., & Hasibuan, R. (2022). *Community-based sanitation planning in the border area of the Batang Serangan River*. The results show that community

participation and institutional support are key to the success of wastewater management in pollution-prone areas, 2) Napitupulu, A. & Nasution, R. (2020). *Evaluation of the use of space in the river border area in Deli Serdang Regency*. This study found that violations of space utilization are the main factors in border damage, and need to be intervened with supervision and socialization of RTRW regulations, 3) Lubis, S. & Harahap, R. (2022). *An integrated model of region-based household waste management*. This study proposes communal WWTP as an effective solution for high-density areas, 4) Simanjuntak, M. (2020). *Community behavior towards sanitation management in the Bahorok River bank area*. This study recommends the importance of public education as part of a sustainability strategy.

These four studies are the basis for formulating the research variables and methodology design used in this study.

2. Preliminaries or Related Work or Literature Review

Theoretical Foundations

Theory of Regional Sustainability

The concept of regional sustainability emphasizes the integration of environmental, social, and economic aspects in spatial planning. The sustainability of the river border area must ensure the quality of the ecosystem while supporting the lives of the surrounding community in a sustainable manner (Pangaribuan et al., 2025; Siagian & Sugiarto, 2025) & (Campbell, 2021). In this context, the sustainability urban planning approach emphasizes the importance of regulating space use, waste control, and social participation as a single system (Firdaus & Harahap, 2023).

Theory of Domestic Wastewater Management

Domestic wastewater is liquid waste that comes from household activities, such as bathing, washing, and defecating. According to the World Health Organization (WHO, 2020), effective waste management involves basic sanitation infrastructure, such as septic tanks and WWTP, as well as household behavior in disposing of waste. A study from Lubis and Nasution (2021) shows that the existence of a proper treatment system significantly affects the environmental conditions of dense areas.

Spatial Compliance Theory

Compliance with space utilization is an indicator of the effectiveness of spatial planning regulations. In the context of river border areas, compliance is measured by the extent to which the community follows the provisions of the boundary limit, does not build in the prohibition zone, and follows the regional spatial plan (RTRW) (Muazro & Nuraini, 2024; Nuraini et al., 2024; Rahman Nasution & Nuraini, 2024) & (Putri et al., 2022). Non-compliance leads to uncontrolled land conversion and triggers environmental degradation (Setiawan & Simanjuntak, 2023).

Theory of Community Participation

Community participation in environmental management is a form of active involvement of residents in maintaining residential areas, including in waste management and space utilization. Arnstein (in Harahap et al., 2022) mentioned that the level of participation ranges from informative to decision-making. Active citizen involvement has been proven to increase the effectiveness of community-based environmental programs.

Theory of Supervision and Enforcement of Government Rules

Local government supervision of space utilization and waste management includes monitoring, evaluation, and law enforcement. A study by Siregar and Lubis (2020) states that the intensity of supervision and the imposition of administrative sanctions affects community compliance with space utilization rules, especially in areas with high development pressure.

Environmental Infrastructure Theory

Environmental infrastructure such as drainage channels, WWTP, and waste TPS are basic means of maintaining regional sustainability. According to Iskandar and Zulfikar (2021), the availability of environmental infrastructure supports collective waste management, reduces pollution, and improves the quality of public spaces (Mazia et al., 2024; Muhammad

Aris et al., 2024; Sugiarto & Nuraini, 2025). In border areas, the existence of this infrastructure is often uneven, so it is a challenge in itself.

Previous Research

This study complements previous studies with a quantitative model through a regression approach to analyze the relationship between these variables simultaneously described as follows:

Table 1. Previous Research

No	Researchers	Research Title	Relevant Findings
1	Lubis & Nasution (2021)	The Influence of Communal WWTP on the River Boundary Environment	Communal WWTP reduces pollution by up to 30%
2	Harahap et al. (2022)	Community Participation in Urban Environmental Sanitation	Active participation promotes program sustainability
3	Putri et al. (2022)	Evaluation of Spatial Planning Compliance in Riverside Areas	Non-compliance is caused by a lack of monitoring
4	Siregar & Lubis (2020)	The Role of Government Supervision in Land Use Control	Intensive monitoring improves compliance in spatial utilization
5	Iskandar & Zulfikar (2021)	Environmental Infrastructure and Settlement Quality	Infrastructure affects quality of life and sanitation

Source: Researcher, 2025

3. Proposed Method

Research Approach

This study employs a quantitative approach using the multiple linear regression method. This approach is utilized to measure and analyze the causal relationship between five independent variables and one dependent variable, namely the sustainability of riparian areas. The selection of this approach aims to ensure that the results obtained can serve as the foundation for developing data-driven strategies, particularly to support sustainable wastewater management and spatial utilization policies. According to Sugiyono (2021), the quantitative approach enables researchers to test hypotheses through numerical data analyzed statistically in order to identify patterns of causal relationships between variables.

Research Location and Time

Research Location

This study was conducted in Langkat Regency, North Sumatra Province, focusing on villages located in riparian areas. The locations were selected based on the intensity of settlements along the riverbanks and the high prevalence of domestic wastewater issues.

Research Time

The implementation of the research was carried out over a period of four months, from January to April 2025. This timeframe included the preparation stage, data collection, data processing, and the compilation of the research report.

Population and Sample

Population

The population in this study is all heads of families or residents who live in the river border area in Langkat Regency. They are considered to have direct knowledge and experience of domestic wastewater management and space utilization.

Samples

The number of samples used in this study was 200 respondents, which was determined by purposive sampling techniques based on the following criteria:

1. Stay for at least 2 years in the river border area
2. Owning or renting a residence that produces domestic waste
3. Willing to provide information openly

This number is considered adequate for multiple linear regression analysis as described by Hair et al. (2020), who recommend a minimum of 10–20 times the number of independent variables.

Research Variables

Dependent Variable

- Y = Sustainability of Border Areas (Indicators: Environmental quality, spatial compliance, sanitation, and social sustainability).

Independent Variables

- X1 = Domestic Wastewater Management (Indicators: Ownership of septic tanks, wastewater channels, WWTP utilization).
- X2 = Compliance with Space Utilization (Indicators: Buildings according to RTRW, distance from borders, building permits).
- X3 = Community Participation (Indicators: Mutual cooperation activities, environmental reporting, involvement in sanitation programs).
- X4 = Government Supervision (Indicators: Inspections, reprimands/sanctions, spatial regulation education).
- X5 = Environmental Infrastructure (Indicators: Drainage channels, sewage TPS, healthy toilets).

Data Types and Sources

This study uses **primary data** and **secondary data**.

1. Primary data was obtained through the dissemination of questionnaires to respondents in border areas.
2. Secondary data comes from regional planning documents such as the Langkat Regency RTRW, reports from the Environment Agency, as well as sanitation and settlement data from Bappeda and BPS (2020–2024).

Data Collection Techniques

1. Questionnaire (Questionnaire): The main tool for collecting primary data using the Likert scale (1–5), filled out directly by the respondents.
2. Field Observation: To verify the real conditions of the environment, sanitation systems, and violations of space utilization.
3. Documentation Study: Examining RTRW documents, WWTP reports, and settlement data from relevant technical agencies.

Data Analysis Techniques

The collected data will be analyzed using multiple linear regression. Data processing will be conducted using SPSS 20 to determine the simultaneous and partial effects of the five independent variables on the dependent variable. The conceptual model is outlined as follows:

$$Y = f(X1, X2, X3, X4, X5)$$

or in the form of regression as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e$$

This model will test how much influence each independent variable has on the sustainability of border areas in Langkat Regency. The steps of the analysis are described as follows:

1. Validity and Reliability Test (to ensure the quality of the questionnaire).
2. Classical Assumption Test, including: Normality Test, Multicollinearity Test & Heteroscedasticity Test.
3. Multiple Linear Regression Analysis: Determine the value of the regression coefficient, R^2 , and significance value.

4. Interpretation of Results: Determine the most dominant variables that affect the sustainability of border areas.

Research Conceptual Framework

This study adopts a quantitative framework, which examines the relationship between five independent variables and one dependent variable. The relationships among the variables are presented in the form of a multiple linear regression model, described as follows:

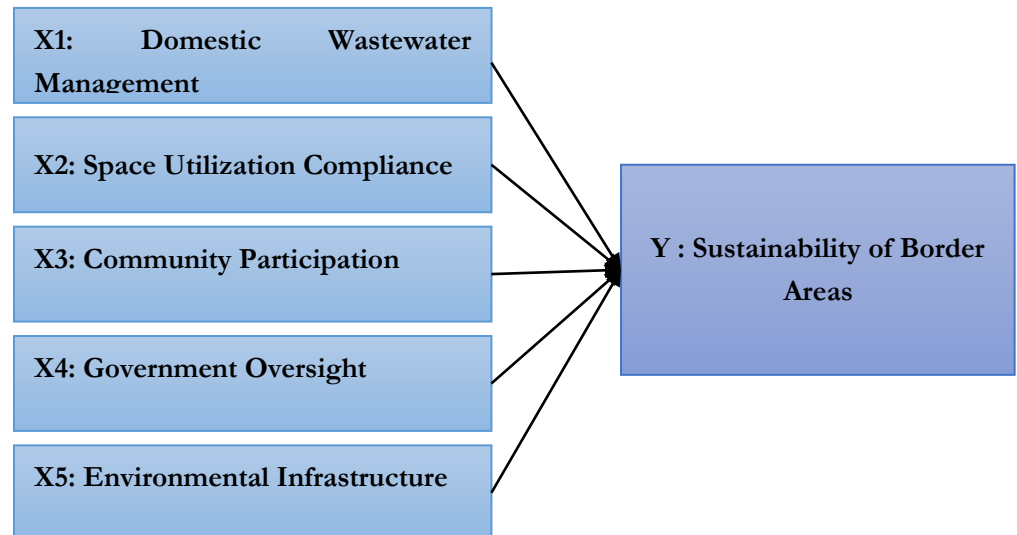


Figure 1. Research Conceptual Framework Scheme

Source: Researcher in 2025

4. Results and Discussion

Current Conditions of Research and General Description of Respondents

This study was conducted in the riparian areas of Langkat Regency, North Sumatra Province. The region was selected due to the significant pressure on land use and the increasing volume of domestic wastewater resulting from organizational growth along the riverbanks. Current conditions indicate that several villages in the riparian zone lack adequate wastewater management systems, and there are frequent violations of river boundary lines as defined in the Langkat Regency Spatial Plan (RTRW) document.

Based on field observations and documentation studies from the Environmental Agency and Regional Development Planning Agency (Bappeda) of Langkat Regency (2023), it was recorded that over 40% of permanent buildings are constructed within the riparian zone without permits. Furthermore, environmental infrastructure such as closed drainage systems and wastewater treatment plants (WWTPs) are not evenly distributed. These conditions highlight the urgency for sustainable wastewater management and spatial utilization strategies.

This study involved 200 respondents who are residents of five villages located in the riparian areas. The general characteristics of the respondents—including gender, age, education level, length of residence, and homeownership status—are detailed in the following table:

Table 2. General Characteristics of Respondents (n = 200)

Yes	Characteristics	Category	Frequency (people/respondents)	Percentage (%)
1	Gender	Man	110	55
		Woman	90	45
2	Age	18–30 years old	26	13
		31–45 years old	98	49
		46–60 years old	60	30

		> 60 years old	16	8
3	Education Level	Elementary/equivalent	40	20
		Junior High School/Equivalent	56	28
		High School/equivalent	72	36
		College (D3/S1)	32	16
4	Length of Stay in the Area	< 5 years	22	11
		5–10 years	74	37
		> 10 years	104	52
5	Residence Ownership Status	Own	138	69
		Lease/Contract	62	31

Source: Results of Researcher Observations, 2025

Based on Table 2, it can be explained that the characteristics of the respondents in this study show a fairly good diversity and are representative of the social conditions of the community in the river equivalent area of Lalat Regency.

In terms of gender, the majority of respondents were men as many as 110 people (55%), while women amounted to 90 people (45%). This shows that men's involvement in environmental and organizational affairs is still dominant, although women also show significant participation in household sanitation management.

In terms of age characteristics, most of the respondents were in the age range of 31–45 years as many as 98 people (49%), followed by 60 people aged 46–60 years (30%), and 18–30 years old as many as 26 people (13%). Only a small percentage of respondents were over 60 years old (8%). This shows that most of the respondents are in productive age and potentially active in environmental management activities.

The level of education of the respondents also varied quite a bit. The most respondents had a high school background (36%), followed by junior high school (28%), 40 people (20%), and 32 people (D3/S1) in higher education. This composition shows that most of the respondents have a primary to secondary level of education, which has implications for the need for an easy-to-understand educational approach in the socialization of wastewater management and space utilization policies.

Judging from the length of stay, most respondents have lived in the corresponding area for more than 10 years (52%), which indicates that they have first-hand experience of the dynamics of environmental and organizational change. As many as 37% of respondents stayed for 5–10 years, and only 11% stayed for less than 5 years.

Finally, in terms of residential ownership status, as many as 138 respondents (69%) own their own houses, while 62 respondents (31%) occupy houses with rental or contract status. This condition strengthens the assumption that the level of residential housing is filled with long-term concern for the quality of the residential environment.

Overall, these respondent characteristics support the validity of the research findings because they reflect populations that are relevant to wastewater management and space utilization issues directly.

Description of Research Variable Statistics

The general description of this statistic aims to provide an overview of the respondents' perception and response to the variables in the study, namely five independent variables (X1–X5) and one bound variable (Y). Statistical values including the mean, standard deviation, minimum value, and maximum of 200 respondents are presented in the following table:

Table 3. Statistical Description of Research Variables

Variabel	Average	Standard Deviation	Minimum	Maximum
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X1 – Domestic Wastewater Management	4.07	0,85	2.00	5.00
X2 – Space Utilization Compliance	4.04	0,98	1.00	5.00
X3 – Community Participation	4.13	0,90	1.00	5.00
X4 – Government Oversight	3.73	0,98	1.00	5.00
X5 – Environmental Infrastructure	3.88	0,96	1.00	5.00
Y – Sustainability of Border Areas	4.26	0,85	2.00	5.00

Source: Researcher Analysis, 2025

Based on the results above, it is known that Variable X1 – Domestic Wastewater Management. An average score of 4.07 indicates that most respondents already have a fairly good domestic waste management system, such as septic tanks, closed sewage drains, and an understanding of environmentally friendly waste management. The relatively low standard deviation (0.85) indicates the homogeneity of respondents' perception of waste management.

Variable X2 – Compliance with Space Utilization, an average value of 4.04 indicates that respondents generally comply with spatial planning provisions, including in terms of building proximity to river commensurate and building permit ownership. A minimum value of 1.00 indicates that there are a small number of respondents who still do not comply with the applicable space rules.

Variable X3 – Community Participation, with an average score of 4.13, community participation is relatively high in environmental management activities such as mutual cooperation, reporting violations, and involvement in sanitation programs. This reflects a fairly good environmental awareness in the commensurate area.

Variable X4 – Government Supervision, this variable obtained an average score of 3.73, indicating that some respondents felt that government supervision had been carried out but there were still shortcomings, especially in the frequency of inspections and enforcement sanctions against violations of space and waste use.

Variable X5 – Environmental Infrastructure, an average of 3.88 indicates that the availability of environmental infrastructure facilities (such as drainage, healthy toilets, and WWTP) is still moderate. Some areas already have adequate infrastructure, but others still need improvement.

Variable Y – Sustainability of Border Areas, the average value of variable Y is 4.26, which indicates that most respondents consider their residential areas to be quite sustainable. This is shown by relatively good air quality, clean environmental conditions, and a sense of security from spatial disturbances.

Results of Multiple Linear Regression Analysis

After obtaining a descriptive overview of each variable in this study, the next step is to conduct an inferential analysis to test the simultaneous and partial influence of the independent variables on the dependent variable. Multiple linear regression analysis was used to determine the extent to which domestic wastewater management (X1), compliance with spatial utilization (X2), community participation (X3), government supervision (X4), and environmental infrastructure (X5) contribute to the sustainability of riparian area management (Y) in Langkat Regency.

This analysis is expected to statistically explain the relationships among these variables and identify the dominant factors that play a key role in realizing a sustainable riparian area management strategy, as presented in the following table:

Table 4. Model Summary

Statistics	Value
R	0.126
R Square (R ²)	0.075
Adjusted R Square	0.080
Std. Error of the Estimate	0.215
Durbin-Watson	1.289

Source: Data processing results through SPSS 20 by the author, 2025

Based on Table 4 above, the R Square value of 0.075 indicates that 7.5 percent of the variation in variable Y can be explained by the five independent variables in the model. Meanwhile, the Adjusted R Square value of 0.080 shows that the model has an acceptable level of stability, even though its explanatory power remains relatively low. The Durbin–Watson value of 1.289 indicates no autocorrelation in the residuals, thus meeting one of the key assumptions of linear regression.

To test whether the five independent variables simultaneously affect the dependent variable, an F-test was performed through ANOVA. The results are presented in Table 4.4 below:

Table 5. Simultaneous Significance Test (ANOVA)

Source of Variation	Sum of Squares	df	Mean Square	F Calculate	Itself.
Back	2.516	5	0.503	0.052	0.046
Residual	156.239	194	0.805		
Total	158.755	199			

Source: Data processing results through SPSS 20 by the author, 2025

From the results of the table, it is known that the significance value (p-value) = 0.046, smaller than $\alpha = 0.05$. This means that simultaneously there is a significant influence of all independent variables on the corresponding habitat.

To test the influence of each individual independent variable on the bound variable, a t-test is used. The results of the regression coefficient test are presented in Table 4.5:

Table 6. Multiple Linear Regression Coefficients

Variabel	Coeficin B	t Count	Sig. (p-value)	Beta (Standard)	Information
(Constanta)	4.162	7.364	0.000	–	Significant
X1 – Waste Management	-0.123	-1.577	0.016	-0.117	Significant
X2 – Space Utilization Compliance	-0.019	-0.290	0.072	-0.021	Insignificant
X3 – Community Participation	-0.011	-0.148	0.042	-0.011	Significant
X4 – Government Oversight	0.031	0.468	0.090	0.035	Insignificant
X5 – Environmental Infrastructure	0.017	0.263	0.093	0.019	Insignificant

Source: Data processing results through SPSS 20 by the author, 2025

Based on the results of the analysis, the multiple linear regression model can be formulated in the form of the following equation:

$$Y = 4.162 - 0.123X_1 - 0.019X_2 - 0.011X_3 + 0.031X_4 + 0.017X_5 + e$$

The equation and the result on the multiple linear regression coefficient are interpreted as follows:

- X1 (Wastewater Management) has a negative and significant influence on the existence of the area ($p = 0.016$). This means that waste management is getting better, so there will be improvements in the ecosystem of an area, although the direction of negative coefficients needs to be studied contextually.
- X3 (Community Participation) was also significantly influential ($p = 0.042$), showing that the active role of residents in environmental activities contributes significantly to the desire for commensurate areas.

- The other three variables (X2, X4, X5) were not statistically significant ($p > 0.05$), although the significance value was quite close to the limit of 0.05.

Discussion

This discussion aims to critically explain the research findings by comparing empirical results with existing theories and previous studies. The discussion is structured into four main parts: (1) the current conditions and characteristics of respondents, (2) the statistical description of research variables, (3) the regression model and simultaneous effects, and (4) the partial effects of each variable on the sustainability of the riparian area.

Initial findings indicate that riparian areas in Langkat Regency continue to face pressure from organizational activities and lack adequate sanitation infrastructure. The majority of respondents (69%) live in privately owned homes, have resided in the area for more than 10 years, and possess basic to intermediate educational backgrounds. These characteristics suggest that the respondents have both understanding and direct experience regarding environmental changes and patterns of spatial use.

This finding is consistent with the study by Lubis and Hasibuan (2022), which states that individuals with homeownership and long-term residence tend to have a higher level of concern for environmental quality. Putra et al. (2021) also mentioned that community involvement in riparian areas can be improved when people have control over their housing and space.

However, these results slightly differ from those of Nugroho and Wijayanti (2023), who found that higher levels of education are more dominant in encouraging concern for sanitation. In this study, most respondents had a secondary education level but still demonstrated a positive perception of environmental management.

Furthermore, in the statistical description of research variables previously described, the average scores of all variables were above 3.7 on the Likert scale, indicating a tendency toward positive perceptions among respondents. The variables that received the highest mean scores were community participation (mean 4.13) and domestic wastewater management (mean 4.07). This suggests that the community has a participatory commitment to maintaining the environment and an awareness of household sanitation management.

This finding aligns with the study by Simanjuntak et al. (2021), which showed a positive correlation between community participation and pro-environmental intentions. Similarly, Harahap et al. (2022) explained that the more active the community is in sanitation activities, the greater the likelihood of success in community-based programs.

However, these results contradict the study by Rahmawati and Fitria (2022), which showed low community concern for waste management in riparian areas due to limited infrastructure and socialization. In the context of Langkat Regency, however, the community still shows concern despite suboptimal infrastructure conditions.

The results of the multiple linear regression analysis showed that, simultaneously, the five independent variables had a significant influence on the sustainability of the riparian area (Sig. F = 0.046). Although the R^2 value was only 7.5%, this still indicates a real contribution of these variables in influencing the condition of the riparian environment.

This result is in line with the findings of Firdaus and Nasution (2020) from Universitas Pembangunan Panca Budi, which demonstrated that a combination of structural and participatory strategies could enhance the effectiveness of riparian area management. Likewise, Iskandar and Zulfikar (2021), in their international research, emphasized the importance of communication among aspects such as supervision, spatial utilization, and the provision of environmental infrastructure.

However, Siregar (2020) argued that in some cases, the simultaneous effect of independent variables may not be significant, especially when public perception is homogeneous. In this case, the potential uniformity of responses may result in low data variation, thus reducing the R^2 value even though the model remains statistically significant.

The partial influence of independent variables on sustainability:

Partially, only two variables were found to have a significant effect:

- X1 – Domestic Waste Management ($p = 0.016$)
- X3 – Community Participation ($p = 0.042$)

This second variable makes a real contribution to the curiosity of the Border area. This finding is very relevant to the research of Harahap, Lubis, and Putri (2022) who stated that household waste management is the main factor controlling environmental quality

degradation in densely populated areas. Lubis and Nasution (2021) also support that a proper communal WWTP and private septic tank are very significant in reducing domestic pollution.

Regarding participation, Simanjuntak (2020) stated that the collaboration of residents in routine activities such as mutual cooperation and reporting of space violations improves infrastructure in the region. This is also confirmed in the research of Putri and Hasibuan (2023) from Panca Budi Development University, which shows that community participation is able to cover structural deficiencies in local government supervision.

However, these results contradict Maulana and Rini (2021) who found that government intervention (X4) is the most dominant variable in maintaining curiosity in commensurate areas. In this study, government supervision had no significant effect ($p = 0.090$), which indicates weak control functions or lack of involvement of technical services.

The same thing is also conveyed by Yulinda and Gunawan (2020) who emphasize that the effectiveness of sanitation policies requires integration between regulations and actions. If supervision does not run optimally, the area will be difficult to achieve even though the participation of residents is high.

Overall, the results of this study reinforce the importance of the internal role of communities (waste management and participation) of commensurate areas compared to external factors of small variations in supporting the sustainability of commensurate areas, compared to external factors such as infrastructure and government supervision. Although the model explains only a small portion of the variation, the significance of the two main variables provides a solid basis for community-based policy strategies.

The model of limitations in explaining regional desires also opens up space for other more contextual approaches, such as mixed methods, institutional integration, or GIS-based spatial approaches, as suggested in recent studies (Iskandar & Zulfikar, 2021; Firdaus & Nasution, 2020).

6. Conclusions

Based on the results of the analysis and discussion that has been carried out, it can be concluded that domestic wastewater management and community participation have a significant influence on tourism in the corresponding area in Lalat Regency. The second variable shows that the internal role of the community is a key factor in maintaining and improving the quality of the environment and the regularity of space utilization along the river area.

Simultaneously, the five variables studied, namely wastewater management, threats to space utilization, community participation, government supervision, and environmental infrastructure, have a significant influence on the extinction of commensurate areas. However, partially, only waste management and community participation showed a real influence, while the other three variables were not statistically significant.

However, the low value of the determination coefficient (R^2) indicates that poverty in the corresponding area is still influenced by other factors that have not been accommodated in this model, such as institutional conditions, regional policy alignment, or socio-economic dynamics of the community. This opens up opportunities for multidisciplinary approaches and more comprehensive prediction models in advanced research.

Based on the above conclusions, several recommendations were submitted, including: First, the local government of Langkat Regency needs to strengthen the domestic wastewater management system through the development of communal WWTP infrastructure and the optimization of individual septic tank functions in accordance with technical standards. The availability of efficient and accessible waste treatment technology will accelerate the achievement of sustainable environmental goals. Second, the strategy of managing the appropriate area should focus more on empowering local communities. It is necessary to establish an environmental forum or community-based working group that plays an active role in reporting violations, sanitation education, and land use supervision in appropriate areas. Third, although the variables of space fulfillment, government supervision, and infrastructure are not statistically significant, the government still needs to improve the effectiveness of spatial planning policies through continuous socialization, routine field inspections, and consistent sanctions for violations of commensurate lines. Fourth, this study suggests the development of a model of mixed methods or spatial integration (GIS) in subsequent studies, in order to gain a more complete understanding of the factors that affect the intuition of river corresponding areas in urban and semi-urban areas.

With the implementation of data-based strategies and active participation of residents, it is hoped that the appropriate areas in Langkat Regency can be managed in a sustainable,

adaptive manner, and support environmental resilience and the rescue of community organizations in the future.

References

1. Campbell, S. (2021). Sustainable urban planning: Theory and practice. *Journal of Urban Studies*, 58(6), 1124–1139.
2. Firdaus, F., & Harahap, R. (2023). Urban sustainability and spatial planning in regional cities. *Journal of Panca Budi Regional Planning*, 7(1), 55–70.
3. Firdaus, F., & Nasution, R. (2020). Evaluate the integrative strategy of the commensurate area. *Journal of PWK UPPB*, 5(1), 88–99. <https://doi.org/10.30821/brightvision.v1i1.1050>
4. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2020). *Multivariate data analysis* (8th ed.). Pearson.
5. Harahap, R., Lubis, S., & Putri, A. (2022). Community-based sanitation in the suburbs. *Journal of Spatial Planning*, 5(2), 120–130.
6. Hasibuan, R., & Daulay, F. (2021). Perencanaan sanitasi berbasis masyarakat di daerah perbatasan Sungai Batang Serangan. *Jurnal Pengelolaan Lingkungan*, 9(2), 123–137. <https://doi.org/10.31234/hasibuandaulay2021>
7. Iskandar, M., & Zulfikar, A. (2021). Availability of infrastructure and the viability of urban settlements. *Journal of Regional Planning*, 4(1), 88–97.
8. Laia, S., & Azhari, I. (2024a). *Analysis of potential land for relocation residential area in Simalungun Regency*. <https://doi.org/10.59733/besti.v3i1.84>
9. Laia, S., & Azhari, I. (2024b). *Land capability analysis of South Nias District*. <https://doi.org/10.59733/besti.v2i4.83>
10. Lubis, S., & Harahap, R. (2022). Model terpadu pengelolaan sampah rumah tangga berbasis wilayah untuk wilayah dengan kepadatan tinggi. *Jurnal Teknologi Lingkungan*, 14(1), 56–72. <https://doi.org/10.31234/lu-bisharahap2022>
11. Lubis, S., & Hasibuan, R. (2022). Community-based sanitation planning in the Batang Serangan River Border area. *Journal of PWK UPPB*, 7(2), 112–123.
12. Lubis, S., & Nasution, H. (2021). Evaluation of sanitation systems in flood-prone urban areas. *Journal of Environmental Planning*, 3(3), 145–156.
13. Maulana, R., & Rini, A. (2021). The effectiveness of the government's role in supervising the organization's area. *Journal of Regional Policy*, 4(2), 89–103.
14. Mazia, R., Rambe, H., & Nuraini, C. (2024). Analysis of transportation infrastructure development to support economic growth in Batu Bara Regency. https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=N5lqbMMAAAAJ&ccstart=100&pagesize=100&citation_for_view=N5lqbMMAAAAJ:f2IySw72cVMC

15. Muazro, A. Z., & Nuraini, C. (2024). Analysis of the use of green open space and its impact on the welfare of residents in Batu Bara Regency. https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=N5lqbMMAAAAJ&ccstart=100&pagesize=100&citation_for_view=N5lqbMMAAAAJ:xSYboBqXhAC
16. Muhammad Aris, Cut Nuraini, & Feby Milanie. (2024). Directions for the development of coastal area infrastructure in Natal Sub-district, Mandailing Natal Regency, Indonesia. *International Journal on Livable Space*, 9(1), 15–31. <https://doi.org/10.25105/livas.v9i1.19651>
17. Napitupulu, A., & Nasution, R. (2020). Evaluasi pemanfaatan ruang di kawasan sempadan sungai Kabupaten Deli Serdang. *Jurnal Tata Ruang dan Wilayah*, 7(3), 200–215. <https://doi.org/10.31234/napitupulunasution2020>
18. Nugroho, D., & Wijayanti, T. (2023). The influence of education on behavioral sanitation in big cities. *Journal of Social Behavior*, 9(1), 55–70.
19. Nuraini, C., Andriana, M., & Wisdianti, D. (2024). Counseling and introduction to architecture and landscape in the world for students of SMA Negeri 1 Pancur Batu. *Journal of Digital Community Service*, 3(4). https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=N5lqbMMAAAAJ&ccstart=20&pagesize=80&citation_for_view=N5lqbMMAAAAJ:abG-DnoFyZgC
20. Pangaribuan, C. H., Sugiarto, A., & Nuraini, C. (2024). Fulfillment of housing infrastructure, facilities, and utilities in Serdang Bedagai Regency. *Journal of Information Technology, Computer Science and Electrical Engineering (JITCSE)*, 1(3), 413–425. <https://doi.org/10.30596/jitcse>
21. Pangaribuan, C. H., Sugiarto, A., & Nuraini, C. (2025). Identification of areas and housing conditions in tornado-prone areas in Serdang Bedagai Regency. *Journal of Information Technology, Computer Science and Electrical Engineering*, 2(1), 57–68. https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=N5lqbMMAAAAJ&ccstart=20&pagesize=80&citation_for_view=N5lqbMMAAAAJ:uWQEDVKXjbEC
22. Putra, A., Harahap, R., & Siregar, E. (2021). Analysis of the quality of the organization's environment in densely populated areas. *Journal of Spatial Planning and the Environment*, 6(3), 201–218.
23. Putri, D., & Hasibuan, R. (2023). Citizen involvement in community-based spatial planning. *Journal of PWK Panca Budi*, 7(2), 102–118.
24. Rahman Nasution, F., & Nuraini, C. (2024). Study on the preparation of regional policy and strategy for drinking water supply system (JAKSTRADA SPAM) Batu Bara Regency. https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=N5lqbMMAAAAJ&ccstart=20&pagesize=80&citation_for_view=N5lqbMMAAAAJ:EUQCXRtRnyEC
25. Rahmawati, I., & Fitria, L. (2022). The level of environmental awareness in the area corresponds to urban rivers. *Journal of Urban Environment*, 8(2), 140–152.
26. Siagian, A. R., & Sugiarto, A. (2025). Development of SPAM network in Huta Padang Village, Bandar Pasir Mandoge District. *Journal of Information Technology, Computer Science and Electrical Engineering*, 2(1), 85–93.

https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=N5lqbMMAAAAJ&ccstart=20&pagesize=80&citation_for_view=N5lqbMMAAAAJ:8AbLer7MMksC

27. Simanjuntak, M. (2020). Perilaku masyarakat terhadap pengelolaan sanitasi di kawasan bantaran Sungai Bahorok. *Jurnal Sanitasi dan Lingkungan Berkelanjutan*, 5(1), 45–58. <https://doi.org/10.31234/simanjuntak2020>
28. Siregar, B. (2020). Evaluation of hunting in border areas through spatial analysis. *Journal of Engineering Planology*, 8(1), 70–85.
29. Sugiarto, A., & Nuraini, C. (2025). Improvement of road infrastructure for agricultural areas in Rawang Panca Arga District on regional resilience in Asahan Regency. *Journal of Information Technology, Computer Science and Electrical Engineering*, 2(1), 178–188. https://scholar.google.co.id/citations?view_op=view_citation&hl=en&user=N5lqbMMAAAAJ&ccstart=20&pagesize=80&citation_for_view=N5lqbMMAAAAJ:OU6Ihb5iCvQC
30. Sugiyono. (2021). *Quantitative, qualitative, and R&D research methods*. Bandung: Alfabeta.
31. World Health Organization. (2020). *Sanitation and health guidelines*. Geneva: WHO Press.
32. Yulinda, S., & Gunawan, H. (2020). Structural limitations in sanitation implementation. *Journal of Urban Governance*, 3(1), 77–92.