International Journal of Sustainable Development and Planning
Vol. 20, No. 5, May, 2025, pp. 1813-1829
Journal homepage: http://iieta.org/journals/ijsdp

Urban Harmony: Integrating Spatial Suitability and Socio-Economic Factors to Enhance Quality of Life in Kotalama Riverbank Settlements, Malang City, Indonesia

Surjono[1*], Erland Raziqin Fatahillah[1], Abdul Wahid Hasyim[1], Mustika Anggraeni[1], Aurellia Parasti Jasmine[1], Andik Isdianto[2]

[1] Department of Urban and Regional Planning, Faculty of Engineering, Universitas Brawijaya, Malang 65145, Indonesia
[2] Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Brawijaya, Malang 65145, Indonesia

Corresponding Author Email: surjono@ub.ac.id

https://doi.org/10.18280/ijsdp.200502

Received: 24 February 2025
Revised: 3 May 2025
Accepted: 9 May 2025
Available online: 31 May 2025

Keywords:
community well-being, disaster risk assessment, flood mitigation, gis mapping, housing standards, socioeconomic integration, sustainable urban planning, urban resilience

ABSTRACT

This study aims to understand the influence of spatial suitability and standard of living on the quality of life of residents in the riverside settlement of Kotalama, Malang City, in the context of sustainable urban planning. The methodology applied involves the use of Geographic Information System (GIS)-based overlay analysis to evaluate land use suitability, as well as the use of multiple linear regression analysis to examine the relationship between the standard of living variables and community-reported perceptions of quality of life. The results show that increasing distance from the river, improving housing quality, and increasing asset ownership are significantly associated with improved quality of life. These results emphasize the importance of integrating spatial suitability and socio-economic factors into urban planning policies to support sustainable development. The implications of this study are highly relevant to the achievement of SDG 11 which targets the creation of inclusive, safe, resilient, and sustainable cities and communities. This study proposes that urban planning policies should prioritize improving housing quality and providing better access to infrastructure to improve quality of life, while reducing the risk of natural disasters such as floods and landslides.

1. INTRODUCTION

Current urban policy and scientific research analyze urban growth based on the interaction of urbanization (intensive land use, population density) and social inequality in the environment [1] and well-being [2]. Land use and population growth drive urban development, increasing housing demand [3], often imbalanced with the supply. In Indonesia, housing is one of three basic needs, i.e., clothing, food, and shelter [4], that precede other basic needs such as affection, safety, self-esteem, and other well-being indicators [5]. Housing serves as a shelter and a place to fulfil various life needs, including socialization and reinforcing community values [6]. These three basic needs precede other basic needs, such as affection, safety, self-esteem, and other well-being indicators [7]. However, there is a mismatch between supply and demand [8] that results in an unresolved housing backlog and limited access to affordable shelters for low-income groups.

In the context of settlement location, spatial planning regulation is central to urban policy discussions [9]. The Indonesian Housing and Settlement Act defines settlements as part of the ecosystem, encompassing living areas and activities supporting the community's welfare. However, disadvantageous communities with less choice of shelter often violate land-use planning by living in unrecommended areas. These disadvantageous community groups find and form settlements in slum and squatter areas near the activities of economic sectors and industrialization [10]. Even though they live in such a location, they try to adapt to disaster-prone conditions and develop non-physical aspects of community life, such as social and cultural interactions among residents [11]. This phenomenon is particularly apparent in many parts of the Malang City area [12, 13], where these settlements are mainly located on riverbanks or railroad buffer zones near the city centre and access to main roads [14].

In Kotalama Sub-District, the riverbanks are occupied by houses built without following existing spatial planning regulations [15], which designate riverbanks as green areas to prevent the risk of flooding, landslides, and water pollution. Violations of this regulation persist in Kotalama [16]. This condition risks the community and environment, reducing the riverbank zone's natural function [17]. Singh et al. [18] claimed that uncertainty about their quality of life in the new location caused residents' resistance. Many residents consider their current housing adequate [19] and already feel a strong emotional and social connection in their settlement [20]. This situation highlights the importance of considering individual perceptions of quality of life, which includes physical health, psychological well-being, environmental conditions, and social relationships [21]. Therefore, the quality of life of residents living in disaster-prone areas with inadequate infrastructure is significant [22].

This study was designed to examine the interaction between land use suitability, standard of living, and perceived quality of life among residents living along the Kotalama Riverbank (Brantas and Amprong Rivers), in Kotalama Sub-District. By applying Geographic Information Systems (GIS)-based overlay methods and multiple linear regression analysis, this study tests two main hypotheses: (1) proximity to the river negatively affects quality of life due to increased disaster risk; and (2) higher levels of standard of living positively contribute to improved quality of life.

The relevance of this study is based on a literature review that states the importance of integration between urban planning policies and the socio-economic needs of residents. The results of this study are expected to provide a basis for developing policies that support the SDGs, especially Goal 11 in realizing inclusive, safe, resilient, and sustainable cities.

Therefore, this study not only provides an important contribution to the local context in addressing riverside settlement issues, but also enriches the global dialogue on sustainable urban planning strategies. Through an innovative methodological approach, this study proposes a new perspective on the dynamics between spatial planning, standard of living, and quality of life, as well as the implications of these findings in formulating more effective and inclusive urban policies.

2. METHODOLOGY

2.1 Study area

The study area for this research is Kotalama Sub-District, Kedungkandang District, Malang City, East Java Province, Indonesia (Figure 1), located in the southeastern part of the city. It comprises 11 RWs (neighbourhood groups) and 141 RTs (neighbourhood units).

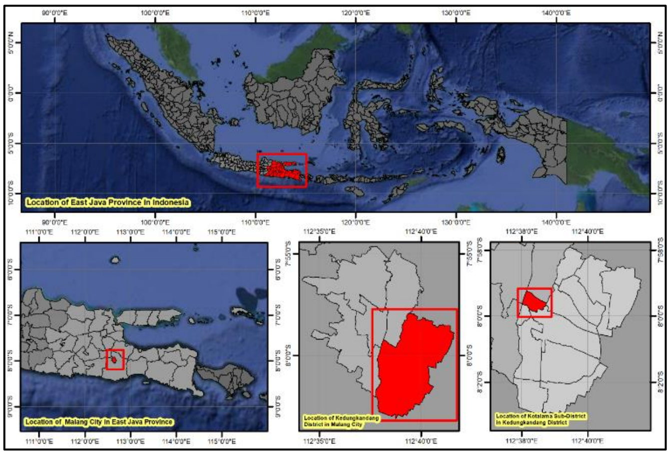

Figure 1. Orientation of the administrative area of the study area in Kotalama Sub-District

This area was selected based on its physical and administrative boundaries, focusing on the Brantas and Amprong Rivers. The riverbank boundaries are defined as 15 meters from both the left and right edges of the river channel, as outlined in the 2022-2042 Malang City Spatial Plan (RTRW) and the 2016-2036 Malang Southeast Urban Planning and Zoning Regulation (RDTR-PZ BWP). The delineated study area covers 10.5 hectares, encompassing 8 RWs, from RW 04 to RW 11 (Figure 2). This location is also characterized by dense informal settlements and high exposure to environmental hazards, making it a critical focus for spatial and socio-economic analysis.

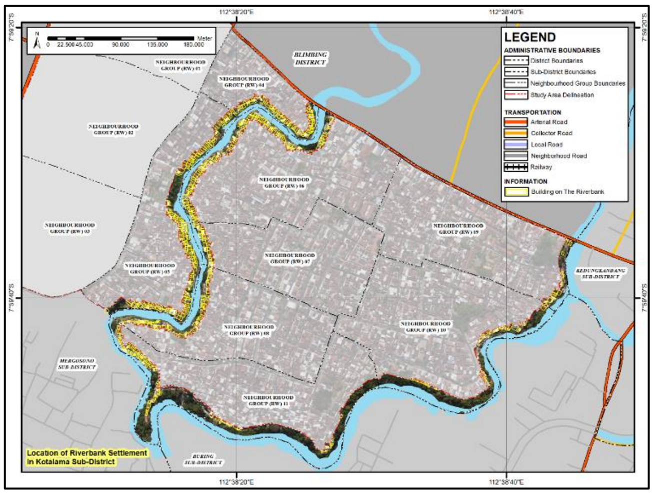

Figure 2. The study area of riverbank settlement in Kotalama Sub-District

2.2 Data collection

This study employed both secondary and primary data collection (Figure 3). A secondary survey at government institutions collected secondary data. The information obtained from these institutions includes the required spatial planning documents. Observation and distribution of questionnaires to respondents collected primary data. Observation obtained data on the alignment of spatial patterns, applying the Euclidean distance method, which calculated the distance between two objects based on the sum of the differences between those objects. The questionnaires for the respondents living on the riverbank of the Brantas and Amprong Rivers gathered data on the community's perceived living standards and quality of life.

Respondents were selected from 684 buildings located within 15 meters of the riverbanks in RW 04 to RW 11, areas identified as non-compliant with spatial planning regulations. Using Slovin's formula with a 10% margin of error [23], a sample of 90 respondents was selected to proportionally represent each RW. The number of samples per RW was determined by dividing the number of non-compliant parcels in each RW by the total number of parcels across all RWs and then multiplying by the total sample size. The questionnaire gathered data on community perceptions of living standards and quality of life.

While this proportional method ensured representational balance, the use of purposive sampling may have introduced potential response bias, especially concerning self-reported quality-of-life data. This bias could stem from individual subjectivity or social desirability effects. Future studies are encouraged to adopt stratified sampling techniques based on socioeconomic classifications to capture more nuanced variations in quality of life experiences across different community groups.

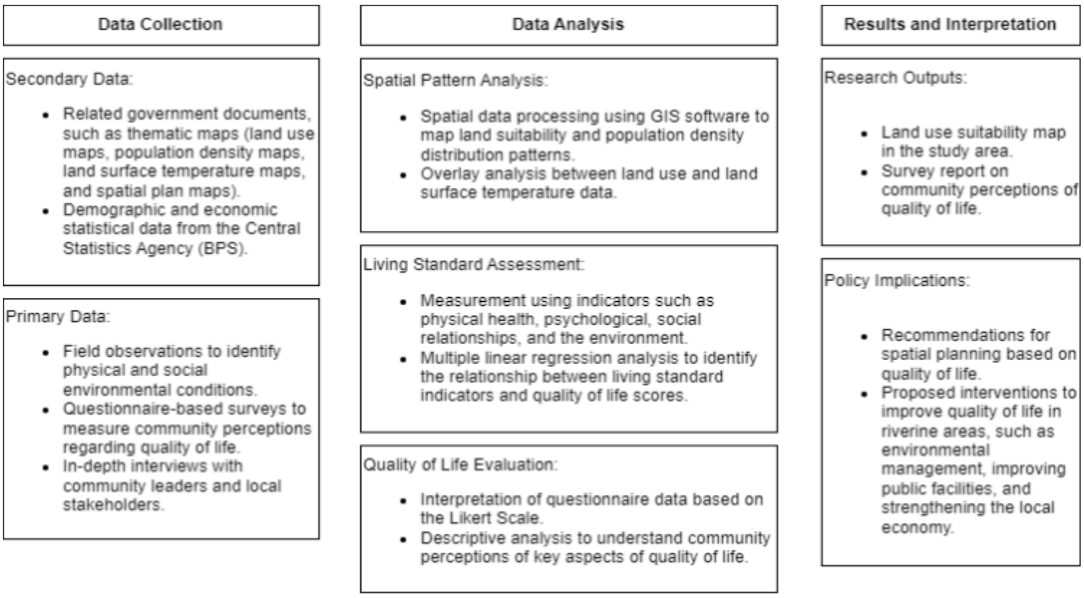

Figure 3. Research framework

2.3 Spatial patterns (land-use) analysis

Urban land use is a complex process involving interactions of various factors, including natural or biophysical conditions, socioeconomic elements, infrastructure, accessibility, spatial planning policies, and environmental concerns [24]. The assessment measures how appropriate a specific land area is for a particular use [25]. Land-use suitability is affected by proximity to essential human needs (Table 1). The closeness of resident's houses to these driving factors can significantly influence land use decisions [26]. Accessibility to the river is not included in this study, as residents do not rely on rivers as a source of clean water.

Relevant spatial planning documents of Malang City determine a 15 meter buffer zone along riverbanks for environmental and risk prevention concerns. This requirement reduces the spatial suitability value as the proximity of buildings to rivers increases [27]. The following Table 1 explains the spatial suitability of each component indicator, providing a comprehensive view of each aspect. Based on frequency distribution for each class interval, the assessment uses a scale of 1 (very low) to 5 (very high), from low to high suitability.

The spatial suitability analysis was conducted using a GIS-based overlay method, incorporating five spatial indicators: proximity to riverbanks, arterial roads, government centres, commercial centres, and healthcare facilities. These variables were each assigned equal weight due to their shared importance in determining urban spatial functionality and accessibility.

Table 1. Description of spatial patterns suitability indicator

No.	Variable	Suitability Criteria	Legal Basis and References
1	Distance to River	The closer to the riverbank, the lower the suitability score due to increased disaster risk.	Minister of Public Works and Housing of the Republic of Indonesia Regulation No. 28/PRT/M/2015 (Minimum riverbank distance of 3 meters in urban areas) [17, 28].
2	Distance to Arterial Road	The closer to arterial roads, the higher the suitability score due to improved accessibility.	Law of the Republic of Indonesia No. 2 of 2022 on Roads (Arterial roads serve as major transportation routes) [29, 30].
3	Distance to Government Center	The closer to government centres, the higher the suitability score as it facilitates access to services.	Indonesian National Standard (SNI) 03-1733-2004 (Provision of government centres considers service radius coverage) [31].
4	Distance to Commercial Center	The closer to commercial centres, the higher the suitability score as it supports social interaction.	SNI 03-1733-2004 (Provision of commercial centres considers service radius for residents) [31, 32].
5	Distance to Healthcare Facility	The closer to healthcare facilities, the higher the score for access to health services.	SNI 03-1733-2004 (Provision of healthcare facilities with a minimum radius of 1 km for health posts, 1.5 km for auxiliary health centres, and 3 km for community health centres) [31, 33].

2.4 Living standards assessments

Living Standards refer to the level of living considered as the minimum required to meet basic human needs and reflect the daily life patterns of society [34]. Sabina Alkire and Maria Emma Santos introduced the theory of living standards by publishing the Multidimensional Poverty Index (MPI) [35]. This publication identified three dimensions: health, education, and living standards [36]. In 2018, the SDGs [37] revised the living standards indicator within the MPI. Table 2 explains the living standards for each component indicator to provide a comprehensive view of its aspects. A scoring system of 1 (very bad) to 5 (very good) for each criterion fulfilment indicates the level of compliance from non-compliance to full compliance.

Table 2. Living standards indicators

No.	Variable	Criteria for Meeting Standards	Legal Basis and References
1	Cooking Fuel	Acceptable cooking fuel types comprise 3kg LPG, 12kg LPG, natural gas, or electric power (induction).	Minister of Energy and Mineral Resources of the Republic of Indonesia Regulation No. 28/2021 [38, 39].
2	Sanitation	It has independent sanitation facilities (not shared) and uses septic tanks, soak pits, or piping systems.	SNI 03-1733-2004 (Wastewater volume) [31]; Minister of Public Works and Housing of the Republic of Indonesia Regulation No. 29/PRT/M/2018 [40].
3	Drinking Water	Has access to clean drinking water from wells, drilled wells, HIPPAM (Association of Drinking Water Users), or PDAM (Municipal Waterworks) within a 30-minute walk.	Minister of Public Works of the Republic of Indonesia Regulation No. 18/PRT/M/2007 [41]; Minister of Public Works and Housing of the Republic of Indonesia Regulation No. 29/PRT/M/2018 [40].
4	Electricity	Has access to electricity with a minimum power of 450 watts, increased to 900 watts, 1300 watts, or renewable energy.	Minister of Housing and Urban Development of the Republic of Indonesia Regulation No. 22/Permen/M/2008 [42]; Presidential of the Republic of Indonesia Regulation No. 112/2022 [43].
5	Housing	Housing materials comprise floors (vinyl, ceramic), roofs (zinc, asbestos, tiles), and walls (brick, concrete blocks).	[44, 45].
6	Assets	Asset ownership (at least one) comprises radio, TV, telephone, computer, motorcycle, or refrigerator.	Types of Assets Included in the Non-Building Tangible Assets Group for Depreciation Purposes in the Regulation of the Minister of Finance of the Republic of Indonesia Number 96/PMK.03/2009 [46].

2.5 Quality of life evaluation

According to the World Health Organization (WHO), quality of life is the subjective assessment of an individual's position in life, influenced by cultural contexts and the values surrounding them. This assessment includes their perspectives on life goals, expectations, standards, and concerns [47]. Physical health, psychological conditions, levels of independence, social relationships, personal beliefs, and environmental interactions all influence quality of life. While often referred to as well-being [48], quality of life is more closely associated with an individual's subjective evaluation of their life, whereas well-being refers to the objective conditions of life that apply to populations in general. Quality of life or well-being consists of subjective components, including personal assessments using scales such as satisfaction or happiness, and objective components, which others can measure. The indicators below describes the quality of life in society across each element and dimension.

2.5.1 Physical health dimension

(1) Activities of daily living: It assesses individuals' abilities to perform daily tasks independently, including self-care and property management, and their dependence on assistance. Still, it excludes other factors like fatigue, sleep issues, depression, and family support [47, 49].
(2) Dependence on medicinal substances and medical aids: It explores reliance on traditional or alternative medicine (e.g., acupuncture, herbal remedies) and medical aids. It also considers both positive and negative impacts on daily life. Specific drug types are not discussed [47, 50].
(3) Energy and fatigue: It examines individual energy levels and resilience in daily tasks and recreation, excluding social impact and reliance on others due to fatigue [47, 51].
(4) Mobility: Evaluates the ability to move independently, with or without aids. Excludes sudden vs. gradual mobility changes and physical transport options (e.g., cars, buses) [47, 52].
(5) Pain and discomfort: Assesses pain experiences and management ease, emphasizing minimal life disruption but excludes non-physical pain experiences or social impact [47, 53].
(6) Sleep and rest: It considers sleep quality and rest's impact on life quality, covering common issues like difficulty falling asleep and excluding topics like early rising or using sleep medication [47, 54].
(7) Work capacity: It evaluates energy usage in main activities (e.g., paid work, childcare), excluding perception or workplace quality [47, 55].

2.5.2 Psychological dimension

(1) Body image and appearance: It assesses self-perception and body satisfaction, including external responses [47]. It supports honest responses across diverse body image conditions [47, 56].
(2) Negative feelings: It measures experiences of negative emotions (e.g., guilt, anxiety) and their impact on daily functions. It excludes severity level evaluation [47, 57].
(3) Positive feelings: It explores positive emotions like happiness and future optimism, excluding negative feelings covered in another aspect [47, 58].
(4) Self-esteem: It evaluates self-view, confidence, and control, including social interactions, self-acceptance, and family relationships, excluding direct body image or social relationship references [47, 59].
(5) Spirituality/religion/personal beliefs: It examines the role of personal beliefs in quality of life, including diverse religious and spiritual views. It aims to uncover the impact of belief on life's meaning and support [47, 60].
(6) Thinking and learning: It investigates cognitive abilities,

including learning and decision-making. It focuses on personal perception, acknowledging that some may be unaware of difficulties [47].

(7) Memory and concentration: It explores how well an individual can think clearly, learn new information, remember things, and focus their attention [47].

2.5.3 Social relationships dimension

(1) Personal relationships: It examines satisfaction and support in close relationships, including emotional and physical love that covers friendships, marriage, and various relationship types [47].

(2) Social support: It evaluates perceived support from family and friends, especially in crises. This evaluation includes positive and potentially negative roles that family and friends may play [47].

(3) Sexual activity: It assesses the desire, expression, and satisfaction of sexual needs, considering cultural perspectives on sexuality and its impact on life quality but excluding values-based judgments on sexuality [47].

2.5.4 Environment dimension

(1) Financial resources: Reviews financial management and adequacy to support a healthy and comfortable lifestyle. It emphasizes independence and satisfaction with financial resources [47].

(2) Freedom, physical safety, and security: It assesses perceived safety and freedom, covering potential threats and protective resources. Relevant to vulnerable groups and those in risky environments [47].

(3) Health and social care: accessibility and quality: It evaluates the accessibility and quality of health and social care services, including volunteer support. It excludes less relevant healthcare details [47].

(4) Home environment: It assesses the primary living environment's role, covering comfort, safety, cleanliness, privacy, and neighbourhood quality, including diverse living conditions (e.g., refugees and homeless) [47].

(5) Opportunities for acquiring new information and skills: It reviews interest and access to new knowledge, from formal education to stay informed on global news [47].

(6) Participation in and opportunities for recreation/leisure activities: It assesses ability and satisfaction with leisure activities, covering a range of entertainment and relaxation forms [47].

(7) Physical environment (pollution, noise, traffic, climate): It examines environmental factors (e.g., cleanliness, climate) impacting comfort, excluding home and transport considerations addressed elsewhere [47].

(8) Transport: It assesses access to and adequacy of transportation for daily life, excluding transport modes and personal mobility topics [47].

2.5.5 Assessment calculation

Quality of life assessment in this study was carried out using the WHOQOL-BREF, which produces four domain scores. These domain scores are scaled using a Likert scale of 1 (very bad) to 5 (very good) in a positive direction (i.e., higher scores indicate better quality of life). The calculation of the domain score used the average score for each item within a domain. The average score is then multiplied by 4 to align with the scores used in the WHOQOL-100 and subsequently converted to a 0-100 scale. The WHOQOL-100 guidelines [61] outlined the method for calculating the total score from individual questionnaires and the transformation of scores (Table 3) [47].

The calculation of the mean score used the results from the four domains, providing the data for assessing the community's quality of life. The Human Development Index (HDI) approach from the Statistics Central Body (BPS of Indonesia) interpreted the quality of life level, which classifies the assessment into four levels: poor (score < 60), moderate (60 ≤ score < 70), good (70 ≤ score < 80), and very good (score ≥ 80). The interval data presented the quality of life of the respondents.

Table 3. Quality of life assessment calculation

	Calculation of Scores for Each Domain	**Questionnaire Result Score**	**Transformation Score**
Physical Health	1.1 + 1.2 + 1.3 + 1.4 + 1.5 + 1.6 + 1.7	=	
Psychological	2.1 + 2.2 + 2.3 + 2.4 + 2.5 + 2.6	=	
Social Relationships	3.1 + 3.2 + 3.3	=	
Environment	4.1 + 4.2 + 4.3 + 4.4 + 4.5 + 4.6 + 4.7 + 4.8	=	

2.6 Relationship between spatial patterns suitability, living standards, and quality of life

Multiple linear regression analysis was selected in this study due to its suitability for assessing the direct relationships between independent variables and a single dependent variable (quality of life). Although structural equation modeling (SEM) could provide a more complex analysis of socio-environmental interactions, it typically requires a larger sample size and more intricate latent variable structures. Given the relatively modest sample size (n=90) and the study's focus on observable, measurable indicators, multiple linear regression offered a more parsimonious and statistically robust approach for this research context.

This regression analysis involves one or more independent variables and one dependent variable. Linear regression aims to model the linear relationship between the dependent and related independent variables. This analysis describes the relationship between variables with interval and ratio scales. The process involves constructing a linear equation that represents the relationship between two variables, known as the regression line. This line reflects the relationship between the two variables and illustrates the general pattern of the dependent variable (Y) concerning the independent or explanatory variable (X). In multiple linear regression, additional independent variables (X_1, X_2, ..., X_n) help accurately explain or predict the dependent variable (Y). The formula for multiple linear regression is as follows:

$$\mathrm{Y} = a + b_1X_1 + b_2X_2 + b_nX_n \tag{1}$$

Information:

Y = QoL (Dependent variable value prediction)

a = Constant term

b_1 to b_n = First to n^{th} regression coefficients

X_1 to X_n = First to n^{th} independent variable coefficient

This analysis shows the extent of influence each variable has. Table 4 shows the research variables, which are analyzed using SPSS.

Table 4. Research variables

Variable	Indicator
Quality of Life (Yqol)	Total score for physical health, psychological health, social relationships, and environment
Distance to River (Xsp_1)	Distance (meters) between the building and the riverbank
Distance to Arterial Road (Xsp_2)	Distance (meters) between the building and the national road
Distance to Government Center (Xsp_3)	Distance (meters) between the building and the sub-district office
Distance to Commercial Center (Xsp_4)	Distance (meters) between the building and the central market
Distance to Health Facility (Xsp_5)	Distance (meters) between the building and the health centre
Cooking Fuel (Xls_1)	Type of cooking fuel used
Sanitation Condition (Xls_2)	Ownership of sanitation facilities per building
Drinking Water (Xls_3)	Availability of drinking water access
Electricity (Xls_4)	Availability of electricity access
Housing Quality (Xls_5)	Material/components of floor, roof, and walls
Asset ownership (Xls_6)	Information asset ownership, mobilization, and support system

In this study, the output of this analysis will help understand how the alignment of the spatial patterns to land use regulation and the living standards influence the quality of life of the riverbank settlement. The analysis identifies the most influential factors related to spatial patterns and living standards in the study area. Based on the sample size with a desired margin of error of 10% and an accuracy level of 90%, the confidence level indicates that the interval contains valid parameter values. The accuracy level shows how close the predictions are to the actual values.

3. RESULT AND DISCUSSION

3.1 Spatial patterns suitability of Kotalama Riverbank Settlements, Malang City, Indonesia

The "intersect" tool in GIS conducted an overlay analysis, integrating five key factors: proximity to the river, arterial roads, government centres, commercial centres, and health facilities. The study showed (Figure 4) that areas with lower suitability scores, indicating spatial mismatch, were mainly concentrated in RW 10 and RW 11 due to their distance from critical services such as government offices, commercial areas, and health facilities. The analysis also revealed that settlements directly adjacent to the riverbank exhibited lower spatial suitability than those further inland.

The formal spatial plan designed the riverbank area in Kotalama for various land uses, including constructing inspection roads and flood control infrastructure. However, the existing land use data revealed inconsistencies, as conversion into built areas occurred in some protected area zones. Specifically, 2.9 hectares (27.6%) of the land area diverges from the designated land use plan. This result suggests a gap in the implementation of spatial planning.

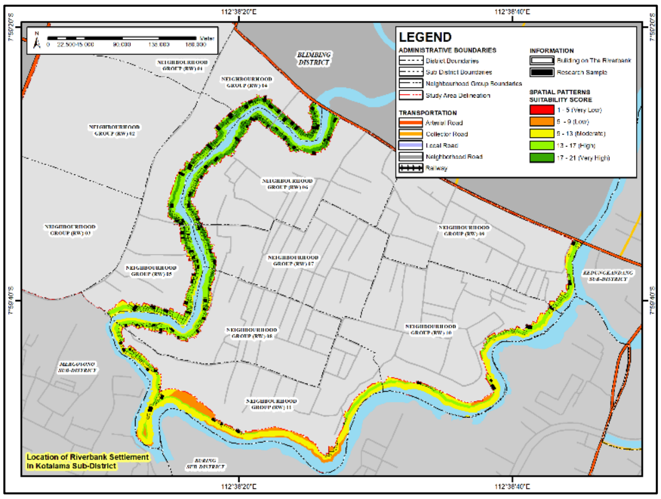

Figure 4. Spatial patterns suitability of riverbank settlement in Kotalama Sub-District map

Note: The spatial suitability scores range from 1 to 5, where 1 indicates very low suitability and 5 indicates very high suitability for residential development.

The spatial suitability scores are classified on a scale of 1 to 5, with 1 representing areas of very low residential suitability and 5 representing areas of very high residential suitability based on the weighted overlay analysis. The overlay analysis combined five factors using the Euclidean Distance tool in ArcGIS, which generated scores based on distances from buildings to critical features like the river, arterial roads, government offices, commercial centres, and health facilities. The results were categorized into five intervals ranging from 1 (very low) to 5 (very high), with the following factors analyzed:

- Proximity to the rivers. Most of the housing buildings in Kotalama are located near the Brantas and Amprong Rivers. Around 50% of the buildings are located between 3-9 meters, and 1.1% of the houses are between 0-3 meters from the river. This proximity increases the risk of landslides, flooding, and other environmental impacts.
- Proximity to arterial roads. Most buildings are located within 468 meters of the main arterial road (Muharto road). Approximately 49% of the buildings are in the "very close" to "sufficiently close" categories. This result indicates good access to transportation routes and enhanced connectivity.
- Proximity to the governmental center. The local government office, the Kotalama subdistrict office, is accessible (within 316 meters) to 46.7% of houses. This good access shows the ease of interaction with local administration and services, enhancing public participation and governance efficiency.
- Proximity to commercial centres. 83.3% of houses are located within 1,078 meters of Malang's primary market. This proximity facilitates economic activity, trade, and the availability of goods and services, positively influencing local economic development.
- Proximity to health facilities. The study found that 56.7% of the houses are more than 1,088 meters from the nearest community health centre. This access to healthcare services affects residents' ability to quickly access medical care, potentially compromising their overall quality of life.

This analysis, which combines geographic proximity to critical infrastructure with land use suitability, provides valuable insights into the spatial suitability and living standards in the Kotalama Riverbank Settlements. The findings highlight areas of concern, particularly regarding accessibility to health services and flood risks, while emphasizing the positive impacts of good connectivity to government and commercial centres on the local economy and governance.

3.2 Living standards of Kotalama Riverbank Settlements, Malang City, Indonesia

Living standards in Kotalama reveal critical aspects of daily life and the fulfilment of basic needs for the community around the Kotalama Riverbanks (Figure 5). Data indicate that most residents use LPG for cooking, with a small percentage utilizing natural gas in certain areas (RW 04). Sanitation infrastructure is mostly in place, with the majority having individual septic tanks, though a small portion relies on communal facilities. Access to drinking water is well-provided by the Local Water Enterprise (PDAM) network, and electricity is available in all households, with 80% using 450 watts and 20% using 900 watts.

Housing quality varies, with most homes having ceramic tile floors and tile roofs. However, some houses still use less suitable materials, such as having no flooring material and using zinc for roofing. All homes have brick walls, yet some do not have reinforced concrete frames.

Asset ownership is diverse, with most households having essential communication and transportation tools. These discrepancies suggest that most of the respondents have met their basic needs. However, access to resources and the safety of house construction need to improve. Addressing these issues would support community welfare, especially for those living along the Brantas and Amprong Riverbanks.

3.3 Quality of life of Kotalama Riverbank Settlements, Malang City, Indonesia

The findings of the community's perception revealed that residents living along the riverbank generally exhibit a good quality of life (Figure 6). Among all RWs, physical health and environmental dimensions were notably low.

Figure 5. Distribution of living standards assessments

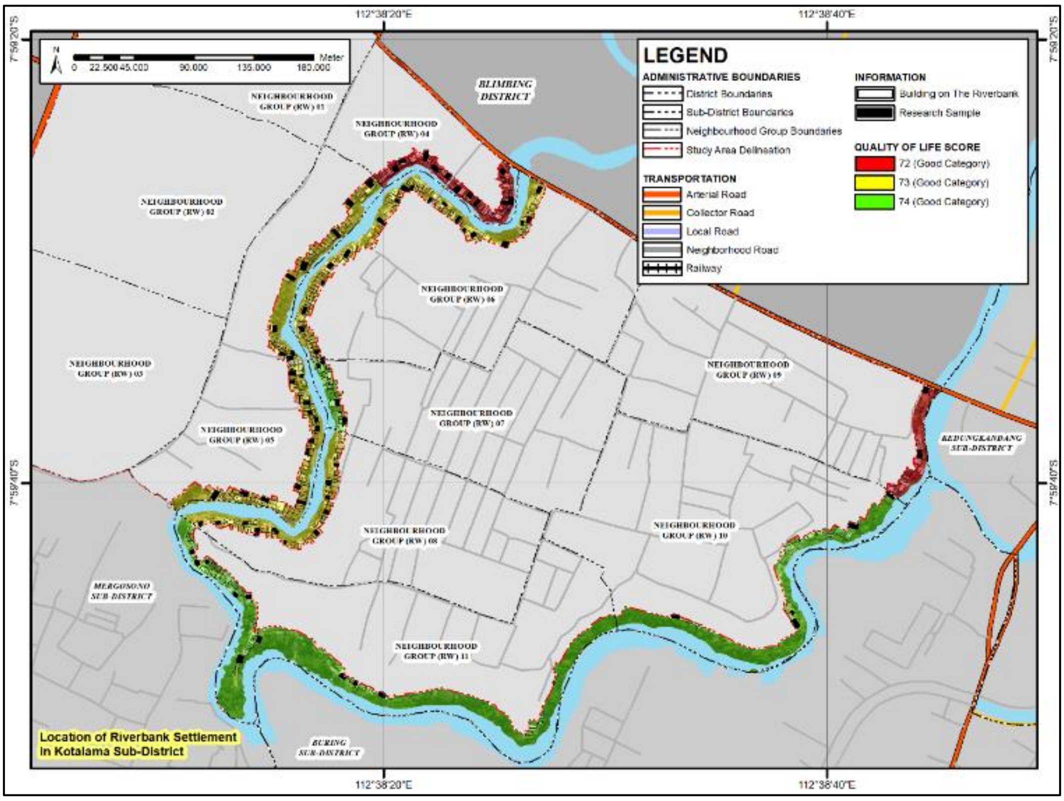

Figure 6. Quality of life of riverbank settlement in Kotalama Sub-District map

The lowest scores in RW 04 and RW 09 were attributed to their proximity to major arterial roads. These neighbourhoods scored particularly low in environmental factors, indicating that although accessibility to services and facilities is high, the physical environment does not adequately support the quality of life. Notably, some houses do not meet housing standard criteria. Moreover, the poorly maintained environmental conditions could increase perceived risks to residents' safety and well-being. On the other hand, RW 07, RW 10, and RW 11 had the highest scores, attributed to their location in the central residential zones of Kotalama. These areas were firm in the social dimension, with an average length of residence exceeding 35 years. This finding shows that residents in these neighbourhoods experienced social bonding with strong emotional support from family and neighbours. The long-term commitment to these neighbourhoods likely fosters a sense of community and belonging, positively influencing individual happiness and overall quality of life.

The survey results indicated that most indicators fall within the "good" to "very good" categories. However, areas such as recreational opportunities, mobility, and management of discomfort and pain require further attention (Figure 7). Addressing these aspects would likely contribute to a further improvement in the quality of life for residents of Kotalama.

Improving these factors through targeted interventions, such as enhancing public spaces and accessibility, could provide a more sustainable solution than large-scale displacement. The findings of the quality of life analysis provide valuable insights that if the residents' quality of life is the ultimate objective of the development, then it can be suggested that relocation, as recommended by the Ministry of Housing and Public Works of The Republic of Indonesia Regulation No 2 of 2016 [62], is unnecessary.

3.4 Linear regression analysis

This study assesses how factors related to spatial conformity and living standards influence the quality of life. The analysis includes the following tests: the coefficient of determination, F-test (ANOVA), and T-test, to validate the extent and significance of these relationships.

3.4.1 Coefficient of determination (R Square)

This test determines how much the independent variables collectively explain the variance in the quality of life. Table 5 summarises the result.

The study's adjusted R-squared value of 0.442 indicates that spatial and socioeconomic factors collectively explain 44% of the variation in quality of life, while 56% is due to other variables. Key factors significantly affecting quality of life include proximity to the river, house quality, and asset ownership. Proximity to the river negatively impacts the quality of life, while improved house quality and asset ownership positively impact the quality of life.

Table 5. Model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.665	0.442	0.371	192.519	2.292

3.4.2 F-test (ANOVA)

The F-test assesses the joint significance of all independent variables in predicting quality of life. Table 6 shows the results:

Table 6. Anova test

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	231.697	10	23.170	6.251	0.000
Residual	292.803	79	3.706		
Total	524.500	89			

With a significance value of $p < 0.05$ (0.000), the test indicates that the independent variables collectively significantly affect the quality of life. This result implies that spatial conformity and living standards contribute meaningfully to predicting quality of life.

3.4.3 T-test for individual variables

The T-test assesses the significance of each independent variable individually. Table 7 provides details on coefficients, significance levels, and multicollinearity diagnostics.

An F-test result of 0.000 confirms that the model's independent variables significantly impact the quality of life when assessed simultaneously. However, in the T-test, only proximity to the river, home quality, and asset ownership have a statistically significant partial impact on quality of life. Distance to river, housing quality, and asset ownership contribute significantly ($p < 0.05$) to quality of life. Positive coefficients for these variables suggest that greater values (e.g., increased distance from the river) correlate with higher quality of life, potentially due to reduced flood risk or discomfort from close river proximity. This finding aligns with previous studies emphasizing the negative externalities of riverbank settlements, particularly in terms of environmental and health risks. Besides, variables such as distance to arterial roads, distance to government centres, and electricity show no statistically significant relationship with the community's quality of life in the study area. This is understandable because the distance between the settlement, arterial roads, and government centres is relatively the same. Electricity is not a significant variable since all community houses are connected to an electricity power network. Each house also has its own sanitation.

Table 7. Coefficients

Variable	B (Unstan-Dardized Coeff.)	Std. Error	t	Sig.
Constant	64.754	4.329	14.959	0.000
Distance to river (Xsp_1)	0.047	0.007	6.400	0.000
Distance to an arterial road (Xsp_2)	-0.023	0.018	-1.274	0.206
Distance to government offices (Xsp_3)	-0.005	0.017	-0.312	0.756
Distance to trade centre (Xsp_4)	0.025	0.017	1.536	0.129
Distance to health facilities (Xsp_5)	0.027	0.021	1.337	0.185
Cooking fuel type (Xls_1)	0.000	0.042	-0.009	0.992
Sanitation condition (Xls_2)	0.023	0.037	0.616	0.540
Electricity (Xls_4)	-0.030	0.023	-1.278	0.205
Housing quality (Xls_5)	0.028	0.009	3.228	0.002
Asset ownership (Xls_6)	0.015	0.007	2.132	0.036

Regression coefficients indicate that a 1-unit increase in proximity to the river, home quality, or asset ownership leads to proportional changes in quality of life. Diagnostic tests confirm the model's assumptions of normality, absence of multicollinearity, and homoscedasticity. Model validation through a simulation reveals an average deviation of 4.32%, suggesting the regression model is a reliable predictor of quality of life.

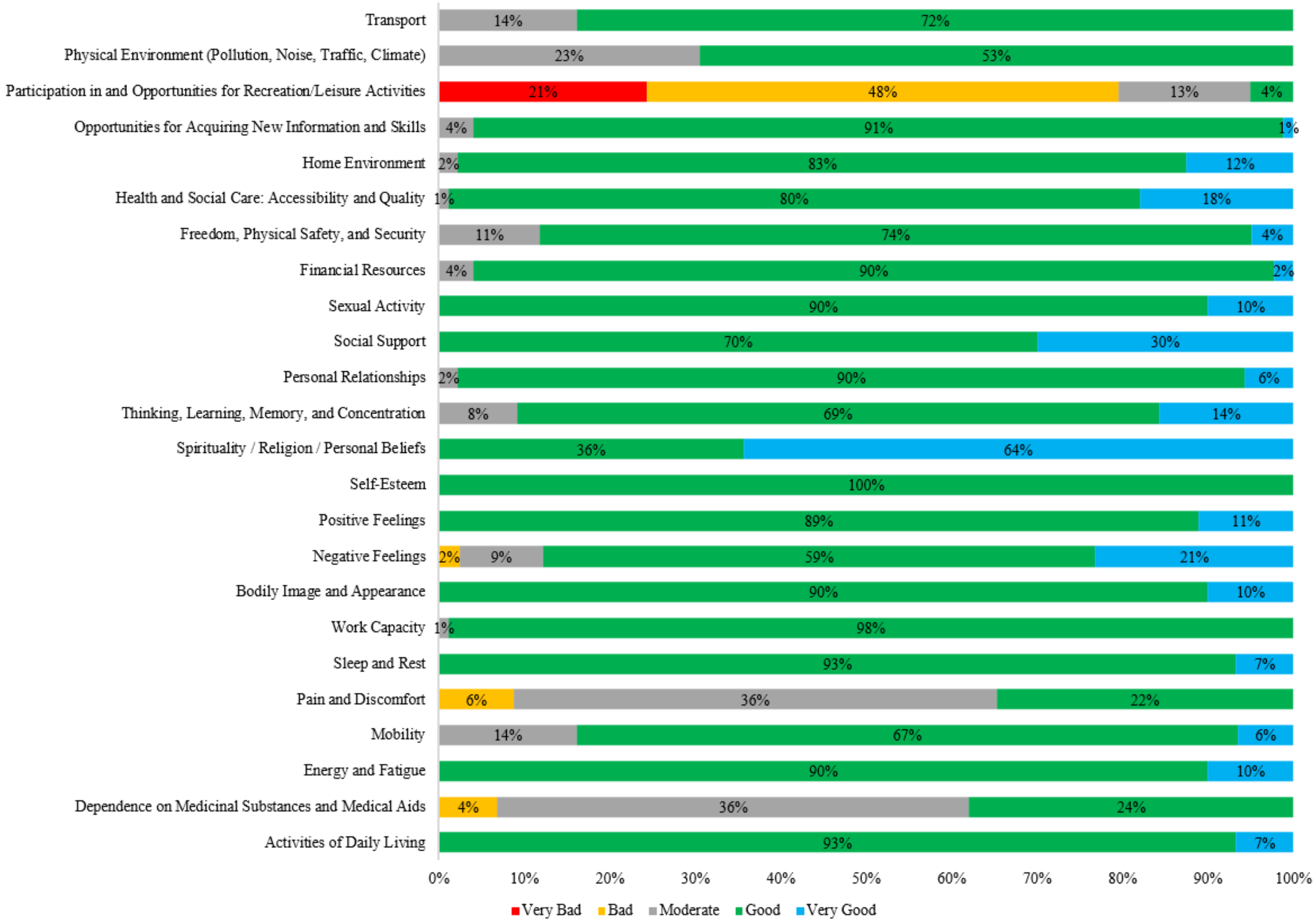

Figure 7. Distribution of community's quality of life evaluation

3.4.4 Uniform service provision and its impact on variable significance

The variable reduction process identifies three significant variables from the initial eleven hypothesized variables. This was achieved through T-tests, which revealed that only variables distance to river, housing quality, and asset ownership had a statistically significant relationship with the dependent variable.

Meanwhile, other variables are insignificant because they can be caused by the following things based on field observations. The variable "distance" was found to have negligible variation within clusters, with differences of only several meters, which is considered practically insignificant in this context. Similarly, access-related variables were excluded as they demonstrated uniformity across the study area, reflecting consistent resource accessibility. These findings underscore the importance of focusing on variables with distinct impacts while recognizing the role of local conditions in shaping the results. The implications of this reduction highlight the need for tailored interventions that address the most influential factors, particularly in areas where homogeneity minimizes the effect of other variables.

Due to their uniformity across the study area, the regression analysis model did not include other variables, such as cooking fuel type, sanitation condition, and electricity. In terms of cooking fuel, all households utilize 3kg LPG gas cylinders, as the Indonesian government mandates, to support low-income families with subsidized gas. This ensures equal access to adequate cooking fuel for all residents, eliminating any significant variability or gap. Similarly, sanitation conditions were consistent, with all households using private septic tanks that meet standard requirements, indicating uniformly acceptable sanitation across the population. Every household is connected to the State-Owned Electricity Network (PLN of Indonesia) for electricity, fulfilling the government's goal of providing affordable and reliable electricity access to low-income communities. This widespread availability leaves no discernible differences among the households in these variables.

On the other side, the variable of drinking water was also excluded from the regression analysis due to uniform access provided by the Regional Water Supply Company (PDAM of Indonesia). All households in the study area are connected to the PDAM network, ensuring an adequate and equitable clean water supply. This achievement aligns with the PDAM's objective to expand service accessibility, particularly for low-income populations. As a result, no significant gaps or differences in drinking water access were observed across the study area, further supporting its exclusion as a variable in the analysis.

The statistical insignificance of variables can be attributed to the limited variability in these conditions across the surveyed population. Since nearly all respondents had consistent access to these basic services, such as the existence of electricity and sanitation networks that have been connected and owned by every existing house, their influence on variations in perceived quality of life could not be effectively captured by the regression model. Nevertheless, the uniform provision of such basic utilities remains crucial for supporting overall living standards, even if their effect is not statistically distinguishable in this particular study context.

3.4.5 Model validation: Normality and homoscedasticity diagnostics

The regression model's validity and assumptions were assessed using graphical diagnostic tools, focusing on normality and homoscedasticity of residuals (Figure 8).

The Normal P-P Plot of Regression Standardized Residuals illustrates the distribution of residuals relative to the expected normal distribution. The points closely follow the diagonal line, with minor deviations, indicating that the residuals approximate a normal distribution. This supports the assumption of normality, which is critical for the reliability of statistical inferences in regression analysis.

The Scatterplot of Regression Standardized Residuals vs Predicted Values evaluates homoscedasticity or the constancy of residual variance across predicted values. The residuals appear randomly scattered around the horizontal axis (zero) without any discernible pattern. This randomness suggests that the assumption of homoscedasticity is satisfied, meaning that the variance of errors remains consistent regardless of the level of predicted values.

Together, these diagnostic results confirm that the regression model satisfies the key assumptions of normality and homoscedasticity, ensuring the robustness of the conclusions drawn from the analysis. This validates the model's ability to reliably capture the relationship between spatial conformity, living standards, and community quality of life.

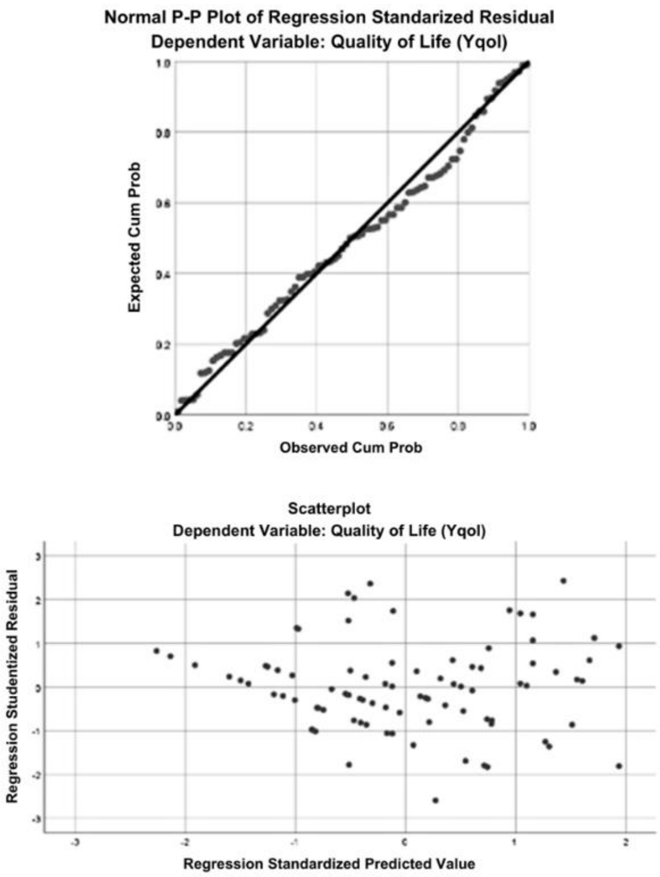

Figure 8. Normal P-P plot and scatterplot of regression

3.4.6 Regression model

The regression model developed in this study aims to measure the influence of spatial conformity and living standards, such as housing quality and asset ownership, on community quality of life. The resulting linear regression model is as follows:

$$Y\text{qol} = 63.574 + 0.047\, X\text{sp}_1 + 0.028\, X\text{ls}_5 + 0.015\, X\text{ls}_6 \quad (2)$$

Interpretation of the Regression Model:

- Constant value (a = 64.754): The constant of 64.754 indicates that if all independent variables are assumed to be zero, the predicted quality of life (Y) for the community is 64.754 (moderate). This serves as the baseline quality of life when there is no influence from spatial conformity and living standards.
- The regression coefficient of the spatial conformity variable (Xsp_1): The regression coefficient of 0.047 for spatial conformity regarding distance to the river (Xsp_1) suggests that a one-unit increase in this variable will raise the community's quality of life by 0.047. This indicates that increased spatial conformity, specifically regarding proximity to the river, is associated with higher community quality of life.
- The regression coefficient of the living standards variable - housing quality (Xls_5): The regression coefficient of 0.028 for living standards in terms of housing quality (Xls_5) implies that a one-unit increase in this variable will increase the community's quality of life by 0.028. This highlights that higher housing quality contributes positively to the quality of life.
- The regression coefficient of the living standards variable - asset ownership (Xls_6): The regression coefficient of 0.015 for living standards in terms of asset ownership (Xls_6) suggests that a one-unit increase in asset ownership will increase the community's quality of life by 0.015. This indicates that the more assets individuals own, the better the quality of life.

This regression model shows that spatial conformity and living standards regarding housing quality and asset ownership positively influence community quality of life. This finding conforms to the quality of life assessment at the previous processes, i.e., the community's quality of life is at least in the "moderate" category, even if all independent variables' scores are minimum. This finding is also interesting since the community perceives their quality of life as being 'good' to 'very good', although common perception considers their quality of life deprived.

3.5 Strategizing for urban resilience

Based on the regression analysis, strategizing for urban resilience can be developed to support Sustainable Policy Planning, aligning with the SDG 11: "Make cities and human settlements inclusive, safe, resilient, and sustainable." The analysis indicates that enhancing spatial suitability and living standards, specifically through housing quality and asset ownership, positively impacts the quality of life. Therefore, policy planning should prioritize urban design and housing improvements that promote safe, accessible, and environmentally harmonious living spaces [63].

First, policymakers should strengthen zoning regulations to protect rivers and prevent urban sprawl [64]. Integrating green spaces and enhancing river accessibility can promote urban resilience, foster community well-being, and contribute to climate adaptation efforts, meeting SDG 11 targets for inclusive and sustainable urbanization [65].

Second, investment in housing quality is crucial. governments must invest in energy-efficient, disaster-resilient housing accessible to diverse socioeconomic groups [66]. Incentives for retrofitting older homes with sustainable materials and energy-efficient systems would support low-income families, improve public health, and reduce urban energy demands [67].

Third, enhancing asset ownership opportunities for low-income households can provide economic stability and promote social inclusion [68]. Asset-building programs, including homeownership grants and access to microfinance, can help families accumulate wealth, reduce inequality, and contribute to urban stability [69].

These policy recommendations are consistent with SDG 11, focusing on sustainable urban development that addresses urban life's economic, social, and environmental dimensions. Collectively, these initiatives can create more livable, resilient, and equitable cities, fostering a higher quality of life and supporting the broader SDGs.

This study finds that housing quality and asset ownership significantly influence quality of life, aligning with previous research on urban poverty and spatial planning. However, recent global studies emphasize the critical role of social capital and community cohesion in enhancing urban resilience and well-being. Research in Ho Chi Minh City, Vietnam, highlights how bridging and bonding social capital improve community problem-solving and resource access [70]. Similarly, Chen et al. [71] demonstrate that social cohesion and collective efficacy in Nanjing, China, significantly enhance resilience in flood-prone areas. Baldwin and King [72] based on case studies from 14 countries, argue that strong social networks often outweigh physical infrastructure in sustaining community resilience. In Bandung City, Indonesia, Setiawan and Ningtyas [73] found that while green spaces and housing conditions matter, robust social networks are pivotal in promoting community development and enhancing quality of life.

Beyond these findings, broader research on housing and quality of life reveals complex relationships between various physical and social factors. Housing quality and asset ownership significantly influence quality of life, particularly in riverbank settlements prone to flooding and lacking infrastructure [74]. Social capital also plays a role, with studies in Delhi and Tehran showing strong correlations between social capital indicators and quality of life, although the specific predictors vary between cities [75]. Housing affordability is closely linked to quality of life, with better affordability associated with higher quality education, healthcare, and stability [76]. The importance of cultural diversity, environmental conservation, and alternative building techniques in housing and urban design is also highlighted [77].

These findings underscore the multifaceted nature of quality of life in urban settings, emphasizing the need for comprehensive approaches to housing and community development that consider both physical and social factors. These differences suggest that although improvements in housing quality and asset ownership are essential, integrating strategies to strengthen social cohesion could provide a more comprehensive approach to improving quality of life and resilience in riverside settlements.

3.6 Policy context in integrating research findings into urban planning

This study provides important insights into the relationship between spatial suitability, living standards, and quality of life, which can be integrated into existing urban planning policies. By leveraging these findings, planning policies can be developed to focus not only on economic growth but also on the sustainability and resilience of urban communities.

3.6.1 Integration into urban spatial plans

The recommendations from this study should be considered as a critical component in developing or revising urban spatial plans. This integration covers several key aspects:

1. **Zoning and Land Use:** Reorganizing zoning to ensure that land use is in line with environmental sustainability needs and reducing the risk of natural disasters. Hasyim et al. [78] highlight the necessity of integrating mitigation measures into urban planning to address the challenges posed by urban densification and climate change. Hasyim et al. [79] advocate for a comprehensive flood risk assessment framework that incorporates socio-economic factors and environmental conditions to improve urban infrastructure resilience in cities like Malang, Indonesia. Globally, the trend of urban expansion into flood-prone areas necessitates a reevaluation of land use policies. Urban growth significantly increases flood risk by altering land use and hydrological processes, especially through the expansion of impervious surfaces that reduce water absorption and raise surface runoff in cities like Kunming and Zhengzhou [80, 81]. Studies in Doha, Zhengzhou, and Kathmandu show that rapid urbanization, combined with inadequate infrastructure, has substantially heightened these cities' vulnerability to flooding [82-84].
2. **Sustainable Infrastructure:** Encouraging the development of infrastructure that supports low-emission mobility, such as pedestrian and bicycle paths, and public facilities that are accessible to all. Gore et al. [85] found that the implementation of bicycle and pedestrian paths at the census tract level could significantly enhance health benefits by encouraging more active commuting behaviors. This is supported by the work of Cheng and Liu [86], who proposed an integrated model for evaluating infrastructure sustainability, highlighting the importance of accessibility in sustainable development.
3. **Inclusive Urban Design:** Providing safe and inclusive public spaces that promote social interaction and community integration, such as public parks, safe play areas, and community centers. Francis et al. [87] found that public spaces contribute to a stronger sense of community by providing venues for social gatherings and recreational activities. Additionally, Zalloom [88] highlighted that access to parks is associated with better health outcomes, emphasizing the importance of integrating green spaces into urban planning. Hassanain and Al-Suwaiti [89] examined the development of community centers in Jeddah, Saudi Arabia, noting their historical significance in promoting social interaction and community engagement.

3.6.2 Financing policies

Advocating for specific budget allocations to support these policies is a vital step. Some financing strategies that can be adopted include:

1. **Government Budget:** Ensuring that a portion of the city's development budget is allocated to projects that support sustainable development and resilient infrastructure. This could include funds to retrofit older housing to make it safer and more energy efficient. Javid analysis in Pakistan, highlights the importance of public investment in creating better infrastructure conducive to private sector activity, which ultimately supports economic development [90]. Monstadt and Schmidt emphasize that sufficient financial resources and planning authority are critical for effective infrastructure governance, particularly in the context of urban resilience in German cities [91]. Abdulaal [92] explored how public-private partnerships in regenerating unplanned settlements in jeddah, highlighting the potential for collaborative approaches to address infrastructure deficits [92].
2. **Public-Private Partnerships:** Seeking partnerships with the private sector to finance sustainable infrastructure projects. This could be through fiscal incentives or revenue-sharing models that attract private investment in social housing or green infrastructure projects. Buso and Greco discuss how public-private partnerships can optimize resource allocation under financial constraints, emphasizing the importance of creating value for taxpayers while addressing public needs Buso and Greco [93]. Li et al. [94] emphasize that incorporating ESG factors into public-private partnership projects can yield competitive economic returns while also delivering favorable societal outcomes. Arimoro [95] discusses how creating an enabling environment for private sector participation can stimulate investment in infrastructure, particularly in emerging economies. This includes establishing clear legal frameworks and providing fiscal incentives that make public-private partnership attractive to private investors.
3. **International Funds:** Accessing funds and grants from international organizations that focus on disaster risk reduction, sustainable development and climate change. These funds can be used for pilot projects or innovative initiatives that can serve as models for broader policy. Delicado et al. [96] highlight the role of children and education in disaster risk reduction policies in Portugal, suggesting that international funding can support educational initiatives that empower communities to engage in disaster preparedness. This approach is echoed in the work of Tozier de La Poterie and Baudoin [97], who advocate for integrating disaster risk reduction with climate change adaptation in development activities, a strategy that can be supported through international funding.
4. **Green Bond Fundraising:** Issuing green bonds that can help finance sustainable infrastructure projects in the city, such as improved drainage systems and the construction of environmentally friendly housing. Fatica and Panzica highlight that green bonds signal a commitment to climate-friendly practices, which can enhance a company's reputation and attract further investment Fatica and Panzica [98]. Liaw's [99] survey indicates that the attractiveness of green bonds is driven by the urgent need to finance climate and environmental solutions, suggesting that standardization and high disclosure standards are necessary to unlock their full potential. Huang et al. [100] provide evidence that green finance, including green bonds, can stimulate economic growth by financing projects that contribute to sustainability goals. Shah et al. [101] discuss how green bonds can be instrumental in achieving the Paris Agreement and the SDGs by directing funds toward eco-friendly projects. Baştürk [102] emphasize that promoting green bonds can help redirect financial resources toward low-carbon projects, thereby supporting climate change mitigation efforts.

By integrating the research recommendations into effective spatial planning and budget allocation, city governments worldwide can develop policies that not only support economic growth but also improve the quality of life, resilience, and sustainability of the urban environment. This approach will ensure that urban development is harmonious and inclusive, providing long-term benefits for the entire community. Such policies could serve as a model for global urban development strategies, encouraging cities around the world to adopt similar measures that prioritize sustainable and inclusive growth. This global perspective reinforces the relevance of our findings and demonstrates their applicability in diverse urban settings, thereby broadening the impact and significance of our study.

4. CONCLUSION

This study has examined the interaction between spatial suitability, standard of living, and quality of life in the riverside settlement of Kotalama, Malang City. Through linear regression analysis conducted, it was found that distance from the river, housing quality, and asset ownership have a significant positive relationship to improving quality of life. Specifically, the developed regression model shows that each unit increase in distance from the river (Xsp1) increases the quality of life score (Yqol) by 0.047 points, while improvements in housing quality (Xls5) and asset ownership (Xls6) increase the score by 0.028 and 0.015 points respectively.

These results underscore the importance of spatial planning that takes into account socio-economic and environmental factors to improve quality of life. The implementation of policy recommendations based on the results of this study supports the achievement of SDG 11, which focuses on building inclusive, safe, resilient, and sustainable cities and communities. Furthermore, this study highlights the importance of paying attention to environmental sustainability and resilience in dealing with natural risks such as floods and erosion.

However, there are limitations to this study including the limited geographic coverage and the potential for local variability not to be fully captured. Further research is needed to verify these findings in other locations and using methodologies that can integrate more environmental and social variables.

Future research directions could involve the development of more complex predictive models to assess the impact of urban planning policies on quality of life, including broader socioeconomic factors. This is important to provide a stronger basis for policymakers in designing effective and sustainable interventions.

This conclusion not only summarizes the results of the study but also highlights the practical applications of the findings in the broader context of urban planning. By addressing the limitations and suggestions for future research, this study makes an important contribution to the literature on sustainable urban planning and offers new insights for improving urban planning practices that support the SDG goals.

While this study provides valuable insights into the influence of spatial suitability and living standards on quality of life in riverbank settlements, certain limitations must be acknowledged. The research focused primarily on physical and economic variables, with limited incorporation of social dimensions such as community resilience and land tenure security. These factors are recognized as critical in shaping long-term urban sustainability and social well-being, particularly in informal or marginalized settlements. Future studies should integrate measures of community resilience, collective action capacity, and security of land tenure to develop a more comprehensive understanding of the dynamics influencing quality of life in similar urban contexts.

ACKNOWLEDGMENT

We want to thank all parties who have contributed to the preparation of this research. We want to thank Brawijaya University for supporting the implementation of this research project by providing financial grant support so that we can participate in Research Funding for Professors in 2024 (Grant No.: 16/UN10.F07/PN/2024).

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