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Regional Case Study

Development of Environmental Management Strategies for Slums in Southwest Aceh Regency

Cut Zulfa Husna[1]*, Andrea Emma Pravitasari[2,3], Andi Syah Putra[3], Nisa Latifa[4]

[1] Regional Planning Science Study Program, Department of Soil Science and Land Resources, Faculty of Agriculture, Jalan Raya Bogor Darmaga, IPB University, Bogor, Indonesia 16680

[2] Division of Regional Development Planning, Department of Soil Science and Land Resources, Faculty of Agriculture, Jalan Raya Bogor Darmaga, IPB University, Bogor, Indonesia 16680

[3] Center for Regional, Systems, Analysis, Planning, and Development (CRESTPENT), IPB University, Jalan Pajajaran, IPB Baranangsiang, Bogor, Indonesia 16144

[4] Laboratory of Regional Planning, Graduate School of Global Environmental Studies, Kyoto University, Japan 606-8501

* Corresponding Author, email: cutzulfa@apps.ipb.ac.id

Abstract

Slums represent a complex issue found in various regions, including Southwest Aceh Regency, caused by poor management and inadequate settlement planning. This study analyzes the spatial patterns of slum areas in Southwest Aceh Regency and proposes management strategies. The research utilizes Moran's Index analysis and LISA to identify spatial clustering patterns of slum areas, complemented by SWOT analysis to determine suitable environmental management strategies. Moran's Index analysis of slums in Southwest Aceh Regency for 2014 and 2020 reveals a positive spatial autocorrelation with clustered pattern, but less concentration in 2020. LISA analysis shows the spatial distribution of slum areas in 2014 showed high-high (HH) clusters concentrated along coastal and mid-district regions, while in 2020, clustering shifted and became concentrated in the regency capital. Overall, the distribution of slums in 2020 appears more dispersed. The primary environmental management strategy recommended for slum upgrading in Southwest Aceh Regency a Defensive Strategy. This involves strengthening stakeholder collaboration to improve sanitation infrastructure, thereby mitigating disaster risks such as flooding; reorganizing residential areas to accommodate urbanization while attracting developers; and educating the community to enhance compliance with environmental regulations. Additionally, maintaining financing programs despite potential budget reductions is critical to ensuring sustainable living conditions.

Keywords: Environmental management strategy; LISA; Moran's index; slums, regional development

1. Introduction

Slums, as a complex urban and rural phenomenon, have become a significant concern in regional development. This issue generally arises from rapid population growth, particularly in urban and rural areas, which sets immense pressure on land availability for adequate housing. High demand for residential space, if not balanced by proper spatial planning, often results in the emergence of slum areas. The challenges are further intensified by rapid urbanization and suburbanization, where population migration from rural to urban areas creates pressure on land, housing, and public facilities (Pravitasari et al., 2015; Ebaid & Helmi, 2024). Additionally, low-income communities, unable to afford decent housing, are forced to settle in poorly planned areas that lack essential infrastructure and services (Hartini, 2019; Rahmah, 2019). Inadequate attention to spatial planning and environmental management further

worsens this situation, leading to areas with a poor quality of life and heightened vulnerability to social, economic, and environmental challenges.

This slum phenomenon is not exclusive to urban areas but also occurs in rural regions, such as the Southwest Aceh Regency. Data from Regional Development Planning Agency (Bappeda, *Badan Perencanaan Pembangunan Daerah*) of Southwest Aceh indicated that the extent of slum areas increased from 561.62 hectares in 2014 to 829.51 hectares in 2020, Within six years the slum area in Southwest Aceh Regency increased by 267.89 Ha (32.29%). This trend reflects declining environmental quality, driven by rapid population growth without adequate housing provision. According to the Central Bureau of Statistics (BPS, *Badan Pusat Statistik*), the population in Southwest Aceh Regency increased significantly from 138,140 residents in 2014 to 150,775 residents in 2020. The high population growth rate of 1.25% in 2021 has intensified the demand for housing. However, the poverty rate of 16.34% and extreme poverty rate of 6.91% remains to be major obstacles in fulfilling housing needs. Based on the Regional Development Plan Document (RPD, *Rencana Pembangunan Daerah*) document of Southwest Aceh Regency (2023–2026) from Bappeda, 9.9% of the population still lives in uninhabitable housing, while 20.66% of residential areas are categorized as slums. This condition is further compounded by the population's employment structure, which is dominated by self-employed workers and farmers with irregular incomes, limiting their access to adequate housing.

The presence of slums not only degrades the quality of life for residents but also poses significant environmental challenges. Poor environmental conditions, such as inadequate sanitation, insufficient waste management, and disaster vulnerability, further increases the unsustainability of these areas. Furthermore, slums contribute to broader societal issues, including public health challenges, socio-economic inequality, vulnerability to natural disasters, and inadequate public services (Budiharjo, 1997; Singht & Singh, 2023; Kosova et al., 2024, Marvi et al., 2024). This aligns with the definition of slums outlined in the Minister of Public Works and Housing Regulation No. 02/PRT/M/2016, which describes slums as residential areas that fail to meet livability standards, characterized by high population density, substandard housing quality, and limited access to essential infrastructure.

Based on the aforementioned conditions, it is imperative to address slum management as a critical aspect of achieving the Sustainable Development Goals (SDGs). One of the primary targets of the SDGs is the creation of inclusive, safe, resilient, and sustainable cities and settlements, with the aim of eliminating slums by 2030. This goal reflects a global commitment in providing access to decent, safe, and affordable housing for all, thereby improving the quality of life, reducing social inequality, and fostering sustainable urban development (United Nations, 2021; Sharma & Kumar, 2023). The slum area reduction target set in the National Mid-Term Development Plan (RPJMN, *Rencana Pembangunan Jangka Menengah Nasional*) 2020-2024 is to turn 10,000 Ha of slum areas into 0 Ha of slum areas. Based on this target, slum area reduction by the end of 2022 has reached 6,872 hectares (69%) and there is still a 31% gap to reach the target in 2024 (Ministry of Public Works and Housing, 2023). Based on the Regional Spatial Plan (RTRW, *Rencana Tata Ruang Wilayah*) document 2013-2033 from the Office of Public Works and Spatial Planning (PUPR, *Dinas Pekerjaan Umum dan Penataan Ruang*) the area of Southwest Aceh Regency is 188,205.02 hectares, but with this very large area, most of the land use in this area is dominated by forests including protected forests. In line with this objective, this research aims to identify the spatial distribution patterns of slums in Southwest Aceh Regency to facilitate better-targeted environmental management policies and programs. By understanding the transformation of the function of the region, the pattern and direction of regional development can also be known (Wang et al. 2023a). A comprehensive strategy, as suggested by Soemarno (2021), should emphasize integrated spatial planning, consistent policy implementation, and active community participation. In addition, improving the quality of housing and slum areas is also in line with the government's desire to realize the function of settlements that meet the requirements of the Minimum Service Standards (SPM, *Standar Pelayanan Minimum*). Through this approach, it is expected that slum management efforts in Southwest Aceh

Regency will become more effective, ultimately enhancing community welfare and environmental sustainability.

Previous research related to slum management strategies has been conducted by Mardjuni et al. (2023) which focused more on handling based on the causes of slums such as economic factors, urbanization, and land use, Rahayu et al. (2022) and Pratama et al. (2023) which focus more on handling based on infrastructure, and Luli and Fadjarani (2018) which focus on handling the environment. These studies develop slum upgrading strategies based on the factors that cause slums. Research that compiles slum upgrading strategies based on slum distribution patterns has also been conducted by Sartika et al. (2023) and Aspin & Nafsi (2021), but only with qualitative descriptive methods. The distribution pattern of slums with a spatial analysis approach has been conducted by Adiputra et al. (2022), but not accompanied by a handling strategy. Research on slums is also mostly conducted in urban areas where urbanization has occurred, therefore the location of Southwest Aceh Regency was chosen because this region is a developing area, but already has slum areas. This is largely due to the environmental conditions of the settlement area. Therefore, this research aims to develop slum management strategies that focus on environmental management based on the distribution pattern of slums with a spatial analysis approach.

2. Methods

The location of this study is in Southwest Aceh Regency, Aceh Province, with coordinates of 3°34'24" to 4°05'37" LU and between 96°34'57" to 97°09'19" East with an area of 1,882.02 km². This research was conducted with a spatial analysis, qualitative and quantitative approach. Spatial analysis was conducted to identify the distribution patterns of slum settlements using ArcGIS 10.8 software. The qualitative approach aimed to explore the environmental management factors affecting slum areas through a literature review and in-depth interviews with key persons. The quantitative approach was used to assess the score of each factor by administering questionnaires to key persons. The key persons in this study included stakeholders from the regional planning and environmental sectors, as well as community leaders in Southwest Aceh Regency, who had extensive knowledge of the region's conditions and issues. Primary data for this research was collected through the administration of questionnaires and interviews with these key persons. The questionnaire was developed by the author based on the research objectives, which focused on assessing the environmental factors influencing slums. Secondary data included slum data for Southwest Aceh Regency in 2014 and 2020, regional planning documents of Southwest Aceh Regency from the Bappeda, and shapefiles of village administrative boundaries from the Office of Public Works and Spatial Planning.

2.1 Determine the Location of Slum Upgrading

2.1.1 Identification of Spatial Autocorrelation of Slum Areas

The identification of spatial patterns of slum areas is done using spatial autocorrelation analysis. Spatial autocorrelation is one of the spatial statistical methods used to describe the phenomenon of interaction in a space or observation location that refers to the relationship of the same variable in different spatial locations (Wang et al. 2023b). Indices for measuring spatial autocorrelation are Moran's I and Geary's C (Anselin, 2019). In this study, the index used to measure spatial autocorrelation is Moran's I because according to Wang et al. (2023b) Moran's index has better distribution characteristics. Moran in 1950 provided the Moran's index equation which can be seen as following equation (1):

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}\sum_{i=1}^{n}(x_i-\bar{x})^2} \quad (1)$$

Where: I : Indeks Moran's; n : Number of villages (spatial units); $\bar{x}$: Average slum area over spatial units; x_i = Slum area of ith village; x_j : Slum area of the jth village; W_{ij} : Elements in the weight matrix between villages i and j.

Moran's index can show whether there is autocorrelation between the area of slums and the unit of analysis of Southwest Aceh District. The Moran's index value can assess whether there is positive or negative autocorrelation across the region. The shape of the spatial pattern can be known based on the value of Moran's index (I) which is (-1 < I < 1), where if I > 0 then there is positive spatial autocorrelation indicating villages with high (low) slum areas are surrounded by villages with high (low) slum areas or called clusters, if I < 0 then there is negative autocorrelation indicating villages with high (low) slum areas are surrounded by villages with low (high) slum areas having a dispersed pattern, and if I = 0 then there is no spatial autocorrelation which does not show the same or different patterns (random).

2.1.2 Local Analysis of Spatial Autocorrelation of Slum Settlement Areas

Moran tends to ignore local patterns of spatial relationships, therefore to identify autocorrelation locally in each region, we can use the Local Indicator of Spatial Autocorrelation (LISA) analysis. According to Lee & Wong (2001), the higher the local value, the closer locations have similar values or form a clustered distribution. The calculation of LISA is following equation (2):

$$I_i = Z_i \sum_{i=1}^{n} W_{ij} Z_j \quad (2)$$

Where: $Ii:$ Koefisien LISA; Zi dan $Zj:$ Standardization of data; Wij : Weighting between locations i and j.

2.2 Development of Environmental Management Strategies for Settlement Areas

The development of environmental management strategies in slum areas is a systematic effort to improve the quality of the environment as well as the welfare of the people living in the area. SWOT (Strengths, Weaknesses, Opportunities, Threats) method is a strategic analysis tool used to evaluate an organization or project through the identification and comparison of internal factors (IFAS), namely Strengths and Weaknesses, with external factors (EFAS), namely Opportunities and Threats (Gurel & Tat, 2017). SWOT is used as a tool to analyze an organization's situation and identify effective interventions in the context of slum upgrading programs and sustainable development planning strategy (Sorongan et al. 2021, Mardjuni et al. 2023; Marvi et al. 2024). The process involves analyzing internal (IFAS) and external (EFAS) strategic factors, obtained through literature review and in-depth interviews. in line with Hutagaol et al. (2023) research slum upgrading needs to involve various parties. The results are plotted on the Internal-External (IE) Matrix by determining the difference between the scores of strengths and weaknesses in the IFAS matrix, and the difference between the scores of opportunities and threats in the EFAS matrix, will fill the x and y values of the quadrant in the Internal-External (IE) matrix. The next step is to recap the results of each SWOT component in a SWOT table to identify relationships between aspects and come up with effective environmental management strategies. A recapitulation of the integrated SWOT results can be seen in Table 1.

Table 1. Recap of SWOT strategy results

Eksternal (EFAS) / **Internal (IFAS)**	**Opportunities (O)**	**Threats (T)**
Strengths (S)	SO strategies, create strategies that use strengths to capitalize on opportunities.	ST strategies, create strategies that use strengths to overcome threats.
Weaknesses (W)	WO strategy, create strategies that minimize weaknesses to take advantage of opportunities.	WT strategy, create a strategy that minimizes weaknesses and avoids threats.

3. Result and Discussion

3.1 Distribution Pattern of Slums in Southwest Aceh Regency

The distribution pattern of slums in Southwest Aceh Regency between 2014 and 2020 showed significant changes in both area and distribution patterns. In 2014, based on data from the Southwest Aceh Regency Decree No. 393/2014 on the Determination of Slum Areas, slums were spread across 41 villages with a total area of 561.62 hectares (Figure 1). All nine districts in Southwest Aceh Regency have slums, but the largest areas of slums were identified in Susoh and Babahrot district. The distribution shows a more even pattern across several districts, indicating that slums are not concentrated in specific areas but are scattered across various locations with a relatively low level of severity.

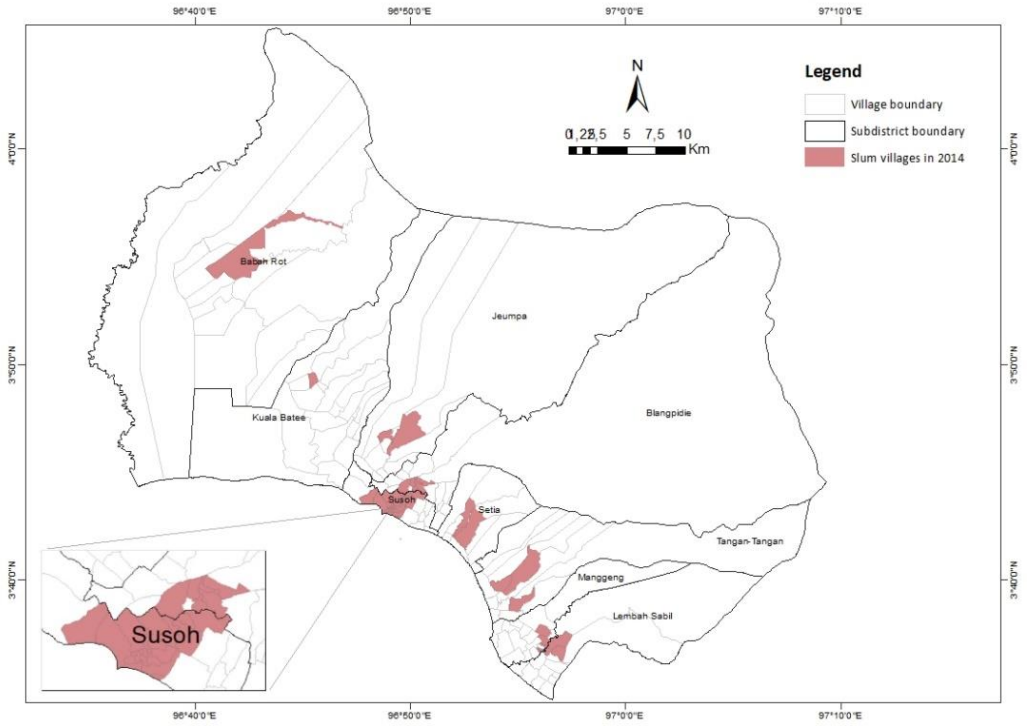


Figure 1. Map of slum settlement distribution in Southwest Aceh Regency in 2014

However, in 2020, after a re-survey by Bappeda of Southwest Aceh Regency, the distribution pattern of slums changed. Although the number of affected villages decreased to 33, the slum area increased significantly to 829.51 hectares. This reflects the tendency for the concentration of slums in certain villages to expand significantly. This distribution pattern suggests that slums are now more concentrated in locations with high levels of environmental pressure and population activity, such as in Susoh District. As can be seen in Figure 2, although the number of slum villages in Susoh District has decreased, their distribution has expanded in each village. This phenomenon due to the fact that Susoh District is a hinterland area of the capital regency. Many migrants enter to this area, because the villages in Susoh Distric still have a lot of open land that is easily inhabited with lower land prices, and good accessibility to the city center. Low land prices can encourage settlement expansion and population increase in certain areas. In this case, more affordable land prices in hinterland or less developed areas facilitate the development of residential and commercial projects, which in turn attracts new residents and increases population density. This phenomenon reflects that cheap land is often a driving factor for migration and regional development, albeit often without adequate infrastructure planning, which has the potential to worsen environmental conditions in the area (Surya et al. 2021).

This change in distribution pattern also indicate that villages with smaller slum areas in 2014 were successfully removed from the slum category thanks to more effective interventions from the government. In contrast, villages with larger slum areas continued to grow without adequate treatment.

This phenomenon is largely due to a lack of public awareness of environmental hygiene, with many communities lacking adequate sanitation facilities, such as household toilets, thus exacerbating open defecation behavior. This practice further exacerbates the condition of slums. This emerging distribution pattern reflects the challenges in prioritizing slum upgrading, where villages with high environmental pressure tend to experience an intensification of problems. In addition, changes in distribution patterns also emphasize the importance of periodic monitoring to ensure that slum upgrading focuses not only on reducing the number of affected villages, but also on controlling the extent of existing slums.

Based on the analysis of slum distribution in Southwest Aceh Regency between 2014 and 2020, it is concluded that there has been a significant increase in both the area and concentration of slums. The results of this analysis are used to develop strategies based on slum distribution patterns, aimed at identifying areas that require more attention for slum upgrading

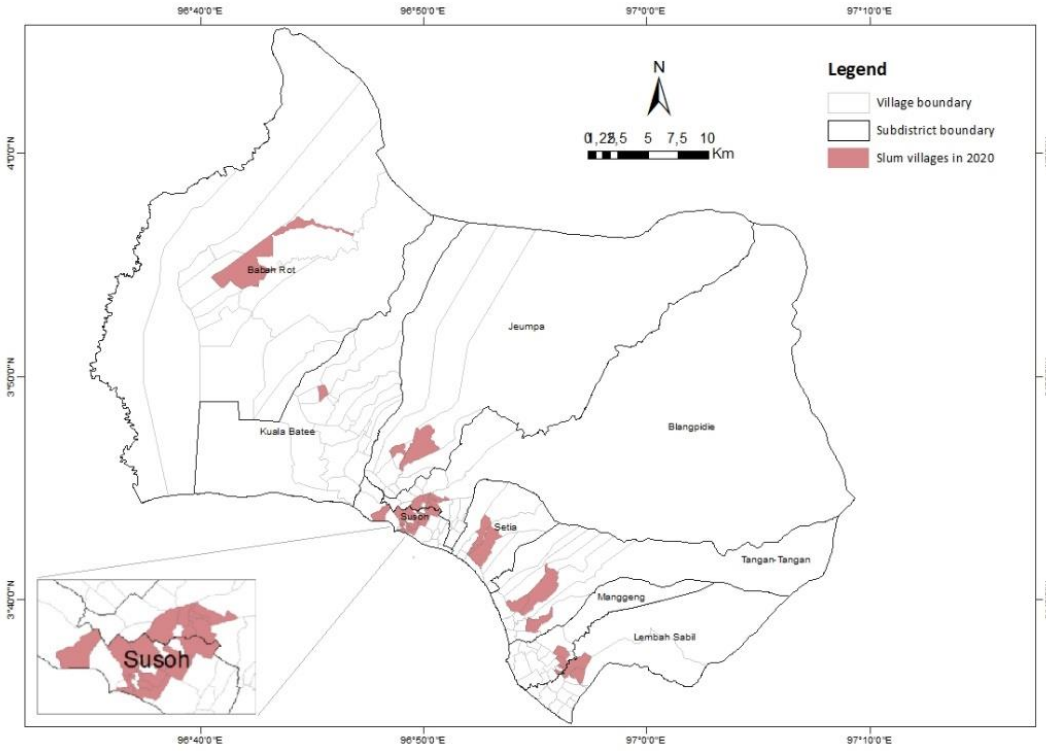


Figure 2. Map of slum settlement distribution in Southwest Aceh Regency in 2020

3.2.1 Moran's Index analysis of Slums in Southwest Aceh Regency

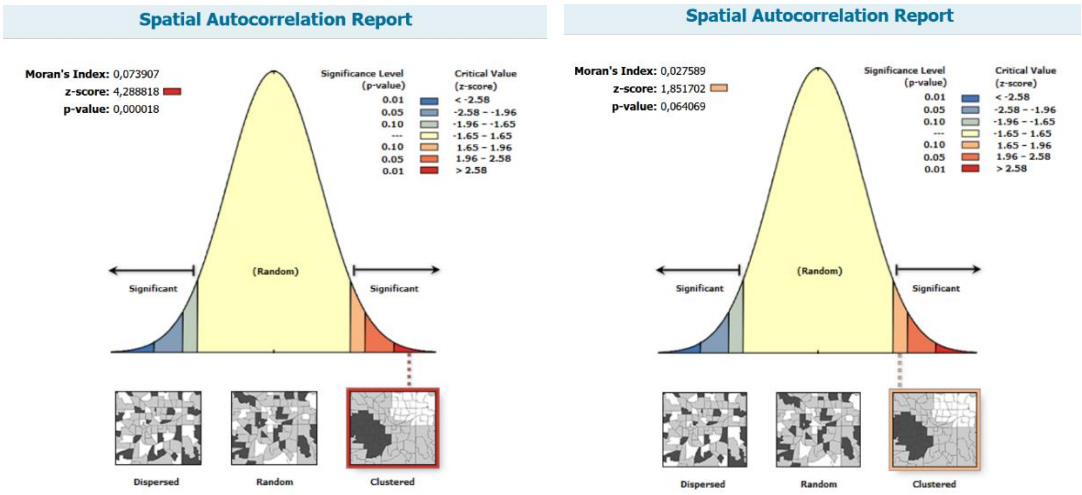
The results of the Moran's Index analysis of slum data in Southwest Aceh Regency provide a clear picture of the spatial dynamics of slums during the period 2014 to 2020 (Figure 3). In 2014, the Moran's Index value of 0.074 indicates a significant positive spatial autocorrelation, where slum patterns tend to be concentrated or clustered. This pattern illustrates that slum areas have similar characteristics and are in close geographical proximity, thus reflecting serious spatial problems in the area. This is also reinforced by the statistical results of a P-value of 0.000018 (smaller than 0.05) and a Z-score of 4.289, which confirms that the spatial clustering is not random, but rather influenced by significant internal and external factors.

In 2020, the Moran's Index value decreased to 0.027, which still indicates positive spatial autocorrelation but is much weaker than in 2014. This decrease was followed by a significant change in spatial patterns, where slums began to show a distribution that was closer to random, or less concentrated in certain locations. This is also reflected in the P-value of 0.064069 (greater than 0.05) and Z-score of 1.852, which indicates that the spatial pattern of slums in 2020 is no longer statistically significant. This decrease can be interpreted as a result of the slum upgrading efforts that have been undertaken, such as infrastructure improvements, affordable housing development, and overall include inadequate housing,

lack of sanitation, and insufficient access to clean water l spatial improvements. This result reflects that the intervention program has succeeded in reducing the spatial concentration of slum areas, both through a decrease in slum area and a more equitable distribution of settlements in various locations.

This change in pattern is a positive indication of the success of slum management policies and programs implemented by the Southwest Aceh Regency government, which has implemented various slum reduction activities over the past few years. With the decrease in clustering, it can be assumed that the quality of the environment in these areas has improved, indicating a decrease in the concentration of social, economic, and environmental problems in the slum areas. This is in line with Ponto et al. (2023), which states that government programs through slum revitalization are carried out through improving the quality of the environment with programs such as the construction of decent houses, improving wastewater management facilities and infrastructure, and providing drinking water sources. An example is the existence of Community-based Water Supply and Sanitation Program (PAMSIMAS, *Program Penyediaan Air Minum dan Sanitasi Berbasis Masyarakat*) which is a national program that aims to improve community access, especially in underserved rural and urban areas, to clean water and proper sanitation which has been implemented in Southwest Aceh Regency for 6 years. Nonetheless, it is important to note that while these results show a positive trend, it is important to ensure that this change in spatial pattern is not due to a shift in the problem to another location, but rather a real improvement in environmental quality.

Based on the Moran Index analysis of slum distribution in Southwest Aceh Regency between 2014 and 2020, the findings show a significant shift from a highly concentrated slum pattern in 2014 to a more dispersed and less concentrated pattern in 2020. These results are used to inform the development of environmental management strategies for slum upgrading and prevention in Southwest Aceh Regency



(a) (b)

Figure 3. Results of Moran's Index Analysis of the area of slum settlement in Southwest Aceh Regency (a) in 2014 and (b) in 2020

3.2.2 Local Indicator Spatial Autocorrelation (LISA) Analysis of Slums in Southwest Aceh Regency

The results of the LISA analysis of the 2014 slum data showed a significant spatial autocorrelation pattern in 49 villages (Figure 4). The High-High Cluster (HH) pattern was found in 15 villages, namely Kuta Tinggi, Meudang Ara, West, Gadang, Pawoh, Padang Hilir, Kepala Hilir, Kepala Bandar, Padang Baru, Geulumpang Payong, Keude Siblah, Pantai Perak, Tengah, Kuta Tuha, Pulau Kayu, and Mata Ie. These villages have high slum levels and are surrounded by villages that also have high slum levels, reflecting a significant concentration of slum areas. The Low-Low Cluster (LL) pattern is found in 13 villages, namely Padang Bak Jok, Drien Jalo, Pante Pirak, Lama Tuha, Blang Dalam, Alue Peunawa,

Geulanggang Gajah, Suak Nibong, Lhok Pawoh, Panto Cut, Simpang Gadeng, Pante Cermin, and Cot Seumantok. These low-slum villages are surrounded by other low-slum villages, reflecting areas of relatively good condition. The High-Low Outlier (HL) pattern is found in 5 villages, namely Bineh Krueng, Kota Bahagia Market, Kuta Jeumpa, Pantee Rakyat, and Gunung Cut. This pattern shows villages with high slum levels surrounded by villages with low slum levels. Meanwhile, the Low-High Outlier (LH) pattern is found in 16 villages, namely Cot Mane, Lhung Asan, Blang Dalam, Keudai Paya, Kuta Bahagia, Cot Jirat, Padang Blang Pidie, Lhung Tarok, Ladang Neubok, Guhang, Suenaloh, Geulima Jaya, Panton Jaya, Alue Seulaseh, West Jeumpa, and Alue Dawah. These villages have low slum levels surrounded by villages with high slum levels.

The results of this analysis show that the spatial pattern of slum distribution has significant variations. Villages with High-High Cluster patterns such as Kuta Tinggi and Meudang Ara require priority attention due to the high concentration of slums in these areas. These two villages are among the most densely populated villages in the district capital, Blangpidie district, and poverty in these villages is also high. This is consistent with Galet et al. (2023) who state that spatial trends indicate the presence of concentrated poverty, especially in inner-city slums and informal suburban settlements. In contrast, villages with Low-Low Cluster patterns such as Padang Bak Jok and Drien Jalo can serve as models of successful neighborhood management. The High-Low Outlier and Low-High Outlier patterns reflect spatial inequalities that need to be addressed with more specific approaches, such as improving intervillage stakeholder coordination to prevent slum expansion.

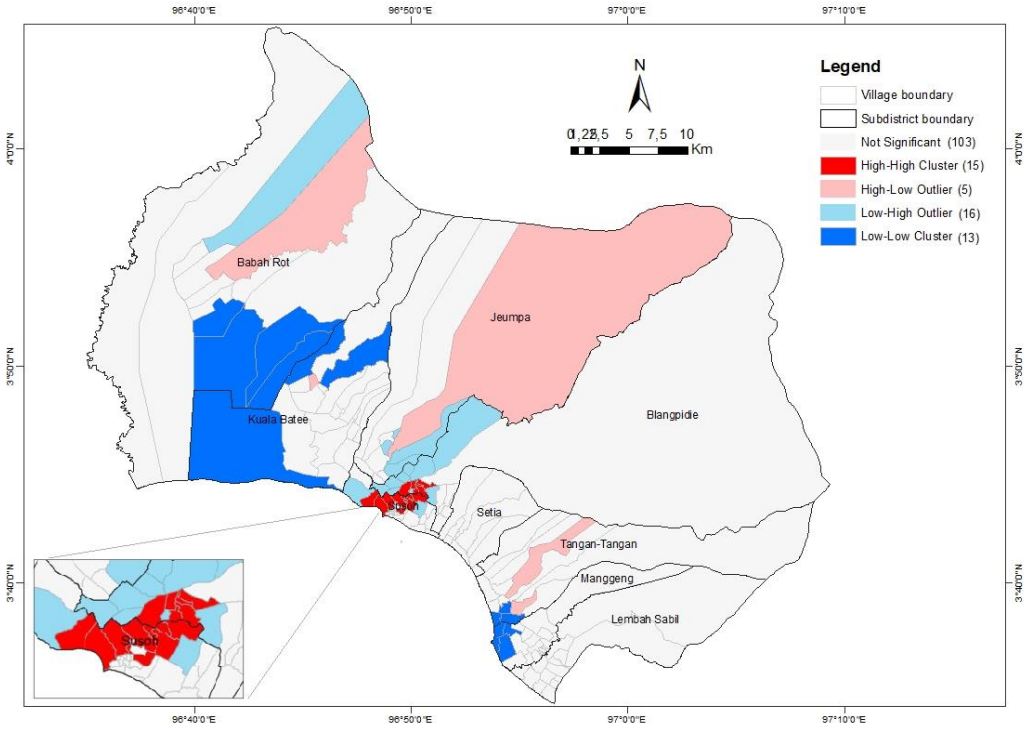


Figure 4. LISA cluster map of the area of slums in Southwest Aceh Regency in 2014

Based on the results of the LISA analysis on the 2020 slum area data, it is known that there are 19 villages identified as having spatial autocorrelation (Figure 5). Based on the analysis results, there are 5 drsa with High-High Cluster distribution patterns, namely Kuta Tinggi Village, Meudang Ara Village, Geulumpang Payong Village, Kuta Tuha Village, and Mata Ie Village. The Low-Low Cluster distribution pattern is also found in 5 villages, namely Lama Tuha Village, Geulanggang Gajah Village, Panto Cut Village, Simpang Gadeng Village, Cot Seumantok Village. Then there are 3 villages with High-Low Outlier distribution patterns, namely Kota Bahagia Market Village, Kuta Jeumpa Village and Pantee Rakyat Village. The Low-High Outlier distribution pattern is seen in Keudai Paya Village, Padang Hilir Village, Central Village, Kuta Bahagia Village, Blangpidie Market Village, and Alue Dawah Village.

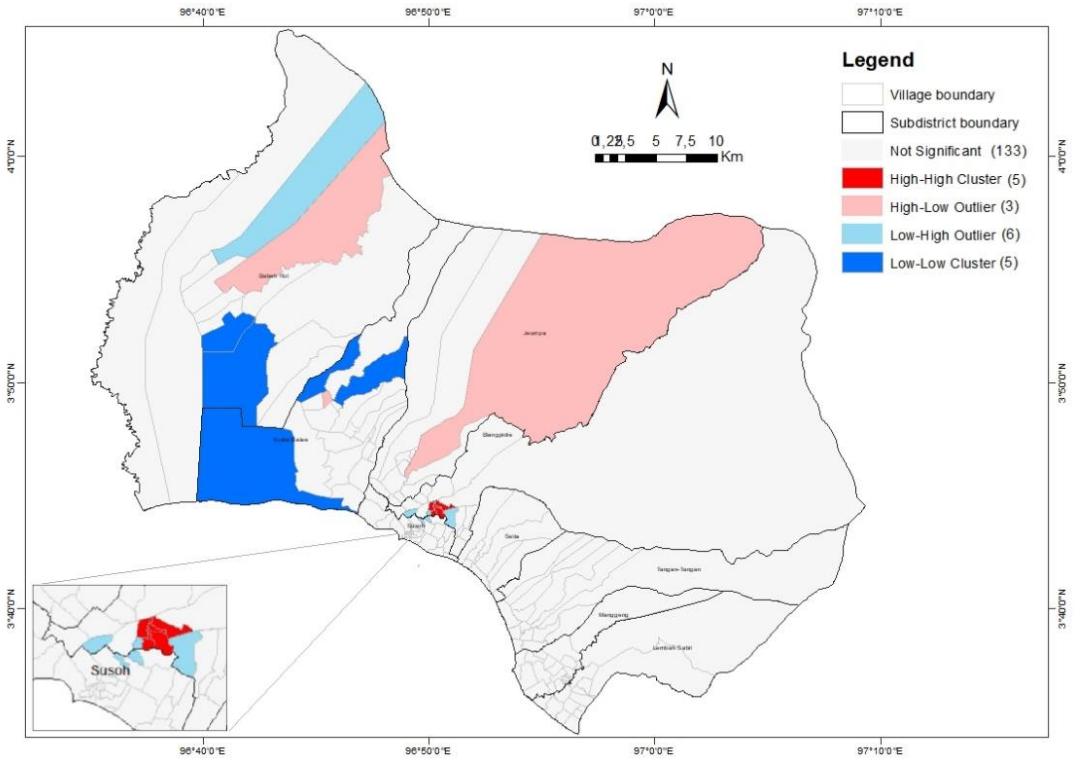


Figure 5. LISA Cluster Map of Slum Area in Southwest Aceh Regency in 2020

The results of the LISA analysis in 2020 showed a change in the spatial distribution pattern of slums in Southwest Aceh Regency compared to 2014. This change is characterized by a shift in the pattern of clustering of slum areas (High-High Cluster or HH) from being concentrated along the coast and in the central part of the district, particularly in Susoh and Blangpidie districts, to being more concentrated in Blangpidie district, the district capital. This decrease in slum clustering area reflects a significant reduction in slum clustering in the coastal areas. However, the increase in slum area in Blangpidie District indicates new challenges in the main urban area of the district.

Meanwhile, the distribution pattern of slums in the Low-Low Cluster (LL) category also experienced a reduction. In 2014, LL areas were identified in the southern part of the district, namely Manggeng and Tangan-Tangan districts, and the western part in Kuala Batee and Babahrot districts. However, in 2020, this pattern was only found in the western part, specifically in Kuala Batee and Babahrot. This indicates an improvement or change in the handling of areas with low levels of slums, but spatially the LL areas become more limited to certain areas. Overall, the distribution pattern of slums in 2020 became more spread out or less concentrated than in 2014. This decrease in clustering indicates the positive impact of intervention programs.

However, the concentration of clustering in district capitals indicates new pressures in urban areas due to increased population and urbanization. This reflects that population growth, whether due to migration or natural growth, creates greater demand for infrastructure, housing and public services in the city center. This condition can worsen the problem of slums if not addressed effectively through inclusive spatial planning and urban revitalization programs. Uncontrolled urbanization often results in limited capacity for basic services, such as access to clean water, sanitation, transportation and health facilities, thereby increasing the risk of new slums forming around major urban areas.

Based on the LISA analysis of slum data in Southwest Aceh Regency between 2014 and 2020, significant changes in the spatial distribution of slums are observed. There has been a reduction in slum clustering in coastal and rural areas, while urban centers, particularly Blangpidie District, have seen an increased concentration of slums. This shift reflects the new challenges brought by urbanization and

population growth. The results of this analysis are crucial for developing environmental management strategies aimed at preventing the spread of slums as population growth continues

3.2 Environmental Management Strategies in Slums

3.2.1 Analysis of the Internal Factor Analysis Summary (IFAS)

The internal factors include the strengths and weaknesses found in the slum settlement areas, for which the strategy will be developed.

Table 2. The result of the Internal Factor Analysis Summary (IFAS) analysis

No	Internal Factors	Rating	Weight	Score
	Strengths (S)			
1	The strategic location of villages	3.6	0.11	0.41
2	Availability of land for infrastructure development	3.2	0.10	0.32
3	Potential natural resources and ecotourism	2	0.06	0.13
4	Local wisdom in environmental preservation	2.4	0.08	0.18
5	Government program support for slum settlement management	3.8	0.12	0.45
	Weaknesses (W)			
1	Lack of sanitation, drainage, and waste management infrastructure	4	0.13	0.50
2	Disorderly building arrangements in residential areas	2.6	0.08	0.21
3	The prevalence of open defecation (BABS) indicates low community awareness of environmental cleanliness	3.6	0.11	0.41
4	A large number of uninhabitable houses for low-income communities (MBR)	3.2	0.10	0.32
5	Limited collaboration among stakeholders in addressing slum settlement issues	3.4	0.11	0.36
	Total IFAS			**3.30**

3.2.2 Analysis of the External Factor Analysis Summary (EFAS)

The external factors include the opportunities and threats present in the surrounding environment of the slum settlement areas, which will influence the development of the strategy.

Table 3. The result of the External Factor Analysis Summary (EFAS) analysis

No	External Factors	Rating	Weight	Score
	Opportunities (O)			
1	The opportunity to achieve SDGs targets	2.4	0.07	0.18
2	Increased public awareness of the importance of sanitation	3.4	0.10	0.36
3	Availability of funding programs from the central government for slum settlement management	3.2	0.10	0.32
4	Improvement in public health	3.8	0.12	0.45
5	Increasing infrastructure for sanitation with new technologies	2.4	0.07	0.18
	Threats (T)			
1	Urbanization exacerbates environmental degradation and increases slum conditions	3.6	0.11	0.40

No	External Factors	Rating	Weight	Score
2	The risk of disasters such as floods and diseases affecting the community	3.4	0.10	0.36
3	The potential reduction of funding programs for slum settlement management	3.6	0.11	0.40
4	Lack of interest from developers in residential development in Southwest Aceh Regency	3	0.09	0.28
5	Insufficient enforcement of regulations related to environmental management	3.6	0.11	0.40
	Total EFAS			**3.31**

Based on the results of the analysis, the internal factor with the highest score are Lack of sanitation, drainage, and waste management infrastructure (0.50) and government program support for slum settlement management (0.45). The results of the analysis show that the main problems in handling slum areas in Southwest Aceh Regency are the lack of basic sanitation infrastructure development and government program support. The lack of basic infrastructure reflects a built environment that does not support the health and well-being of the community, while the lack of government support indicates weaknesses in the program planning.

Based on the analysis, the external factors with the highest scores are Improvement in public health (0.45), Urbanization exacerbates environmental degradation and increases slum conditions (0.40), The potential reduction of funding programs for slum settlement management (0.40), Insufficient enforcement of regulations related to environmental management (0.40). This suggests that while there are opportunities to improve public health through slum upgrading, the pressures of rapid urbanization can threaten the success of such efforts. Uncontrolled urbanization can lead to increased population density, pressure on infrastructure, and environmental degradation. In addition, the threat of budget reductions for slum upgrading programs and weak enforcement of environmental regulations are also challenges that need to be addressed.

The Total IFAS value of 3.3 and Total EFAS of 3.31 indicate that the internal and external factors affecting environmental management in slum areas in Southwest Aceh Regency are relatively balanced with a positive trend. Internal factors such as strengths (such as strategic location and government support) can be utilized to improve infrastructure and environmental awareness, while weaknesses, such as lack of sanitation and settlement irregularities, still need to be improved. On the external side, great opportunities such as government financing programs and increased community awareness can be maximized to improve slum conditions, while threats such as urbanization and natural disasters need to be anticipated with careful planning. This analysis shows the balance of internal and external factors in the handling of slums in Southwest Aceh District, so the results of this analysis are used to determine strategies that are effectively applied to the handling of slums in Southwest Aceh Regency.

3.2.3 Internal-External (IE) Matrix

Internal-External (IE) Matrix is used to evaluate the environmental management strategies in slum settlements by analyzing internal strengths and weaknesses alongside external opportunities and threats. The difference in the IFAS score, which is -0.32, serves as the x-axis, and the difference in the EFAS score, which is -0.36, serves as the y-axis. This results in a point located in quadrant IV, indicating that the environmental management strategy for slum areas in Southwest Aceh Regency should adopt a Defensive Strategy.

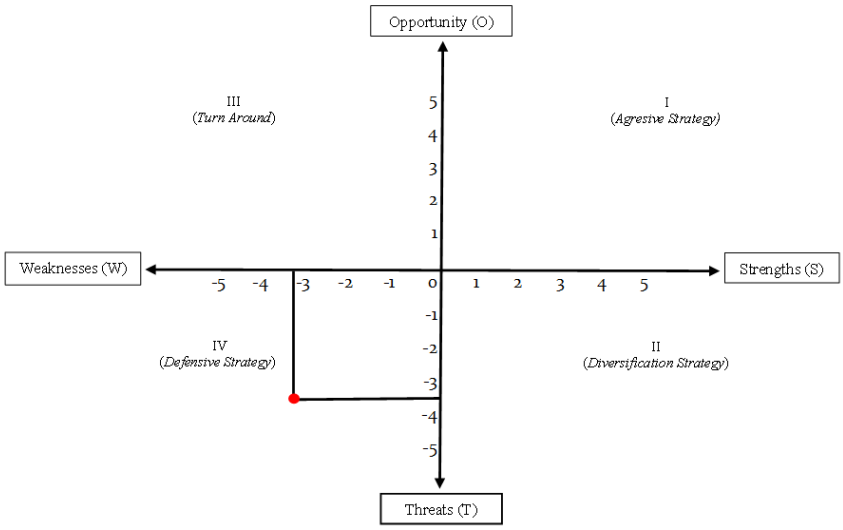


Figure 5. IFAS and EFAS quadrant matrix of environmental management strategies in slums

3.2.4 Environmental Management Strategies for Slum Settlement Improvement

The environmental management strategies in slums, based on the analysis results from the components of Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) in Tabel 2 and Table 3, are organized into four general strategies as follows. The first is aggressive strategi or S-O (Strengths-Opportunities) strategy involves utilizing strategic locations and available land to build new, technology-based sanitation infrastructure, supporting improved public health (S_1, S_2, O_4, O_5), developing ecotourism to improve the local economy, support the SDGs program, and attract public attention to sanitation education (S_3, O_1, O_2), and optimizing local wisdom and government program support in managing the environment, utilizing government financing programs (S_4, S_5, O_3). The second is diversification strategi or S-T (Strengths-Threats) strategy involves using strategic locations and available land to design spatial layouts that are resilient to flood risks and the impacts of urbanization (S_1, S_2, T_1, T_2), utilizing the potential of natural resources and ecotourism to reduce the impact of urbanization and attract developers to invest in the area (S_3, T_1, T_4), and integrating local wisdom and government support to strengthen the enforcement of environmental management rules despite potential reductions in financing (S_4, S_5, T_3, T_5).

The third is turnaround strategy or W-O (Weaknesses-Opportunities) strategy includes utilizing government financing programs to build sanitation infrastructure, reorganize irregular areas, and support SDGs targets (W_1, W_2, O_1, O_3), addressing open defecation behavior through education based on new sanitation technologies that can also improve public health (W_3, O_4, O_5), and strengthening stakeholder collaboration to build livable houses while encouraging community participation in supporting sanitation (W_4, W_5, O_2). The fourth is defensive strategy or W-T (Weaknesses-Threats) strategy includes increasing stakeholder collaboration to improve sanitation infrastructure and reduce the risk of disasters such as flooding (W_1, W_5, T_2), reorganizing residential areas to make them more organized, resilient to urbanization, and attractive to developers (W_2, T_1, T_4), and educating the community to support compliance with environmental regulations and maintain financing programs despite potential budget reductions (W_3, W_4, T_3, T_5).

Based on the results of the SWOT analysis in Figure 5, the implementation of the Defensive Strategy is considered very useful for environmental management in the slums of Southwest Aceh Regency. This strategy includes three main steps. First, increasing cross sector collaboration to improve sanitation infrastructure. This is done by encouraging cooperation between the village government and the district government, namely building drainage infrastructure to prevent flooding, providing Integrated Waste Management Sites (TPST, *Tempat Pengolahan Sampah Terpadu*) in each village, providing water network infrastructure, Domestic Wastewater Management Systems (SPALD, *Sistem Pengolahan Air*

Limbah Domestik), and involving the community to carry out environmental maintenance programs such as routine cleaning of drainage and socialization of waste management and preventing open defecation. This step aims to improve the quality of public health and reduce the risk of environmental disasters. In accordance with the Ministry of Public Works and Housing's 2022 Slum Site Identification and Assessment, there are seven aspects or factors of slums, namely buildings, environmental roads, drinking water supply, environmental drainage, wastewater management, solid waste management, and fire protection. Second, reorganize residential areas. With the increasing need for housing due to urbanization, especially in the district capital, Blangpidie Sub-district, careful planning is needed in the development of residential areas. This reorganization must be supported by strong enforcement of spatial regulations and community engagement to ensure the success of the planning (Kleeman et al., 2017; Monica et al., 2023).

Third, educating the community and maintaining financing programs, in this case efforts are needed to increase public awareness about the importance of protecting the environment, for example by giving awards and appreciation to villages that successfully implement environmental cleanliness, thus encouraging each village to implement environmental management programs, the community will also be more motivated to participate in environmental conservation efforts (Sorongan et al., 2021; Monica et al., 2023). In addition, with the increasing number of environmental awards obtained by Southwest Aceh Regency, it can encourage an increase in environmental management financing from the government, both central and local governments. Developers will also be interested in building housing in Southwest Aceh Regency, with funding assistance from the government for underprivileged communities (MBR, *Masyarakat Berpenghasilan Rendah*), so that people can live in livable houses with complete sanitation facilities because economic factors are the main cause of slums (Aroujo et al., 2023). Therefore, synergy between stakeholders and local communities is needed for environmental management in slum areas in Southwest Aceh Regency to create a safe, comfortable, and sustainable environment.

The main environmental management strategy that needs to be applied for the handling of slums in Southwest Aceh Regency is Defensive Strategy by increasing stakeholder collaboration to improve sanitation infrastructure to reduce the risk of disasters such as flooding, reorganize residential areas to make them more organized, resistant to urbanization, and attractive to developers, and educate the community to support compliance with environmental regulations and maintain financing programs despite potential budget reductions which are expected to create a safe and comfortable environment for community life.

4. Conclusions

The distribution pattern of slums in Southwest Aceh District based on the results of the Moran's index analysis shows a positive spatial autocorrelation with a clustering category in 2014 and 2021. However, in 2020 the autocorrelation is less clustered or closer to a random pattern. Based on the results of the LISA analysis, in 2014, the distribution pattern of High-High Cluster (HH) slums was clustered in coastal areas and the central part of each sub-district, but in 2020 the clustering was concentrated in the regency capital. Overall, the distribution pattern of slums in 2020 is less clustered or more spread out. So, the main environmental management strategy that needs to be applied for the handling of slums in Southwest Aceh District is the Defensive Strategy by minimizing weaknesses and avoiding threats.

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