Analysis of Land-Use Changes in Mojosongo District, Boyolali Regency in 2013 and 2023

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Abstract

One of the causes of land-use change is population growth. The more the population increases, the more land-use changes occur, such as the conversion from non-built to built-up areas. Mojosongo Subdistrict in Boyolali Regency faces issues with land-use change due to the growing population. The increase in construction, ranging from residential houses, factories, to toll roads, has contributed to this change in Mojosongo Subdistrict. The impact of land-use change, such as from non-built to built-up areas, has led to a reduction in available land. Mojosongo Subdistrict had a land area of 4,341.16 hectares in 2023. Based on the problems occurring in Mojosongo Subdistrict, this study aims to (1) analyze the land-use changes in Mojosongo Subdistrict from 2013 to 2023 and (2) analyze the main driving factors of land-use change between 2013 and 2023. The method used in this study is quantitative, involving overlay and digitization of imagery. The analysis method also includes interviews to better understand the main factors driving land-use changes in Mojosongo Subdistrict. The results of this study indicate that land-use change in Mojosongo Subdistrict from 2013 to 2023 involved a change of 1,180.1 hectares or 27.05%, while 3,185 hectares or 72.95% of the land remained unchanged. Residential areas experienced the highest land-use change in Mojosongo Subdistrict, with an increase of 204.4 hectares or 21.47%. The expansion of the area and the ease of obtaining permits were the main reasons behind the land-use changes in Mojosongo Subdistrict

Keywords: analysis, land-use change, Mojosongo District

1. Introduction

The Earth's surface encompasses various characteristics, including the biosphere, atmosphere, geology, soil, plant populations, hydrology, animals, and human imprints over time. These characteristics form the definition of land (Kusrini, 2011). Land is an object that is easily subject to planning changes, and land-use changes occur due to human intentions to fulfill their needs. Land-use change refers to the continuity between humans and the environment they alter, which leaves traces or marks on the land caused by human activities (Ritihardoyo, 2019). In general, land-use change in Indonesia will continue to occur as the population grows and the balance of dynamic conditions in human activities at the boundaries of habitats and land evolves (Syakur, 2020). (Septiono & Mussadun, 2016) emphasized that changes in land use that occur directly or indirectly will have various impacts on the environment, for example climate change, natural disasters (Wahyuni & Suranto, 2021) and the extinction of certain species (Novalia, 2020).

Boyolali Regency is divided into 22 subdistricts, 261 villages, and 6 urban villages. The relocation of the Boyolali Regency government center to Mojosongo Subdistrict in 2013 resulted in significant devel-opment, leading to major land-use changes. However, the relocation also brought positive impacts to Mojosongo Subdistrict, such as balanced economic development and progress. Companies and investors have entered the area, resulting in land-use changes that include government offices, factories, houses, hotels, dormitories, etc. On the downside, some residents' homes have been displaced, and agricultural land has been converted into buildings, while plantations have also been transformed into built-up areas.

As the population grows, the need for more buildings increases, such as housing, healthcare facil-ities, permanent buildings, and shopping centers. With population growth, primary needs like drinking water, markets, and transportation will also develop in tandem. The population of Mojosongo Subdistrict in 2023 is 59,116 people, with a total area of 4,341.16 hectares. The land

area includes both dry land and rice fields, with the availability of dry land making construction easier, which is one of the reasons be-hind land-use changes in Mojosongo Subdistrict.

Geographic Information Systems (GIS) and Geo Eye-1 imagery can be used as tools to observe land-use changes in Mojosongo Subdistrict. The output includes a land cover change map, showing land-use changes in Mojosongo Subdistrict from 2013 to 2023. Clear information will lead to better land-use planning and maintenance in Mojosongo Subdistrict, Boyolali Regency.

2. Research Methods

This research is descriptive-quantitative in nature, using a field survey method combined with remote sensing imagery interpretation. Fieldwork provides actual data that will be adjusted with the imagery, while remote sensing imagery interpretation offers digital land-use values captured by remote sensing in Mojosongo Sub-district. The study was conducted across the entire Mojosongo Subdistrict, Boyolali Regency, to reveal land-use changes.

a. Analyzing the Distribution of Land-Use Changes in Mojosongo Subdistrict from 2013 to 2023
The analysis method for land-use changes involves spatial analysis to examine the distribution of land-use and generate a land-cover map processed using GIS. This process includes overlaying data to produce classifications, map the area, and calculate the extent of land-use changes. Secondary spatial data (imagery, land-cover maps) were processed using GIS. The secondary data were then overlaid, classified, mapped, and the extent of land-use changes was calculated with the help of GIS. After classification, the data were converted into tables and maps.

b. Identifying the Driving Factors Behind Land-Use Changes in Mojosongo Subdistrict from 2013 to 2023
The method for determining the driving factors behind land-use change involves frequency table analysis. Data from interviews were grouped based on responses to the questions asked, and the responses were then scored. The conclusions were drawn from the scoring results, which identified the main factors contributing to land-use change in Mojosongo Subdistrict. Data were obtained from interviews and observations, and then compared with existing theories.
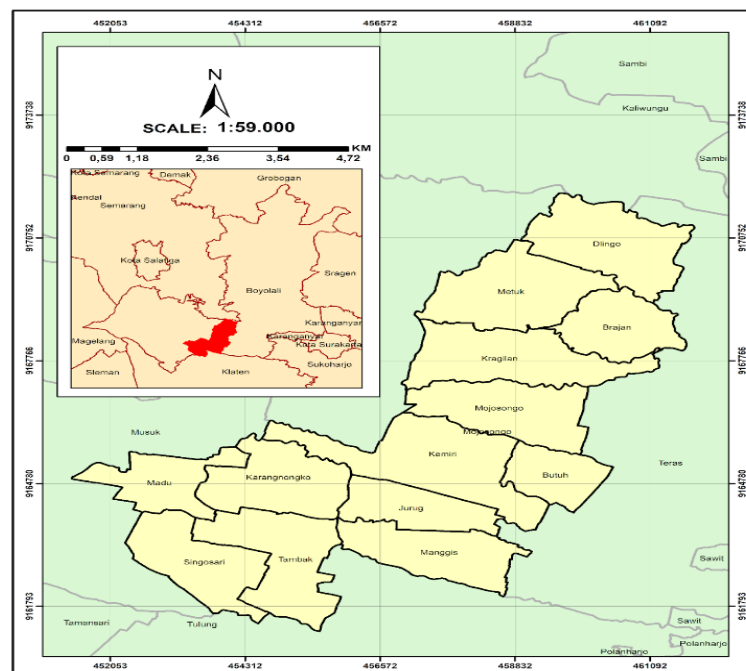

Figure 1. Research Location of Mojosongo Subdistrict, Boyolali Regency

Table 1. Tools Used in Research

Name of Tool	Function
ArcMap 10.2	For processing spatial data and creating maps
Handphone	To take photos of land-use changes in Mojosongo Subdistrict
Laptop	To process the results of land-use changes

Table 2. Materials Used in Research

Name of Data	Function	Source
Road Network Data for Boyolali Regency	To identify road networks in the research area	BAPPEDA
Land-Use Data for Boyolali Regency	To determine the area of irrigated rice fields and dry land	BAPPEDA
Administrative Data for Mojosongo Subdistrict	To define the boundaries of the research area	BAPPEDA
Population Data for Mojosongo Subdistrict	To collect population data	Central Bureau of Statistics (BPS)
Geo-Eye Imagery for 2013 and 2023	To observe the differences between 2013 and 2023	Geo-Eye Satellite

The data collection for this research aims to identify land-use changes between 2013 and 2023 in Mo-josongo Subdistrict, Boyolali Regency. The data used in this research includes both primary and second-ary data. Primary data consists of direct field observations to observe existing changes, assisted by Geo-Eye imagery. Secondary data is obtained from government agencies such as BAPPEDA (Regional Devel-opment Planning Agency) of Boyolali Regency and the Central Bureau of Statistics (BPS). The secondary data collected includes administrative boundaries of Boyolali Regency, population data, area size, and land-use data for Boyolali Regency.

Data analysis for this research uses qualitative descriptive analysis, which involves describing and explaining land-use maps from 2013 and 2023 using an overlay technique. This method helps identi-fy land-use changes and the extent of the land that has changed by 2023. Additionally, qualitative de-scriptive analysis is used to determine the factors influencing land-use changes in Mojosongo Subdistrict by gathering literature on land-use changes from various sources such as journals, books, documents, and related articles. The literature aids in deepening the understanding of land-use changes and the fac-tors affecting these changes.

3. Results and Discussion

3.1. Analysis of Land-Use Changes in Mojosongo Subdistrict from 2013 to 2023

Land use change analysis in the research area needs to be done to find out how much land use change has occurred over the past 5 years. This analysis is processed in ArsGIS software using the map overlay method. Overlay is the process of combining data from different layers. In simple terms, overlay is re-ferred to as a visual operation that requires more than one layer to be physically combined (Latief et al., 2021).

Land-use changes in Mojosongo Subdistrict between 2013 and 2023 have been significant. The increase in land-use is attributed to the relocation of the government center and the development of industrial areas, which have led to the growth and expansion of residential areas. Below are the land-use data for 2013 and 2023.

Table 3. Land Use Based on its Usage in Mojosongo Subdistrict from 2013 to 2023

No	Land Use	Area (ha)		Land-Use Change	
		2013	2023	Area (ha)	Percentage (%)
1	Irrigated Rice Fields	898.58	897.96	0,62	0,03
2	Residential	2,694.43	4,239.21	1544,8	89,9
3	Grassland	51.49	31.24	20,25	1,17
4	Dryland Fields	406.73	254.19	152,54	8,87

Based on Table 3, in 2013, the area of irrigated rice fields was 898.58 hectares, residential areas covered 2,694.43 hectares, grassland was 51.49 hectares, and dryland fields amounted to 406.73 hectares. In 2023, the area of irrigated rice fields was 897.96 hectares, residential areas expanded to 4,239.21 hectares, grassland decreased to 31.24 hectares, and dryland fields shrank to 254.19 hectares. Over the ten years, irrigated rice fields decreased by about 0.62 hectares, residential areas increased by 1,544.8 hectares, grassland reduced by 20.25 hectares, and dryland fields decreased by 152.54 hectares. The largest percentage change occurred in residential areas, which expanded by 89.90%. Below is the land-use change map from 2013 to 2023.

3.2. Analysis of Land-Use Changes in Mojosongo Subdistrict from 2013 to 2023

Land-use changes between 2013 and 2023 in Mojosongo have fluctuated, with both reductions and additions to land-use types. Land use in Mojosongo Subdistrict includes forests, mixed gardens, vacant land, residential areas, dryland fields, and others. Interviews revealed that several respondents identified multiple factors driving land-use changes. The factors examined in this study include infrastructure conditions, accessibility, land-carrying capacity, and the influence of regional expansion. These factors were identified through land-use change data and validated by interviewing local village officials and residents of Mojosongo Subdistrict. The following table shows the frequency scores obtained from interviews with village officials and residents:

Table 4. Frequency Scores from Interviews with the Public & Village Officials

Factor	Community Frequency Value	Village Apparatus Frequency Value
Regional Expansion	71%	100%
Permitting	100%	100%
Infrastructure	43%	86%
Accessibility	100%	71%
Land Carrying Capacity	-	14%

Based on the table above, the respondents from both the government and the public identified several key factors that underlie land-use change: permitting, accessibility, and regional expansion. These three factors were highlighted by the public respondents, while government respondents also emphasized the influence of regional expansion, permitting, infrastructure, and accessibility.

Regional expansion occurs to ensure that government functions are felt beneficially by the public, in accordance with legal regulations, as outlined in the Indonesian Government Decree No. 129 of 2000 concerning the requirements and criteria for regional expansion, elimination, and merger. The goal is to improve public welfare. Therefore, the interview results show that regional expansion has a frequency impact score of 100% for government officials and 71% for the public. The public has largely responded positively to regional expansion, as it has led to more effective governance and improved welfare. The visible impacts include increased village development and improvements in services.

In the interview results, the permitting factor has a high frequency score of 100% for both the village officials and the public. This indicates that there is ease in obtaining building permits, and the permitting process has a strong influence on land-use change.

Permitting is also a key government policy that affects land-use change. Accessibility also showed a high frequency score of 71% and 100%, with the 71% figure coming from interviews with village officials. Some villages are located relatively far from others, particularly from the autonomous center/government center. The ease of access in Mojosongo Subdistrict affects daily activities, as residents can easily reach the central locations, which in turn impacts land-use changes.

Infrastructure in Mojosongo Subdistrict, based on the interviews, is perceived as adequate and evenly distributed across the community. Public facilities that meet the community's needs, such as health centers, educational institutions, government offices, and multi-purpose buildings, are available in every village. Additionally, there are shared water reservoirs and wells that benefit the public. This infrastructure development has contributed to land-use change in Mojosongo Subdistrict. The increase in residential land area to 89.9% in Mojosongo Sub-district has an impact on the reduction of water catchment areas. This reduction in the function of the catchment area can lead to an increased risk of hydrometeorological disasters, such as floods and landslides, especially during high rainfall. In addition, the reduction in water catchment areas can also lead to a decrease in groundwater availability, which in the long run has the potential to trigger drought in the region. Therefore, the government needs to implement a balanced land use control policy between residential development and preservation of water catchment areas. This policy is important to anticipate various potential disasters that can arise due to imbalanced land use.
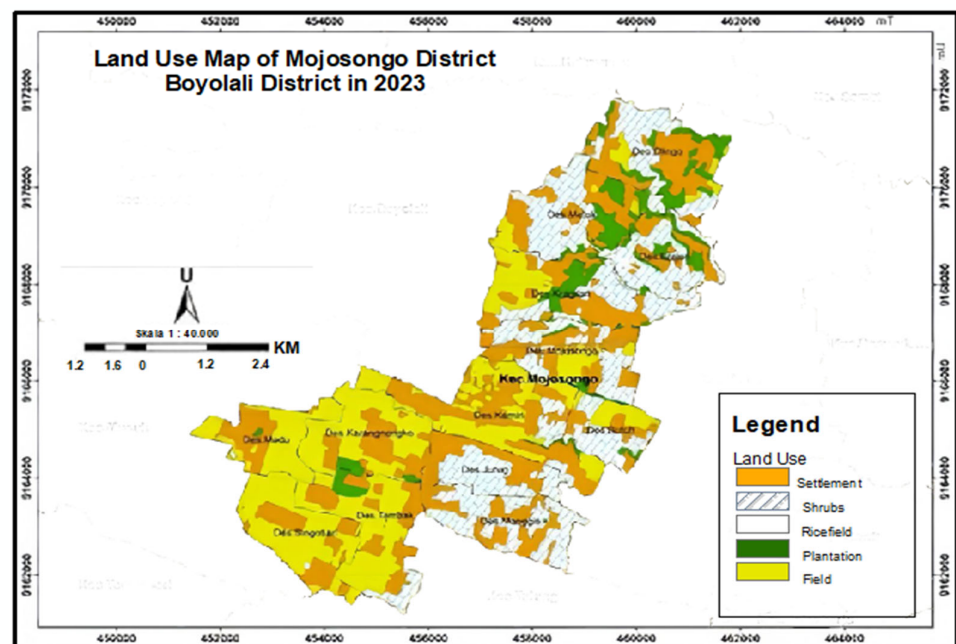

Figure 2. Research Result Map

The results obtained in addition to the feasibility class of Ngembak Landfill, which is in a location worth considering, is the suitability or feasibility for landfill sites in Grobogan Regency, which is presented in the Figure 2 map above with three feasibility classes, namely feasible and suitable, worth considering and not feasible or not suitable. The feasibility class dominates the other two classes with the most significant area. The areas for the three classes of land feasibility for landfill sites in Grobogan Regency are presented in Table 5.

Table 5. Level of Feasibility and Land Suitability of Landfill Sites

Class	Value	Level of Feasibility and Suitability	Area (Ha)
I	162 - 230	Appropriate	20202
II	93 - 161	Worth considering	146440
III	23 - 92	Not feasible/not suitable	31643

3.2. Analysis of Land-Use Changes in Mojosongo Subdistrict from 2013 to 2023

Grobogan Regency, with an area covering 1,975.86 km² can be categorized as a Regency with a large area so that facilities and infrastructure must be able to serve all population activities both during activities and something that is produced from population activities, one of which is waste so that a proper landfill location is a must. The results of the feasibility evaluation of the Ngembak Landfill, which is the only waste landfill in Grobogan Regency, only show a feasibility class worth considering it will be difficult and unwise to continue to be relied upon, so it is necessary to recommend the location of a new Waste Landfill using an overlay analysis so that several locations are suitable and feasible to be used as the location of a new waste landfill in Grobogan Regency with locations that have high accumulated values and feasible suitability classes that will be recommended or selected. The recommended location of the new waste landfill in Grobogan Regency is shown in Figure 3.
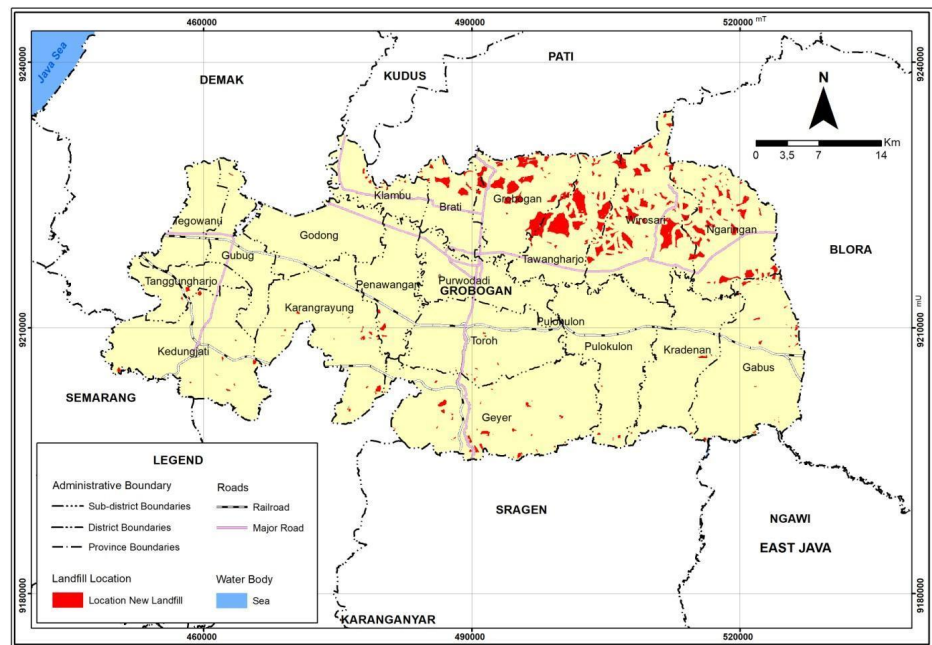
Figure 2. Map of Recommended New Landfill Sites for Grobogan Regency in 2024

4. Conclusion

Land use in Mojosongo Subdistrict has undergone significant changes due to the relocation of the government center to this area. The land-use changes include residential developments, shopping centers, schools, and other facilities. Mojosongo Subdistrict has a total land area of 4,341.16 hectares. The relocation of the government center to Mojosongo Subdistrict has been one of the key factors behind population movement, industrial growth, and the establishment of other central functions. Over eight years, the most significant change occurred in residential

Author Contributions

Conceptualization: Anjar Nur Hidayat, Umrotun; **methodology**: Anjar Nur Hidayat, Rikuto Daikai; **investigation**: Anjar Nur Hidayat, Umar El Izudin Kiat; **writing— original draft preparation**: Anjar Nur Hidayat; **writing—review and editing**: Rikuto Daikai; **visualization**: Anjar Nur Hidayat, Author Y. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

areas, which expanded by 89.90%. Based on the discussion and analysis, the following conclusions can be drawn:

1. The land-use changes in Mojosongo Subdistrict between 2013 and 2023 amount to a total of 1,180.1 hectares, accounting for 27.03% of the total area. The land that remained unchanged covers an area of 3,185.6 hectares, representing 72.97%. The land-use type that saw the most change was residential land, which increased by 204.1 hectares, or 21.45%.

2. Regional expansion and permitting are the dominant factors driving land-use changes. Regional expansion has led to both public and governmental development, while permitting policies have greatly facilitated construction. The expansion of mining and business activities in Mojosongo Subdistrict has been made possible by the ease of the permitting process.

The addition of visualization of 2013 land use data is recommended to provide a clearer spatial picture of land use change. In addition, an explanation of the pattern of land use change during the 2013-2023 period, whether it took place gradually or experienced a spike at a certain time, could strengthen the quality of the analysis. Linking the research results with the local Regional Spatial Plan (RTRW) map can also deepen the study of land use change conformity to spatial policies. Furthermore, this research can serve as a basis for further studies related to the social and economic impacts of land use change in Mojosongo Sub-district. In addition, the data obtained in this study can be used to evaluate spatial management by the government, especially in anticipation of ongoing regional development in the area.

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