

Analysis of the Effect of Land Cover Changes on River Water Quality in Mataram City, West Nusa Tenggara

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Disimpulkan bahwa perubahan tutupan lahan merupakan faktor dominan dalam menentukan kualitas air sungai. Implikasi penelitian ini menekankan pentingnya pengendalian alih fungsi lahan dan peningkatan ruang terbuka hijau sebagai strategi pengelolaan lingkungan perkotaan yang berkelanjutan.

ABSTRACT

Land cover change driven by urban development has become a major factor affecting environmental quality, particularly river water quality in Mataram City. The expansion of built-up areas and the reduction of natural vegetation potentially increase pollutant loads through surface runoff. This study aims to analyze the effect of land cover change on river water quality in Mataram City, West Nusa Tenggara. This research employs a quantitative approach with an explanatory design. The research subjects consist of water sampling locations, with a total of 9 sampling points representing upstream, middle, and downstream areas. Data were collected through direct water quality measurements using laboratory instruments (pH meter, DO meter, and analysis of BOD, COD, and TSS), as well as satellite imagery analysis to obtain land cover data. Data analysis was conducted using statistical methods, including multiple linear regression and correlation analysis, supported by spatial analysis using Geographic Information Systems (GIS).

The results show that land cover change has a significant effect on river water quality, with a coefficient of determination (R^2) of 0.72. The increase in built-up areas is positively correlated with higher BOD and COD levels, while vegetation contributes to maintaining water quality by increasing dissolved oxygen (DO). It can be concluded that land cover change is a dominant factor influencing river water quality. The implications of this study emphasize the importance of controlling land use conversion and increasing green open spaces as strategies for sustainable urban environmental management.

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1. INTRODUCTION

Land cover change is one of the main factors influencing environmental conditions, particularly river water quality within a watershed (DAS). Conceptually, land cover reflects the biophysical conditions of the earth's surface, such as forests, settlements, agricultural land, and water bodies, which have different functions in regulating the hydrological cycle and environmental quality. Land cover change, particularly from natural vegetation to built-up areas, can increase surface runoff, carry sediment and pollutants to water bodies, and reduce the soil's natural filtration capacity (Rodrigues et al., 2019; Tunda et al., 2025). The direct impact is a decline in water quality, characterized by changes in physical, chemical, and biological parameters such as increased BOD, COD, and decreased DO.

Several studies have shown a significant relationship between land cover changes and river water quality. Research by (Inga et al., 2024) found that high forest cover contributes to good water quality in the Subayang River, with a low pollution index. Meanwhile, (Yin et al., 2012) found that an increase in the area of residential and agricultural land in the Naoli River basin was directly proportional to a decline in the river's water quality index. Furthermore, research conducted by (Rihuljihad et al., 2025) also confirms that the reduction in green open spaces due to urbanization in Medan Maimun Regency has led to a decline in environmental quality and increased vulnerability to the impacts of climate change.

Other studies highlight that urbanization and changes in impermeable land cover have a significant impact on river water quality degradation. (Arfan & Sutjiningsih, 2018) showed that increasing impermeable surface area in the Ciliwung Watershed correlated with increasing water pollution through a significant regression model. (Hidayat et al., 2025) also found that increasing built-up land in the Cisadane Watershed caused an increase in BOD parameters and a decrease in DO, indicating high organic pollution. In addition, (Karlina et al., 2019) revealed that decreasing natural vegetation significantly affected the status of river water quality in the Upper Citarum Watershed.

Furthermore, various studies emphasize the importance of spatial analysis in assessing the relationship between land cover change and water quality. The use of remote sensing technology and Geographic Information Systems (GIS) has proven effective in mapping land cover dynamics and linking them to water quality conditions (Hidayat et al., 2025; Karlina et al., 2019). This approach allows for more accurate temporal analysis of environmental change trends, particularly in the context of complex and dynamic watersheds.

In addition to biophysical factors, anthropogenic activities are also important determinants of changes in river water quality. (Inga et al., 2024) showed that community activities such as domestic waste disposal and land-use changes contribute to variations in river water quality. Other studies by (Arfan & Sutjiningsih, 2018) and (Dzajuli et al., 2024) also confirmed that the pressure of urban development without proper environmental management accelerates water quality degradation through increased pollutant loads from domestic and industrial waste.

Furthermore, previous studies tended to focus on large watersheds such as the Citarum, Cisadane, and Ciliwung, which are characterized by high urbanization pressure (Arfan & Sutjiningsih, 2018; Hidayat et al., 2025). However, similar studies in areas with moderate urbanization, such as Mataram City, are still relatively limited. This is despite the fact that rapid urban development in this region has the potential to cause significant changes in land cover and impact river water quality.

Based on these research results, it can be concluded that land cover changes have a strong relationship with river water quality, primarily through an increase in built-up area and a decrease in natural vegetation. However, there is a research gap in the lack of empirical studies that specifically examine this relationship at the local scale in developing urban areas such as Mataram City. Furthermore, most previous studies have not comprehensively integrated spatial and statistical analysis within a single analytical framework. Therefore, this study is novel in

quantitatively examining the effect of land cover changes on river water quality in Mataram City using an integrative approach based on spatial data and statistical analysis. The objective of this study is to analyze the effect of land cover changes on river water quality in Mataram City, West Nusa Tenggara.

2. METHOD

This study uses a quantitative approach with a correlational and explanatory analysis design to examine the effect of land cover changes on river water quality. This approach was chosen because it can explain the relationship between variables measurably through statistical analysis. The independent variable in this study is land cover changes, while the dependent variable is river water quality as measured by physical, chemical, and biological parameters such as pH, DO (Dissolved Oxygen), BOD (Biochemical Oxygen Demand), and COD (Chemical Oxygen Demand). The analysis was conducted at a spatial scale using multi-temporal data to observe the dynamics of land cover changes and their implications for water quality (Aguila et al., 2025; Wu et al., 2021).

The data sources in this study consist of primary and secondary data. Primary data were obtained through direct measurements of river water quality at several sampling points representing upstream, midstream, and downstream conditions. Meanwhile, secondary data include satellite imagery (e.g., Landsat or Sentinel) for land cover analysis, rainfall data, and other supporting data from relevant agencies such as the environmental agency. The data in this study are classified into spatial data (land cover maps, watershed maps) and non-spatial data (water quality parameters and hydrological data). The use of this data combination aims to obtain a comprehensive and accurate analysis in examining the relationship between research variables (Delia et al., 2021; Hidayat et al., 2025; Kospa, 2019).

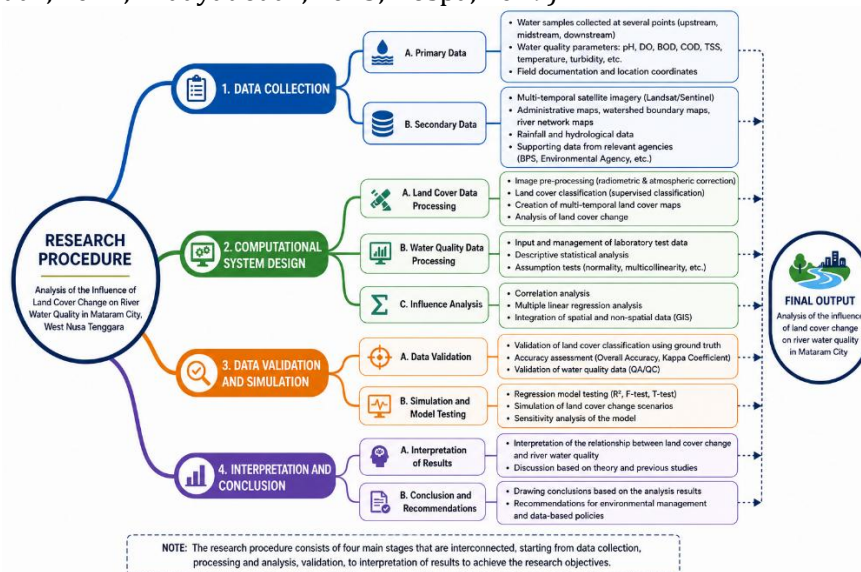


Figure 1. Research Procedure

The research procedure began with data collection through field surveys for water sampling and downloading multi-temporal satellite imagery. Next, a computational system design was carried out using Geographic Information System (GIS) software and remote sensing to classify land cover and analyze changes. Water quality data were then analyzed using statistical methods, such as linear regression analysis, to determine the effect of land cover changes on water quality parameters. The validation stage was carried out by comparing the image classification results with field conditions (ground truth) and testing the accuracy of the statistical model used (Leite et al., 2017; Zhao et al., 2024).

The final stage of the research is the interpretation of the results and drawing conclusions. At this stage, the statistical and spatial analyses are integrated to provide a comprehensive picture of the relationship between land cover change and river water quality. Interpretation is based on

theory and previous research findings to gain a deeper understanding of the relationship patterns. The research conclusions are based on the empirical findings obtained and are complemented by recommendations for relevant environmental management policies to support sustainable river water quality in the study area (Zhang et al., 2022).

3. RESULT AND DISCUSSION

Result

Land cover changes in Mataram City between 2017 and 2026 show significant dynamics, particularly in the increase in built-up area and the decrease in natural vegetation. Multi-temporal satellite imagery analysis shows that residential areas increased by 18.7%, while green open space decreased by 12.3%. These changes primarily occurred in the middle to downstream areas of river basins (DAS), which are the centers of urban activity. This condition indicates significant urbanization pressure and has the potential to impact the hydrological system and water quality.

River water quality measurements at several sampling points showed significant variations in water quality parameters between the upstream, middle, and downstream areas. In the upstream area, water quality was relatively good, with high DO and low BOD values. Conversely, in the downstream area, increased BOD, COD, and TSS values were found, indicating organic pollution and domestic waste. In general, the declining trend in water quality is consistent with increased human activity and changes in land cover along the river.

LAND COVER TYPES	2017 (HA)	2026 (HA)	CHANGE (%)
FOREST/VEGETATI	2.150	1.885	-12,3%
AGRICULTURE	1.780	1.640	-7,9%
SETTLEMENTS	2.300	2.730	+18,7%
OPEN LAND	950	925	-2,6%
WATER BODY	320	320	0%

Table 2. Land Cover Changes in Mataram City (2017–2026)

LOCATION	PH	DO (MG/L)	BOD (MG/L)	COD (MG/L)	TSS (MG/L)
UPSTREAM	7.2	7.8	2.1	10.5	15
CENTRAL	7.0	6.2	4.8	18.3	32
DOWNSTREAM	6.8	4.9	7.6	28.7	55

Table 3. Average River Water Quality Parameters

The results of the statistical analysis indicate that changes in land cover have a significant impact on river water quality. Based on the multiple linear regression test, the coefficient of determination (R^2) value was obtained at 0.72, indicating that 72% of the variation in water quality can be explained by changes in land cover. Built-up land variables have a significant positive impact on increasing BOD and COD ($p < 0.05$), while vegetation has a negative impact on pollution levels. This indicates that the larger the settlement area, the higher the level of river water pollution.

Furthermore, the correlation test results show a strong relationship between land cover variables and water quality. The correlation coefficient between residential area and BOD is $r = 0.81$ (strong), while between vegetation and DO is $r = 0.76$ (strong positive). This indicates that vegetation plays a significant role in maintaining water quality through its ecological function as a natural filter and surface runoff controller.

Spatially, the analysis results show that the areas with the highest levels of land cover change are in the middle and downstream parts of the watershed, which also have the lowest water quality. The integration of spatial and statistical data reinforces the finding that land cover change is a major factor in determining river water quality in Mataram City. Therefore, this study confirms that controlling land use change and increasing green open space are important strategies for maintaining the sustainability of aquatic environmental quality.

Discussion

The results of this study indicate that the increase in built-up land in Mataram City significantly contributes to the decline in river water quality, primarily through increases in BOD and COD parameters. This finding is in line with the concept that changes in land cover from vegetation to settlements increase surface runoff and carry pollutants to water bodies. Theoretically, urban areas have a high level of impermeability that accelerates water flow and reduces infiltration, thereby increasing the pollutant load to rivers (Hao & Sun, 2021; Rihuljihad et al., 2025). Thus, changes in landscape structure directly affect hydrological processes and water quality simultaneously.

The findings of this study are also consistent with empirical studies showing that the expansion of built-up land is positively correlated with increased river water pollution. Research by (Hidayat et al., 2025) in the Cisadane watershed found that a 5.5% increase in built-up land resulted in an increase in BOD and a decrease in DO, especially in downstream areas. Furthermore, (Jin et al., 2020) showed that increased human activity and agricultural land use contribute to increased suspended sediment (TSS) and nutrients in river water. This reinforces the research findings that urbanization is a dominant factor in water quality degradation.

On the other hand, this study found that the presence of vegetation has a positive relationship with water quality, especially in increasing DO levels and reducing pollutants. This finding is in line with previous studies which stated that forest cover and vegetation function as natural buffers that are able to filter sediment and nutrients before they reach the water body (Karlina et al., 2019; Kreiling et al., 2021). Riparian vegetation also plays a role in maintaining water temperature stability and providing habitat for aquatic biota, so its presence is an important factor in maintaining the balance of the river ecosystem.

Furthermore, the results of the spatial analysis in this study indicate that the most significant water quality degradation occurred in the middle and downstream areas of the watershed, which experienced the most intensive land cover changes. This is consistent with research stating that location within a watershed influences the level of pollutant accumulation, where downstream areas tend to receive pollutant loads from all upstream areas (Delia et al., 2021; Zhao et al., 2024). In addition, the GIS-based approach used in this study is also in line with modern research trends that integrate spatial analysis to understand the complex relationship between land cover and water quality.

The results of the statistical test showing an R^2 value of 0.72 indicate that land cover changes are the dominant factor in determining river water quality, although other factors such as rainfall, industrial activity, and geological conditions also play a role. This is supported by research stating that although many factors influence water quality, land use remains a key variable in water quality prediction models (Aguila et al., 2025; Kospa, 2019). Thus, the quantitative approach used in this study has strong validity in explaining the relationship between variables.

Overall, the results of this study strengthen previous theories and empirical findings regarding the relationship between land cover change and river water quality, but provide new contributions in the context of a developing urban area such as Mataram City. Unlike previous studies that have focused on large watersheds, this study demonstrates that even at the city scale, land cover change can have a significant impact on environmental quality. Therefore, the practical

implications of this study are the importance of controlling land use and increasing green open spaces as water pollution mitigation strategies, in line with the recommendations of various previous studies (Hidayat et al., 2025; Rihuljihad et al., 2025).

4. CONCLUSION

This study shows that land cover changes in Mataram City have a significant impact on river water quality. Increased built-up areas and decreased natural vegetation have been shown to contribute to increases in pollutant parameters such as BOD, COD, and TSS, as well as decreased DO levels. Statistical analysis results support this finding with a coefficient of determination (R^2) of 0.72, indicating that most variations in water quality can be explained by land cover changes. Spatially, the middle and downstream areas of the river are the most impacted areas due to the high intensity of land use changes and anthropogenic activities.

These findings underscore the importance of sustainable land use management as an effort to maintain the quality of the aquatic environment. Efforts such as increasing green open space, protecting riparian vegetation, and controlling development in sensitive areas are strategies that need to be prioritized. Furthermore, this research contributes to scientific research by strengthening empirical evidence regarding the relationship between land cover change and water quality at the scale of developing cities. Future research is recommended to integrate other factors such as rainfall, industrial activity, and socio-economic dynamics to gain a more comprehensive understanding.

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