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Evaluating the Suitability of Wetland Conversion into Residential Areas Based on the Spatial Plan of Banjarbaru City for 2024–2043

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Abstract

Wetland conversion for housing can create discrepancies between observed land use and designated zoning. This study examined the distribution and spatial pattern of wetland conversion to residential use in Banjarbaru City from 2019 to 2024 and assessed its alignment with the 2024–2043 Regional Spatial Plan (RTRW). The study identified converted areas by overlaying land-cover maps from 2019 and 2024, used nearest neighbor analysis to assess spatial clustering, and overlaid the converted areas with the plan's zoning map. Approximately 121 ha of wetlands were converted, primarily in Landasan Ulin (58.44 ha) and Liang Anggang (54.07 ha). Conversion exhibited a statistically significant clustered pattern (nearest neighbor ratio = 0.263, $z = -81.61$, $p < .001$). Of the converted area, 73.91 ha fell within designated residential zones, 45.91 ha within nonresidential cultivation zones, and 1.16 ha within protected areas. The concentration of conversion in Landasan Ulin and Liang Anggang identifies priorities for spatial monitoring, while conversion outside designated residential zones highlights the need for stronger land-use controls to support RTRW implementation.

Keywords: Wetland Conversion; Residential Development; Nearest Neighbor Analysis; Spatial Planning; Banjarbaru City

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INTRODUCTION

Urban development increases the demand for land to accommodate housing, infrastructure, and socioeconomic activities. From a geographical perspective, these changes need to be examined through the relationships between human activities, environmental characteristics, and spatial land-use patterns (Suma & Pratama, 2023). Spatial analysis is particularly important because it provides information for understanding regional changes and supporting sustainable development planning (Lane, 2017). However, limited land availability and growing housing demands may encourage the conversion of areas with important ecological functions, including wetlands.

Land conversion refers to changes in the use of an area from its original function to another purpose, potentially affecting environmental conditions and land capability (Al-Vatia & Nugroho, 2019). Such changes are associated with increasing spatial demands resulting from population growth and urban development (Ven et al., 2021). This issue is particularly relevant in Banjarbaru City, South Kalimantan, where residential development takes place alongside existing wetland ecosystems. Syam'ani et al. (2019) documented a decline in wetland areas in Banjarbaru over several decades, highlighting the need to investigate subsequent land-use changes in relation to urban development and spatial planning regulations.

Wetlands perform essential ecological functions that contribute to environmental stability. These ecosystems support water storage, provide wildlife habitats, and sustain various forms of life (Keddy, 2023). They encompass diverse environments, including marshes, peatlands, and natural or artificial water bodies with different hydrological characteristics (Gell et al., 2023). Wetlands also provide ecosystem services such as water-flow regulation, erosion control, and biodiversity conservation (Assefa et al., 2021). Consequently, converting wetlands into residential areas should not be understood merely as a physical change in land cover; it also requires an assessment of the implications for ecological functions and sustainable spatial development.

From a regional planning perspective, land-use changes are shaped by interconnected social, economic, political, and environmental factors (Meyer & Turner, 1992). Land development should also consider the suitability of proposed uses in relation to natural land characteristics to minimize environmental degradation (McDowell et al., 2018). In Banjarbaru, these considerations are particularly important because marshes and water-

infiltration areas must be taken into account when planning residential development and implementing spatial policies (Rotinsulu et al., 2024). Accordingly, evaluating wetland conversion requires an approach that connects spatial dynamics with established land-use allocations.

Previous studies have examined land-use changes and their conformity with Regional Spatial Plans (Rencana Tata Ruang Wilayah, RTRW). Mulyasari et al. (2021), for instance, analyzed land-use changes in Banjarbaru using the overlay method to assess their alignment with the city's spatial plan. Adiyaksa and Djojomartono (2020) investigated the conversion of agricultural land into industrial areas, while Reja et al. (2020) examined land-use changes and their conformity with the spatial plan of Bogor City. These studies provide methodological foundations for evaluating land-use changes, although their research objects and analytical priorities differ from those of the present study.

Other research has explored land conversion and its environmental implications through different analytical approaches. Situngkir et al. (2022) investigated wetland-use changes in relation to flooding in residential areas. Khasanah et al. (2022) examined the conversion of water-infiltration land into residential areas, whereas Putri et al. (2024) assessed agricultural land conversion and its conformity with spatial planning provisions. Although these studies contribute to understanding land-use dynamics and their implications, further investigation is needed to integrate wetland-to-residential conversion, spatial distribution patterns, and conformity with the latest RTRW of Banjarbaru City for 2024–2043.

The research gap lies in the limited integration of these three analytical concerns within a study specifically addressing wetland conversion into residential areas in Banjarbaru under the latest spatial planning framework. Pandita et al. (2024) demonstrated the application of spatial analysis to identify land-use changes, while Rochman and Muryamto (2023) evaluated changes in land use against spatial planning provisions using a different analytical approach. Meanwhile, Aji et al. (2019) employed Nearest Neighbor Analysis to identify spatial patterns of land-use change. Collectively, these studies establish the relevance of spatial methods while leaving room for an integrated investigation of wetland conversion, distribution patterns, and spatial plan conformity in the context of Banjarbaru.

The novelty of this study lies in combining overlay analysis, Nearest Neighbor Analysis, and land-conversion growth analysis to examine wetland-to-residential conversion between 2019 and 2024 and its relationship with the Banjarbaru City RTRW for 2024–2043.

A spatial approach enables geographical phenomena to be examined in terms of location, patterns, and distribution (Yunus, 2010). In addition, overlay analysis integrates multiple map layers to generate new spatial information according to the objectives of an investigation (Karonigi & Iriane, 2025). The integration of these methods is expected to provide a more comprehensive understanding of where conversion occurs, how it is spatially distributed, and whether the resulting land use conforms to the designated spatial plan. This analytical approach is also consistent with the broader application of GIS-based overlay techniques in spatial assessment (Erfani et al., 2023).

Accordingly, this study aims to analyze the distribution and spatial patterns of wetland conversion into residential areas in Banjarbaru City in 2019 and 2024 and to examine the implications of these changes for the city's RTRW for 2024–2043. Evaluating spatial conformity is also relevant to assessing whether land use remains consistent with planned spatial functions and the capacity of areas to support water infiltration (Suhel et al., 2021). Previous research on spatially based land-use change further provides a foundation for this investigation (Nurwanda et al., 2016). The findings are expected to contribute to geographical research and provide an evidence base for evaluating spatial-use control, supporting wetland management, and promoting sustainable residential development.

METHODS

This study employed a descriptive quantitative approach based on spatial analysis using a Geographic Information System (GIS). A census design was applied to wetland and residential areas in Banjarbaru City in 2019 and 2024. Field surveys were conducted to verify existing land conditions, while photographic documentation provided supporting evidence. The spatial approach was used to identify land-cover changes, their distribution patterns, and their conformity with the applicable spatial plan (Yunus, 2010).

The research was conducted in Banjarbaru City, South Kalimantan, encompassing five districts: Banjarbaru Selatan, Banjarbaru Utara, Cempaka, Landasan Ulin, and Liang Anggang. The study population covered the entire administrative area of 30,536.4 hectares. The units of analysis consisted of wetland and residential areas in 2019 and 2024; therefore, no human participants were involved. The census approach enabled the analysis to cover the entire geographical area within the established research boundaries. The selection of

analytical units was based on their geographical characteristics and relevance to the research objectives (Sugiyono, 2013).

The research design addressed two main analytical focuses. The first concerned wetland conversion into residential areas, measured by the area converted in hectares and its spatial distribution pattern, classified as clustered, random, or uniform. The second concerned the conformity of land use with the Banjarbaru City Regional Spatial Plan (Rencana Tata Ruang Wilayah, RTRW) for 2024–2043. Its indicators included the spatial distribution of converted land across designated zones, its location within protected or cultivation areas, and the respective areas conforming and not conforming to the RTRW. These indicators operationalized the study variables and provided the basis for spatial measurement (Maskur, 2024).

Secondary data comprised land-cover maps for 2019 and 2024, administrative boundary maps, and the RTRW spatial-pattern map for 2024–2043, obtained from the Banjarbaru City Department of Public Works and Spatial Planning. Primary data consisted of overlay analysis outputs and field-survey documentation. Data collection involved document review, spatial data processing, direct observation, and verification of existing wetland and residential conditions. The analytical tools included ArcGIS 10.8, Microsoft Excel Office 2021, Google Earth, and GPS Map Camera. Data collection was directed toward obtaining information relevant to the research questions (Sulasmi, 2024).

Data analysis comprised three main stages. First, land-cover data were reclassified into seven categories in accordance with Head of the Geospatial Information Agency Regulation No. 6 of 2015. Second, spatial overlay using clip and intersect operations identified areas classified as wetlands in 2019 that had become residential areas by 2024. The distribution patterns of these changes were subsequently examined using Nearest Neighbor Analysis and the nearest-neighbor index (Riadhi et al., 2020). Third, the resulting change map was overlaid with the RTRW spatial-pattern map to determine the extent and spatial conformity of land conversion. The research procedures comprised preparation, field surveys, and post-field data processing and analysis.

RESULTS

Land-Cover Changes in Banjarbaru City, 2019–2024

A comparison of land-cover data for 2019 and 2024 indicates changes in the composition of land use across Banjarbaru City. Wetland area decreased from 7,649 ha to 3,258 ha, while settlement area increased from 3,078 ha to 5,014 ha. Agricultural land also increased, from 7,819 ha to 11,017 ha. These changes indicate that several land-cover classes experienced substantial changes during the observation period.

Table 1. Land-Cover Comparison in Banjarbaru City, 2019 and 2024

Land-cover class	2019 (ha)	2024 (ha)
Wetlands	7,649	3,258
Settlements	3,078	5,014
Forest	574	571
Agricultural land	7,819	11,017
Grassland	7,358	8,975
Water bodies	323	408
Other land	3,735	1,295
Total	30,536	30,536

Compiled by the researcher (2026)

Table 1. Land-Cover Comparison in Banjarbaru City, 2019 and 2024 shows that wetland area declined, whereas settlement area increased by approximately 1,936 ha. However, this increase cannot be attributed entirely to wetland conversion because settlement expansion may also have occurred on other land-cover classes. Therefore, a specific overlay analysis of the 2019 and 2024 datasets was used to identify areas that changed from wetlands to settlements.

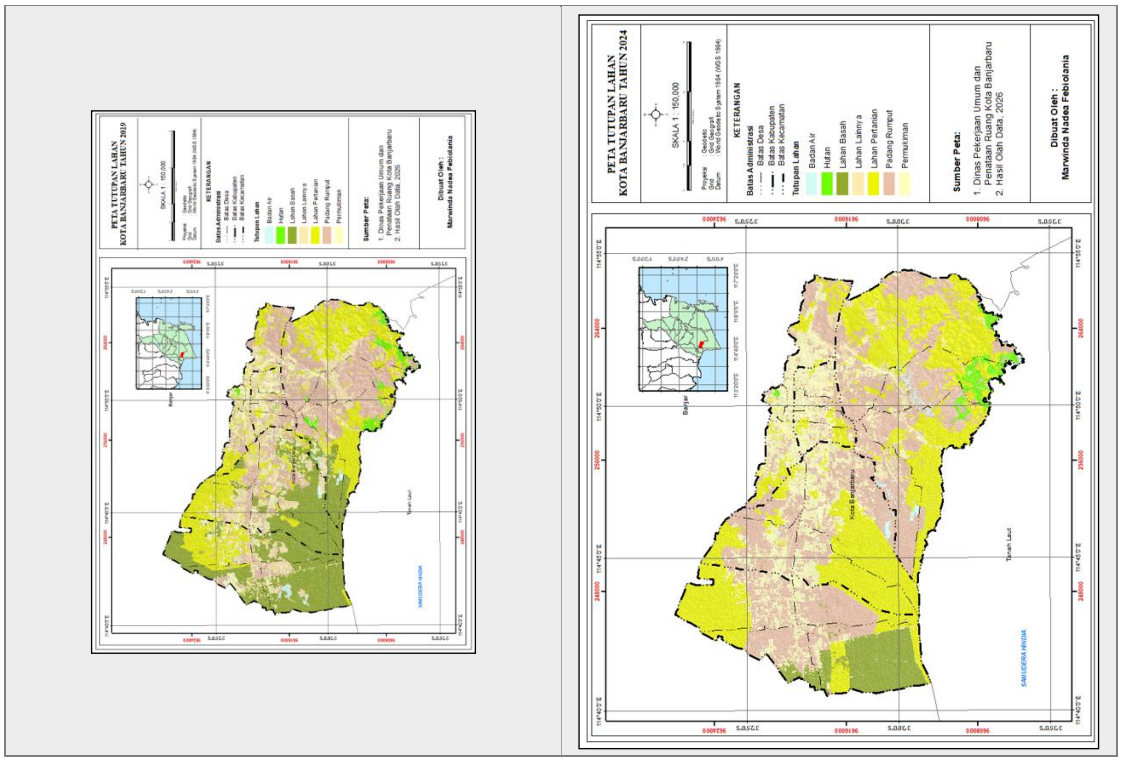


Figure 1. Land-cover maps of Banjarbaru City in 2019 and 2024

Figure 1. Land-cover maps of Banjarbaru City in 2019 and 2024 shows differences in the spatial distribution of land-cover classes between the two observation years. In 2024, wetlands remained concentrated mainly in Liang Anggang and Cempaka, whereas settlements were present across the city's districts. These maps provide the spatial basis for identifying wetland-to-settlement conversion.

Distribution of Wetland Conversion Into Settlements

The overlay analysis identified 120.96 ha of wetlands converted into settlements between 2019 and 2024. The conversion occurred in four districts, with the largest areas recorded in Landasan Ulin and Liang Anggang.

Table 2. Wetland-to-settlement Conversion by District

District	Converted area (ha)	Percentage (%)
Banjarbaru Selatan	0.00	0.00
Banjarbaru Utara	0.07	0.05
Cempaka	8.39	6.94
Landasan Ulin	58.44	48.31
Liang Anggang	54.07	44.70
Total	120.96	100.00

Table 2. Wetland-to-settlement Conversion by District shows that Landasan Ulin and Liang Anggang accounted for approximately 93% of the identified conversion. Cempaka experienced a smaller change, while the conversion identified in Banjarbaru Utara was only 0.07 ha. No wetland-to-settlement conversion was identified in Banjarbaru Selatan.

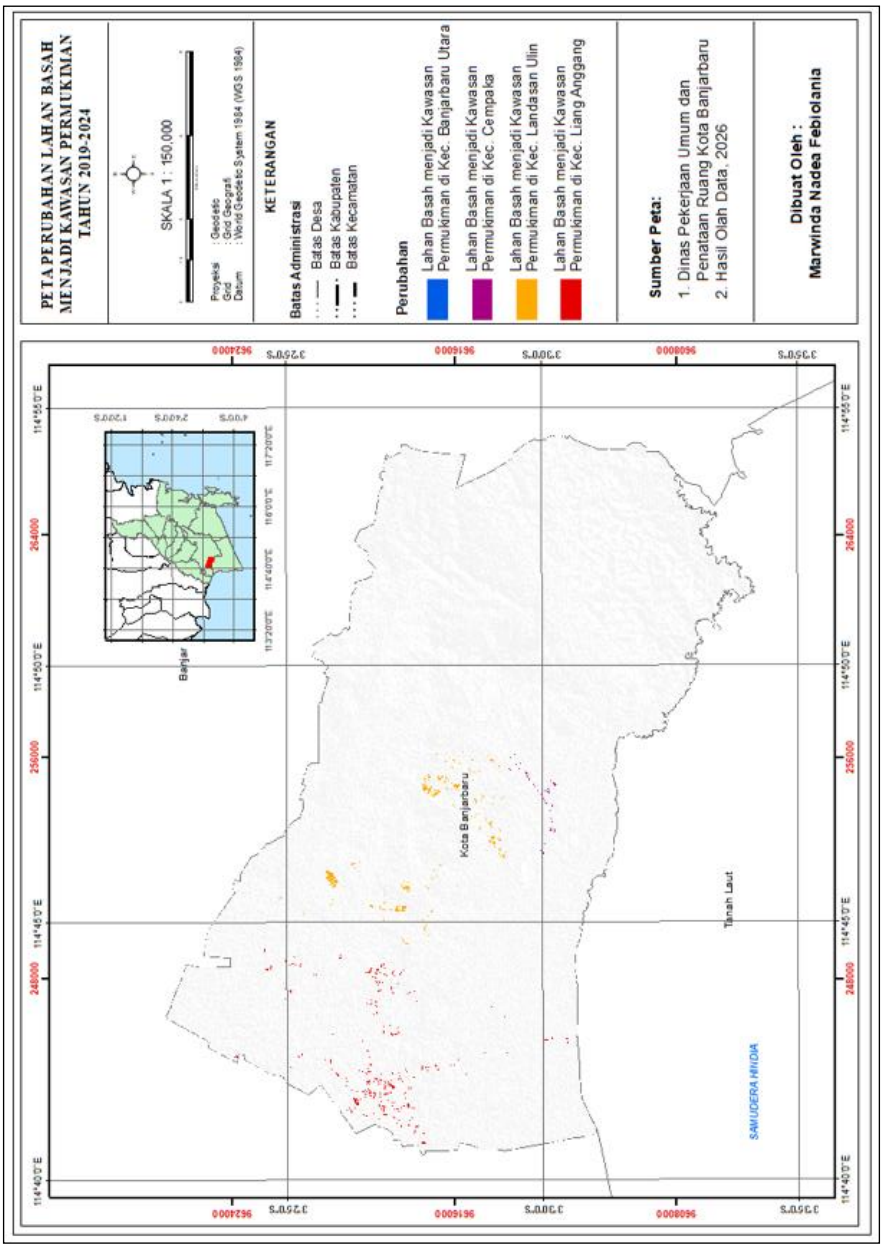


Figure 2. Map of wetland-to-settlement conversion in Banjarbaru City, 2019–2024

Figure 2. Map of wetland-to-settlement conversion in Banjarbaru City, 2019–2024 shows the locations where wetlands were converted into settlements during the study period. The uneven distribution indicates that conversion was concentrated in particular areas, particularly Landasan Ulin and Liang Anggang.

Spatial Distribution Pattern

The Nearest Neighbor Analysis produced a Nearest Neighbor Ratio of 0.263046, a Z-score of −81.612788, and a p-value of 0.000000, as reported in the spatial analysis results. A ratio below 1 indicates a clustered distribution pattern.

Table 3. Spatial Pattern Analysis of Wetland-to-Settlement Conversion

Indicator	Result
Nearest Neighbor Ratio	0.263046
Z-score	−81.612788
p-value	0.000000
Pattern interpretation	Clustered

Compiled by the researcher (2026)

Table 3. Spatial Pattern Analysis of Wetland-to-Settlement Conversion shows that the Nearest Neighbor Ratio of 0.263046, which is below 1, indicates that wetland-to-settlement conversion in Banjarbaru City exhibits a clustered spatial distribution pattern. This means that conversion locations tend to occur relatively close to one another rather than being evenly distributed across the study area. Furthermore, the Z-score of −81.612788 and the p-value reported as 0.000000 indicate that the observed distribution pattern differs significantly from a random spatial distribution. For statistical reporting, the p-value can be expressed as $p < 0.001$ if 0.000000 represents a rounded software output.

The spatial distribution pattern identified through the Nearest Neighbor Analysis is visualized in Figure 3.

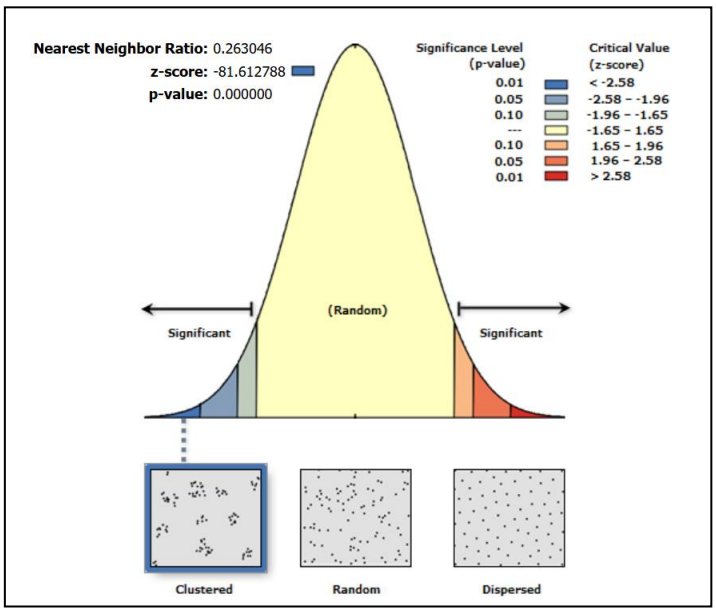


Figure 3. Nearest Neighbor Analysis

Figure 3. Nearest Neighbor Analysis shows that the clustered spatial distribution pattern of wetland-to-settlement conversion in Banjarbaru City. The conversion locations tend to concentrate in particular areas, indicating that individual conversion sites are located relatively close to one another during the 2019–2024 study period.

Conversion in Areas Exposed to Flood Risk

The overlay of conversion locations with the flood-risk map indicated that approximately 56.0 ha of converted land fell within areas identified as exposed to flood risk. Of this area, 12.0 ha were classified as low risk, 36.1 ha as moderate risk, and 7.9 ha as high risk. A further 64.9 ha were located outside areas identified as flood-risk zones in the dataset used.

Table 4. Wetland-to-Settlement Conversion by Flood-Risk Category

Category	Area (ha)	Percentage (%)
Low risk	12.0	21.43
Moderate risk	36.1	64.39
High risk	7.9	14.18
Total area identified as at risk	56.0	100.00
Not identified as flood-risk area	64.9	-

Compiled by the researcher (2026)

Table 4. Wetland-to-Settlement Conversion by Flood-Risk Category shows that the moderate-risk category accounted for the largest share of converted areas identified within flood-risk zones. Liang Anggang had the largest converted area across the risk categories, followed by Landasan Ulin and Cempaka. Nevertheless, conversion also occurred in areas not identified as flood-risk zones, indicating that flood-risk classification alone is insufficient to characterize all locations affected by land conversion.

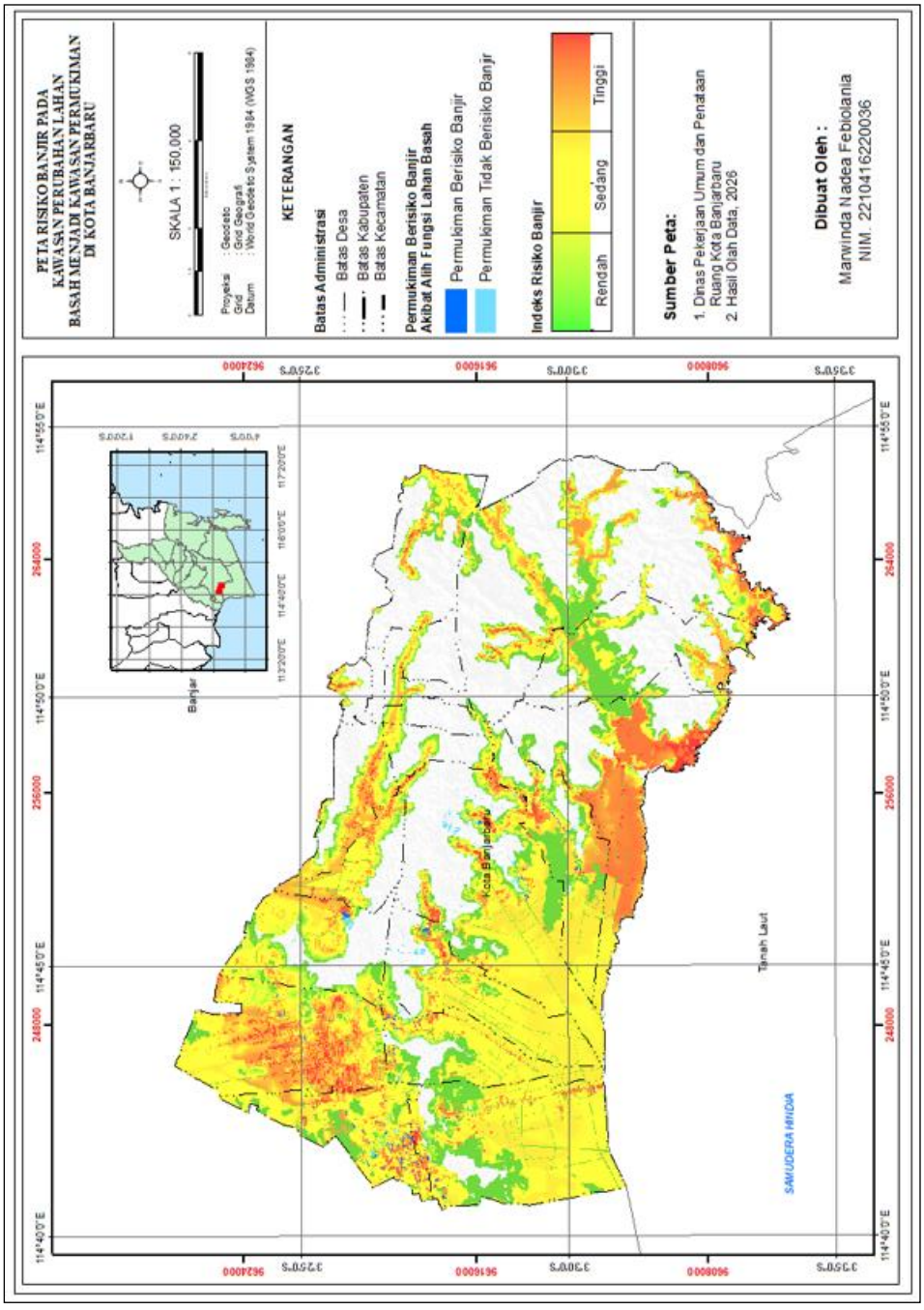


Figure 4. Flood-Risk Map of Areas Affected by Wetland-to-Settlement Conversion

Figure 4. Flood-Risk Map of Areas Affected by Wetland-to-Settlement Conversion shows the spatial overlap between converted areas and flood-risk categories. It helps identify locations that may require closer attention in spatial planning, particularly those within moderate- and high-risk zones.

Conformity with the 2024–2043 Banjarbaru City Spatial Plan

The overlay analysis with the 2024–2043 Banjarbaru City Spatial Plan (RTRW) showed that 73.91 ha of converted land fell within areas designated for settlements. A further 45.91 ha were located in cultivation areas designated for other functions, while 1.16 ha overlapped with protected areas.

Table 5. Conformity of Wetland-to-Settlement Conversion with the RTRW Spatial Pattern

Spatial-plan Category	Area (ha)
Within designated settlement areas	73.91
Within cultivation areas outside designated settlement areas	45.91
Within protected areas	1.16
Total based on category figures	**120.98**

Compiled by the researcher (2026)

Table 5. Conformity of Wetland-to-Settlement Conversion with the RTRW Spatial Pattern shows that most of the identified conversion occurred within areas designated for settlements. However, some converted areas overlapped with cultivation zones assigned to other functions and with protected areas. The findings therefore indicate that wetland-to-settlement conversion has not fully conformed to the spatial pattern stipulated in the 2024–2043 RTRW.

DISCUSSION

Wetland-to-settlement conversion in Banjarbaru City between 2019 and 2024 reflects an uneven pattern of land-use change. The identified conversion of 120.96 ha indicates that settlement development occurred on areas previously classified as wetlands. However, the overall decline in wetland area should not be interpreted as being entirely attributable to settlement expansion, as the land-cover transition analysis also identified conversions into agricultural land, grassland, other land, and water bodies. Distinguishing these transitions is essential to understanding the specific contribution of settlement development to wetland loss. Spatially, the conversion was concentrated in Landasan Ulin and Liang Anggang, which together accounted for approximately 93% of the identified changes. This concentration suggests that wetland conversion was not evenly distributed across the city but occurred predominantly in particular districts. The finding is consistent with the concept of urban expansion, in which built-up areas extend into previously undeveloped land as urban development progresses (Angel, 2023). Nevertheless, the present study did not directly examine the influence of road accessibility, proximity to activity centres, land prices, or

infrastructure availability. These factors may provide potential explanations for the observed distribution, but their effects require further investigation.

The spatial concentration of wetland conversion is further supported by the Nearest Neighbor Ratio of 0.263046, indicating a clustered distribution in which converted locations tend to be closer to one another than would be expected under a random spatial pattern. This result provides additional information about the geographical characteristics of land-use change in Banjarbaru City and suggests that conversion occurred in spatially concentrated areas rather than being dispersed throughout the study area. From a spatial-planning perspective, this pattern can serve as an initial reference for identifying priority areas for land-cover monitoring and evaluating the development of settlements on former wetlands. However, the clustered distribution does not establish the underlying causes of conversion or demonstrate that development in one location directly influences development in neighbouring areas. Therefore, the Nearest Neighbor Analysis should be understood as a means of describing the spatial distribution of conversion rather than establishing causal relationships.

The relationship between wetland conversion and flood risk provides another important dimension of the findings. The analysis identified 56.0 ha of converted areas within mapped flood-risk zones, with moderate-risk areas accounting for the largest share. This finding is relevant because wetlands contribute to water storage and hydrological regulation, making their conversion into built-up areas an important consideration in flood-risk management (Harahap, 2016). Changes in land cover associated with urban development may also influence surface runoff, as discussed by Ridwan and Sarjito (2024) and Nofita et al. (2025). By identifying the extent of converted areas that overlap with different flood-risk categories, this study provides spatial information that can support the evaluation of land-use changes in areas with varying levels of flood risk. Nevertheless, the analysis was based on the spatial overlap between converted areas and an existing flood-risk map. It did not directly measure changes in infiltration, discharge, or runoff volume following conversion. Consequently, the findings indicate the spatial relevance of wetland conversion to flood-risk management but do not establish that the identified changes have increased flood frequency or severity.

Compared with previous literature, the findings extend the discussion of urban expansion presented by Angel (2023) by examining a more specific land-cover transition,

namely the conversion of wetlands into settlements. Rather than focusing exclusively on the general expansion of built-up areas, this study quantifies the extent of wetland conversion, identifies the administrative districts where the changes are concentrated, and evaluates their spatial distribution. The findings therefore provide geographically explicit evidence of where settlement development has replaced wetlands in Banjarbaru City. Furthermore, the integration of spatial distribution analysis with flood-risk mapping provides an additional perspective on the environmental context of these changes. While Harahap (2016) highlights the role of wetlands in water storage and flood regulation, Ridwan and Sarjito (2024) and Nofita et al. (2025) discuss the relationship between built-up land and surface runoff. The present study complements this literature by identifying the extent of converted areas located within low-, moderate-, and high-risk flood zones. However, the spatial overlap should not be interpreted as evidence that wetland conversion has directly altered local hydrological conditions, as establishing such effects would require hydrological measurements or a suitable before-and-after assessment.

The comparison with the Banjarbaru City Spatial Plan (Rencana Tata Ruang Wilayah or RTRW) for 2024–2043 provides further insight into the relationship between observed land-cover changes and designated spatial functions. Of the identified conversion, 73.91 ha occurred within areas designated for settlements, while 45.91 ha overlapped with cultivation areas assigned to other functions and 1.16 ha with protected areas. These results demonstrate the importance of distinguishing between physical land-cover change and conformity with spatial planning. A location may have physically changed into a settlement without being designated for settlement development under the applicable spatial plan. The presence of converted areas within cultivation zones assigned to other functions or protected areas therefore warrants further spatial evaluation. This finding is consistent with the argument that spatial-use control is necessary to identify and address potential deviations from established planning provisions (Nurhikmahwati et al., 2021). Nevertheless, the overlay results alone cannot establish that all such changes constitute legal violations, as this determination requires further verification of the applicable regulations, land-use permits, legal status, and conditions at individual locations.

Taken together, these findings demonstrate the value of integrating land-cover transition analysis, spatial distribution patterns, flood-risk mapping, and spatial-plan conformity within a single analytical framework. Theoretically, this approach provides a more comprehensive understanding of wetland conversion by examining not only the extent of

land-cover change but also its geographical concentration, relationship with mapped flood-risk zones, and position within designated spatial functions. Methodologically, combining overlay analysis, Nearest Neighbor Analysis, and spatial comparison with flood-risk and RTRW maps enables land-use changes to be quantified and evaluated within a broader spatial-planning context. The integration of these analytical dimensions also provides a basis for identifying areas where settlement development on former wetlands deserves closer attention. In practical terms, the concentration of conversion in Landasan Ulin and Liang Anggang provides an initial basis for prioritising land-cover monitoring and reviewing development patterns. Converted areas within moderate- and high-risk flood zones may warrant closer consideration in environmental assessment, drainage planning, and infrastructure development. Similarly, the identification of converted areas within protected zones and cultivation areas not specifically designated for settlements can inform local authorities in reviewing spatial conformity and strengthening land-use monitoring under the 2024–2043 Banjarbaru City RTRW. These implications support evidence-based spatial planning, although administrative and field verification remains necessary before conclusions are drawn about the legal status of individual locations.

Several limitations should be considered when interpreting these findings. First, the study compares land-cover conditions in only two observation years, 2019 and 2024, meaning that it does not establish the precise timing of individual conversion events or the annual progression of settlement development. Second, the accuracy of land-cover classification and overlay analysis depends on the quality, scale, and positional accuracy of the spatial datasets used. Although field verification can help assess the characteristics of identified land-cover classes, it does not necessarily confirm the classification of every pixel or polygon. Third, the flood-risk assessment relies on an existing spatial risk map and does not directly quantify hydrological changes resulting from wetland conversion. Fourth, the RTRW overlay identifies spatial relationships between converted areas and designated land-use functions but does not replace parcel-level verification of permits, legal status, or detailed planning regulations. In addition, a discrepancy remains between the reported total conversion area of 120.96 ha and the combined area of the reported RTRW categories, which amounts to 120.98 ha. This difference should be reconciled against the final spatial data before publication to ensure consistency in the reported results. Despite these limitations, the study provides a spatially explicit account of wetland-to-settlement conversion in Banjarbaru City, including its geographical concentration, clustered distribution, overlap with

mapped flood-risk zones, and relationship with designated spatial functions. The findings offer an empirical basis for further research and spatial-planning evaluation without extending the conclusions beyond what can be established from the datasets analysed.

CONCLUSION

This study found that wetland conversion into residential areas in Banjarbaru City between 2019 and 2024 covered approximately 121 hectares. The largest changes occurred in Landasan Ulin District, accounting for 58.44 hectares (48.31%), followed by Liang Anggang District, with 54.07 hectares (44.70%). Nearest Neighbor Analysis produced a Nearest Neighbor Ratio of 0.263046, a Z-score of −81.612788, and a p-value of 0.000000, indicating a clustered spatial distribution. These findings address the first research objective by quantifying land conversion and identifying its concentration in particular areas.

In relation to the Banjarbaru City Regional Spatial Plan (RTRW) for 2024–2043, 73.91 hectares of converted land fell within zones designated for residential use. Meanwhile, 45.91 hectares were located in cultivation areas allocated for purposes other than residential development, and 1.16 hectares were situated within protected areas. These results indicate that wetland conversion has not occurred entirely in accordance with the designated spatial plan. The second research objective was therefore addressed by identifying the extent and locations of land conversion that conform to, or deviate from, the RTRW.

The study contributes a spatial assessment framework that integrates land-cover change, distribution patterns, and spatial zoning through Geographic Information Systems (GIS). Its findings provide a practical basis for local authorities to monitor land conversion, prioritize field verification, and evaluate spatial utilization, particularly in protected areas. The Banjarbaru City Government should consider developing a GIS-based digital monitoring platform and strengthening development controls. Communities and developers should also consider spatial planning provisions and local environmental characteristics when using land. Future research should incorporate field surveys and interviews to investigate the environmental and social consequences of wetland conversion more comprehensively.

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