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Morphological Transformation Of Situ Cibinong (1901–2025) Based On Colonial Maps And Satellite Imagery

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Abstract

The transformation of urban water bodies due to urbanization has become a critical issue in environmental studies because it affects the sustainability of ecological and hydrological functions within urban landscapes. Situ Cibinong is one of the inland water bodies in Bogor Regency that has experienced significant spatial pressure due to intensive urban development. This study aims to analyze the morphological transformation of Situ Cibinong from 1901 to 2025 through the integration of colonial maps and multi-temporal satellite imagery, while identifying the driving factors behind these changes. This study employed a descriptive-quantitative approach using Geographic Information Systems (GIS) and remote sensing techniques, including georeferencing of a 1901 colonial map, historical water body digitization, 2025 land-use classification, and spatial overlay analysis. Georeferencing validation produced a Root Mean Square Error (RMSE) of ±2.106 meters, while image classification achieved an Overall Accuracy of 85.45% and a Kappa coefficient of 86.26%, indicating reliable results. The findings show that in 1901, Situ Cibinong had a total area of 18.94 hectares. By 2025, it had transformed into two separate water bodies—Situ Citatah (9.42 ha) and Situ Gedong (5.13 ha)—reducing the total area to 14.55 hectares. These changes were primarily driven by residential expansion, which now dominates 83.96% of the study area, contributing to morphological degradation and ecological decline.

Keywords: Landscape Transformation; Water Body Morphology; Historical Cartography; Remote Sensing; Situ Cibinong.

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INTRODUCTION

Rapid development of urban areas in peri-urban regions has exerted substantial pressure on the existence of inland water bodies, particularly lakes and situ that function as natural recharge zones and regional hydrological regulators. Massive residential expansion, road infrastructure development, and intensification of economic activities have radically modified spatial structures, including the conversion of agricultural land and water bodies into built-up areas. This pressure not only threatens significant shrinkage of wet agricultural land but also triggers partial loss of water bodies due to incompatibility with spatial planning(Fajarini et al., 2015). One of the crucial implications of this urban sprawl dynamic is the morphological transformation of water bodies, encompassing reduction in surface area, changes in perimeter shape, spatial fragmentation, and modification of the previously naturally formed basin configuration. Such changes often occur gradually and cumulatively, making them difficult to detect without a long-term spatial analysis approach that integrates historical data with multitemporal satellite imagery(Sahuri et al., 2025).

Although water body transformations have been widely studied in various research, the majority of studies remain focused on surface water area changes, water quality, sedimentation, and land cover dynamics around water areas. Research explicitly examining spatial morphological changes of water bodies from a long-term historical perspective remains relatively scarce. Studies in Bogor Regency tend to emphasize urban sprawl phenomena and land conversion in general, including shrinkage of water areas due to built-up land expansion(Dewa et al., 2026). Therefore, research integrating historical cartographic archives with multitemporal satellite imagery to reconstruct the evolution of water body shapes from the colonial period to the contemporary era remains very limited. This limitation results in suboptimal understanding of the long-term spatial evolution of water bodies, particularly in suburban areas experiencing intensive development pressure(Ananda & Nursadi, 2025).

Advances in remote sensing technology and Geographic Information Systems open broad opportunities to analyze water body spatial dynamics with higher accuracy and efficiency. The use of multitemporal satellite imagery facilitates identification of land cover changes, water body boundary dynamics, and periodic built-up area expansion(Wijanarko et al., 2023). Additionally, geospatial computational innovations enable integration of historical spatial data with modern imagery, allowing more structured reconstruction of landscape dynamics(Wijaya et al., 2020). From a historical research perspective, colonial maps hold strategic value as they represent primary landscape conditions before modern development interventions. Integration of colonial

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maps with contemporary satellite imagery becomes a relevant approach to track longitudinal spatial evolution of water bodies(Sahuri et al., 2025).

Situ Cibinong was selected as the study location due to its strategic position as a major component of the inland aquatic ecosystem in the urban area of Bogor Regency, located near Cibinong Market as a center of local economic activity, as well as being the area most exposed to intensive urban sprawl pressure in recent decades(Kusumaningrum, 2018). Geographically, this area lies within the rapidly developing Cibinong urban expansion corridor resulting from functional shifts from an agrarian landscape to an administrative zone, residential area, and new economic activity center. Previous studies indicate significant spatial changes in Situ Cibinong due to surrounding development, with perimeter modifications and area shrinkage triggered by residential land occupation surging up to 66.9% in built-up areas at transit points(Wilza et al., 2022). This condition makes Situ Cibinong a relevant case for examining longitudinal water body transformation dynamics, particularly the influence of urban pressure on its spatial configuration from the colonial period to the contemporary era.

Although numerous studies have examined land cover change dynamics using remote sensing data, research integrating 20th-century colonial maps with modern satellite technology to comprehensively reconstruct water body morphology remains very limited(Osgouei et al., 2022). This study fills that gap by repositioning Situ Cibinong spatially as an analytical instrument to detect perimeter shifts and morphological degradation over more than a century(Lahay & Koem, 2022). This research emphasizes historical reconstruction of water body morphological shapes and analysis of its shape change dynamics. This approach provides significant contributions to enriching geospatial studies, particularly in understanding longitudinal evolution of urban aquatic landscapes.

Based on the above background, this study aims to analyze the morphological transformation of Situ Cibinong during the 1901–2025 period through integration of 1901 colonial map data with 2025 satellite imagery. Specifically, this research focuses on reconstructing initial morphological conditions of water bodies, identifying occurring shape changes, and analyzing driving factors of morphological dynamics within the context of urban area development dynamics. The research results are expected to provide scientific contributions to landscape change studies while serving as a foundation for sustainable water body management in developing urban areas.

METHODOLOGY

This research applies a spatial-temporal approach in reconstructing the morphological

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transformation of Situ Cibinong through the integration of historical cartographic data with remote sensing technology. This methodological approach combines techniques of digitizing historical analog maps and multitemporal satellite image analysis to detect land cover changes and precise water perimeter boundaries (Pratiwi et al., 2026), while also mapping hydrological patterns that have undergone fragmentation due to development pressures in the surrounding areas (Adi et al., 2022). The primary historical data source in this study is the 1901 colonial map obtained from digital cartographic archives at www.OldMapsOnline.org. This map serves as a baseline reference for identifying the initial morphometric configuration of Situ Cibinong before large-scale anthropogenic interventions (Scherelis et al., 2023). Information extracted from this historical map includes the primary shape of the water body, geographical position, and land use patterns around the situ in the early 20th century.

To represent post-colonial conditions up to the contemporary period, high-resolution satellite imagery from Google Earth in 2025 was used as a reference for current surface conditions to comparatively evaluate area shrinkage and perimeter boundary shifts due to surrounding land use activities (Pratiwi et al., 2019). Additionally, supporting data includes administrative maps, road networks, and historical literature on the development of the Cibinong area. These data were utilized to support the interpretation of land conversion patterns and identify the main driving factors of morphological shifts of the situ within the analysis timeframe (Zahrotunisa, 2017). Supporting data were integrated through georeferencing and digitizing processes using Geographic Information System software to ensure spatial precision between historical maps and satellite data (Merlina et al., 2023).

Subsequently, all previously mentioned spatial data underwent preprocessing stages to ensure uniformity of the spatial reference system across historical and contemporary datasets, allowing accurate analysis of the morphological transformation of Situ Cibinong. Preprocessing stages include georeferencing historical maps, geometric correction of satellite imagery, and cropping the study area. The georeferencing process was carried out by establishing ground control points on permanent features consistently identified in both data sources, such as major road intersections or historical buildings that remain intact (Rani et al., 2022). Specifically for the 1901 colonial map, georeferencing was performed using four control points distributed evenly to minimize geometric distortion and align the projection system with the global datum on contemporary satellite data (Julzarika & Suhadha, 2025).

The selection of these four GCP points was based on permanent geospatial features that have remained relatively unchanged over a century, to ensure coordinate transformation

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accuracy in GIS software (Istianda et al., 2023). Excessive use of GCPs has the potential to introduce unnecessary residual bias, so these four points are considered optimal for reducing geometric distortion and achieving high spatial precision relative to actual field conditions (Faradila et al., 2017). Subsequently, coordinate transformation was applied through the affine transformation method considering translation, rotation, and scaling to match the geometry of the analog map with the modern projection system (Roeoesli & Egli, 2024). Georeferencing accuracy was evaluated through Root Mean Square Error calculation to verify that residuals are within acceptable geometric tolerance limits, calculated based on the position difference between source points and reference points (Prabandaru, 2022). The RMSE formula used in this study is as follows:

$$RMSE = \sqrt{(\sum(dx_i^2 + dy_i^2)/n)} \quad (1)$$

Where dx_i and dy_i represent the coordinate differences between control points on the historical map and reference points on the satellite image, while n is the total number of control points used in the rectification process (Djamaluddin et al., 2019). The standard RMSE value for georeferencing historical maps with affine transformation is generally less than 5 meters, to ensure accountable spatial accuracy in the data overlay stage (Sobala et al., 2017). For ensure the reliability of image interpretation results, water body boundary extraction, and spatial change analysis in this study, thematic validation was performed on the 2025 high-resolution image map using a stratified random sampling method distributed randomly to verify land use classification accuracy (Amarrohman et al., 2022). This validation process aimed to test the accuracy of land use class interpretation including water bodies, vegetation, settlements, roads, and open areas, resulting in a proportional sample point representation (Wulansari, 2017).

Classified sample points were then compared with field observation data or visual interpretation on very high-resolution satellite imagery to determine Overall Accuracy and Kappa Coefficient values as indicators of interpretation validity (Wulansari, 2023). Test results were then compiled in a confusion matrix to calculate overall accuracy level. Overall accuracy represents the percentage of total correctly classified samples, with a minimum threshold value of 70% considered adequate for land use analysis (Hanan et al., 2020; Lasaiba, 2023). Overall accuracy is calculated using the following equation:

$$OA = (\sum X_{ii} / N) \times 100\% \quad (2)$$

where X_ii represents the number of correctly classified pixels on the diagonal of the error matrix, while N is the total number of validation samples. In addition to overall accuracy, this study also applied the Kappa coefficient to assess the level of classification agreement more reliably by

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adjusting for random agreement probability (Karang et al., 2019). This kappa coefficient reflects the reliability of data interpretation, with values ranging from 0.61–0.80 indicating good category and 0.81–1.00 considered very good (Mardalena, 2023). Referring to Anderson standards and Landis and Koch interpretations commonly used in remote sensing research, the Kappa coefficient formula is presented as follows:

Kappa = (P_o - P_e) / (1 - P_e) ..... (3)

where:

N = total number of samples

k = number of classification classes

P_ii = number of correct samples in class i

P_i+ = total row count for class i

P_+i = total column count for class i

Through these validation stages, the validity of spatial data interpretation used in the Situ Cibinong morphological transformation study can be scientifically guaranteed. Thus, identified water body shape changes reflect actual field conditions, not artifacts of spatial data interpretation errors. Subsequently, all datasets were projected into the WGS 1984 UTM Zone 48S coordinate system to ensure uniformity of spatial reference, accompanied by a study area cropping process to focus the analysis on the Situ Cibinong area and its buffer zone. The water body boundary mapping process was carried out by applying on-screen digitization methods on satellite imagery and historical maps to systematically and visually identify shoreline changes. This interpretation includes manual identification of water body edges through detailed observation of pixel contrast in satellite imagery and water contour lines on colonial maps, while maintaining consistent digitization scale at constant magnification levels to reduce potential subjective errors (Jati & Pratomo, 2021). The manual approach was chosen due to the relatively small characteristics of the water body with complex perimeter and its location in an urban area dominated by mixed objects, including riparian vegetation, open land, road networks, and buildings, which risk classification errors if using automatic methods based on spectral indices such as NDWI or MNDWI (Zhu et al., 2016). In medium-resolution imagery such as Landsat, mixed pixel phenomena around water body edges often produce biased and less accurate boundaries compared to manual digitization that can define edge features more definitively (Putri et al., 2023).

The digitization process was carried out using Geographic Information System software such as ArcGIS or QGIS, by forming polygon features following the outermost boundaries of water

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bodies identified in each observation period. Interpretation was conducted carefully by utilizing screen magnification techniques to maintain neatness of feature lines, resulting in more accurate extracted spatial data aligned with morphometric conditions in the field (Setiawan & Syah, 2020). For the contemporary period, digitization results were verified using high-resolution satellite imagery from Google Earth to validate the precision of delineated water body boundaries against aquatic vegetation and anthropogenic structures around the situ edges (Bashit et al., 2019).

Digitization results were subsequently analyzed by applying spatial overlay techniques, intersect, and shape comparison to identify morphological changes between periods. These analyses include calculating changes in water body area, perimeter length, shape orientation, and identifying areas experiencing shrinkage, local expansion, or spatial configuration changes. Through overlay between the 1901 map and 2025 conditions, sections of the water body that underwent significant reclamation or land conversion due to urban development dynamics in the surrounding area can be directly identified (Budiadi et al., 2017). In addition, this study also examines land use transformation in the area around the situ by applying overlay techniques between the water body boundaries and surrounding built-up areas to reveal the relationship between urban area expansion and modifications to the shape of the water body. This method is crucial given that changes in water body morphology in peri-urban areas are typically influenced by pressures from settlement development, transportation infrastructure expansion, and the conversion of open land into built-up areas (Wilza et al., 2022).

RESULTS AND DISCUSSION

Based on the interpretation of the 1901 colonial map, the spatial configuration of the Situ Cibinong water body shows a much larger area coverage with natural boundaries that have not yet experienced fragmentation due to anthropogenic activities. In terms of nomenclature, the area was still within a single unified geographical name, namely Situ Cibinong. Nevertheless, physically the water body was formed in two main spatially separated basins, namely the northern and southern parts. This condition indicates that the naming in the colonial period more represented a unified hydrological area rather than the physical division of the water body known today. Based on spatial digitization results, the northern water body has an area of 13.47 hectares, while the southern water body reaches 5.47 hectares, so the total area of Situ Cibinong in 1901 was 18.94 hectares. Morphologically, the northern water body exhibits a more complex perimeter shape with irregular natural indentations, reflecting the characteristics of a natural wetland that developed according to topographic conditions and natural water flow patterns. In contrast, the

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southern water body has a relatively more compact and elongated shape, indicating a more stable geomorphological configuration.

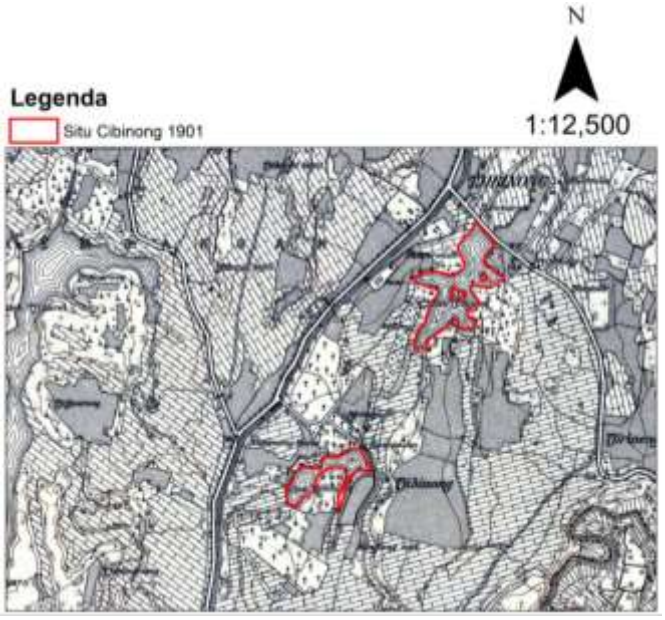


Figure 1: Historical Conditions of Situ Cibinong in 1901

Visual interpretation of the colonial map reveals that the area around the situ in the early 20th century was still dominated by natural vegetation, open land, and relatively limited settlement activities. Road infrastructure during that period was still very minimal and did not show an intensive urban connectivity pattern. This condition indicates that anthropogenic pressure on the water body was still very low, so the ecological and hydrological functions of the situ were still operating optimally. Vegetation around the water body serves as a natural buffer zone that supports water infiltration, maintains the stability of the water body edges, and suppresses sedimentation rates. These historical conditions represent the pre-urbanization phase of the Cibinong area before it developed as a buffer for the Jakarta metropolitan area (Wilza et al., 2022). Large-scale spatial transformations increased after the 1966 Master Plan and Government Regulation Number 6 of 1982, so the 1901 conditions reflect the relatively natural initial form of the water body before development pressures (Supriyadi et al., 2015). This historical reconstruction becomes the main foundation for evaluating changes in area, perimeter, and land dynamics in 2025.

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Table 1. Historical Characteristics of Situ Cibinong in 1901

No	Parameter	Northern Situ	Southern Situ	Description
1	Historical Nomenclature	Situ Cibinong	Situ Cibinong	Both water bodies were identified under the same name in the 1901 colonial map
2	Water Body Area	13.47 Ha	5.47 Ha	Combined total area reached 18.94 Ha
3	Spatial Condition	Physically Separated	Physically Separated	Represented two distinct hydrological basins
4	Perimeter Morphology	Irregular	Relatively Compact	Indicates natural shoreline characteristics
5	Surrounding Vegetation	Dominant	Dominant	Vegetation buffer zones remained well preserved
6	Settlement Presence	Low	Low	Limited built-up area surrounding both lakes
7	Road Infrastructure	Minimal	Minimal	Transportation infrastructure was still underdeveloped
8	Anthropogenic Pressure	Low	Low	Urban expansion had not significantly affected the area
9	Hydrological Function	Optimal	Optimal	Water retention and infiltration functions remained stable

The georeferencing process was carried out to transform the 1901 colonial map into a contemporary coordinate system, allowing integration with 2025 satellite imagery. This step is essential given the incompatibility of digital formats in historical maps. This study implemented Affine Transformation using four Ground Control Points selected based on stable features, such as main roads and topographic elements, to reduce distortion and improve spatial precision. Georeferencing analysis results indicate that residual values at each control point tend to be low, with error ranges between 1.650 meters to 2.485 meters. The Root Mean Square Error obtained is 2.106 meters, indicating that the geometric accuracy of the historical map remains within acceptable tolerance limits for landscape change studies at the local scale. This finding confirms

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that spatial distortion in the colonial map has been successfully minimized, allowing the position of the water body in 1901 to be accurately reconstructed and enabling spatial overlay with 2025 data (Sobala et al., 2017).

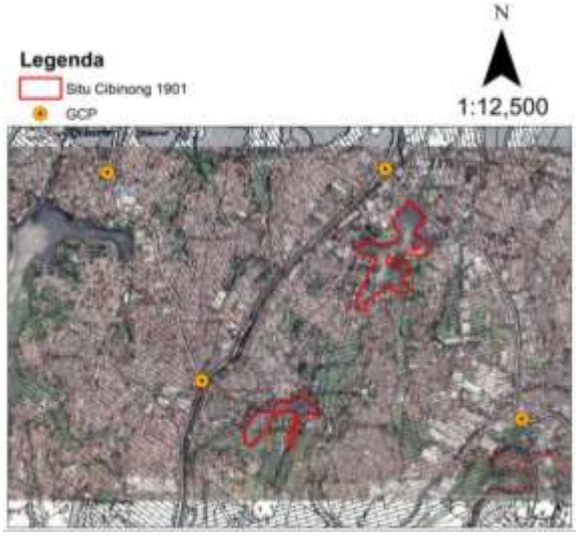


Figure 2: Ground Control Point in Historical Map of Situ Cibinong in 1901

Table 2. Georeferencing Results of the 1901 Colonial Map

Control Point Number	Residual X (m)	Residual Y (m)	Total Residual (m)
1	1.108	-1.223	1.650
2	1.294	-2.104	2.470
3	-1.332	2.098	2.485
4	-1.097	1.454	1.817
RMSE			2.106 m

In addition to geometric validation, this study also validated the continuity of historical spatial features by examining landmark suitability between 1901 and 2025 conditions. This stage was intended to verify that the features used as georeferencing references indeed had spatial stability across periods. Observation results indicate that the road network showed the highest consistency because all observation points remained in existence until 2025 and became the most reliable georeferencing reference. In contrast, some water body components have changed function into built-up areas, while settlement areas have experienced significant expansion. This finding reveals that the greatest transformation occurred in dynamic landscape elements, while

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primary infrastructure tends to maintain its spatial pattern.

Table 3. Landmark Suitability Between 1901 and 2025

Landmark Type	Observation Points	Suitable	Not Suitable	2025 Condition	Description
Road	10	10	0	Road	Road networks remained unchanged and served as stable reference points
Water Body	9	8	1	Road/ Settlement	Partial land conversion occurred due to infrastructure and residential development
Settlement	16	16	0	Settlement	Built-up areas remained identifiable and experienced spatial expansion

After the geometric validation process was completed, the next step was to evaluate the classification accuracy of land cover on the 2025 satellite image using a confusion matrix. This evaluation includes five land cover classes: water body, vegetation, settlement, open area, and road, based on 55 validation sample points. Test results show that 47 samples were correctly classified on the matrix diagonal, yielding an overall accuracy of 85.45%. This accuracy value has exceeded the minimum threshold of ≥85% required in remote sensing studies, so the 2025 satellite image interpretation is declared valid and can be used for further land use change analysis (Sriartha et al., 2019). Classification errors mainly occurred in transition zones between vegetation, settlement, and open areas that have relatively similar spectral characteristics.

Table 4. 2025 Classification Confusion Matrix

Classified Data	Water Body	Vegetation	Settlement	Open Area	Road	Row Total
Water Body	10	1	0	0	0	11
Vegetation	0	7	2	0	0	9
Settlement	0	2	15	0	0	17
Road	0	1	0	0	12	13
Open Area	0	0	0	3	2	5

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Column Total (Reference Data)	10	11	17	3	14	55

In addition to overall accuracy, this study also calculated the Kappa coefficient to measure the level of classification agreement beyond random error probability. Calculation results show a Kappa value of 0.818, which falls into the almost perfect agreement category based on Landis and Koch classification. This value indicates that the classification results have a very strong reliability level and can be validly used to analyze changes in shape and spatial dynamics of Situ Cibinong.

Table 5. Kappa Coefficient Calculation

Land Use Class	Total Classification	Total Reference	Coefficient Value
Water Body	11	10	0.0363
Vegetation	9	11	0.0327
Settlement	17	17	0.0955
Open Area	5	3	0.0128
Road	13	14	0.0231
Total	55	55	0.2006
Kappa Value			0.818

Spatial condition evaluation in 2025 utilized high-resolution satellite imagery to assess current water body states and surrounding land use dynamics. This aimed to depict the contemporary landscape of Situ Cibinong following over a century of development, contrasting with 1901 conditions. Results reveal that the singular nomenclature “Situ Cibinong” on the colonial map has transformed into two distinct water bodies: Situ Citatah (north) and Situ Gedong (south). Measurements indicate Situ Citatah covers 9.42 ha and Situ Gedong 5.13 ha, totaling 14.55 ha. Land use analysis shows settlements dominating at 419.70 ha (83.96%), followed by vegetation (54.77 ha, 10.96%), water bodies (14.55 ha, 2.91%), and open areas (10.77 ha, 2.15%). This urban dominance suggests ecological imbalance, increasing runoff and reducing infiltration (Zhu et al., 2016).

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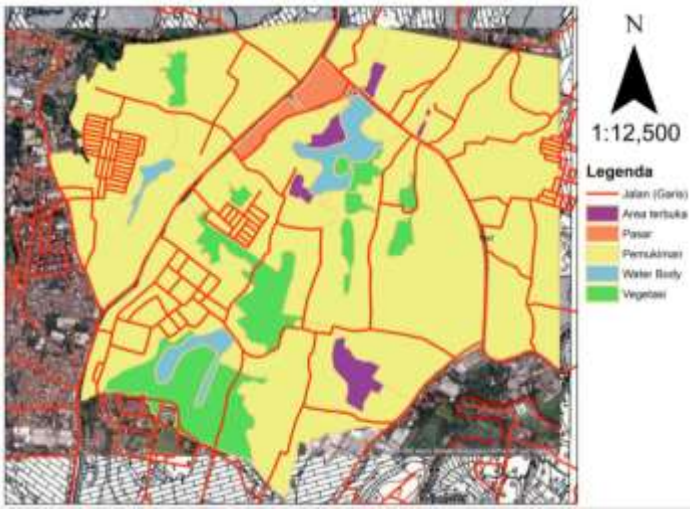


Figure 3. Spatial Conditions of Situ Cibinong in 2025

Visual interpretation highlights higher development intensity around Situ Citatah, with dense settlements, complex roads, and a bordering market. Situ Gedong retains more vegetation but faces settlement pressure. Overall, the 2025 landscape has shifted from semi-natural in 1901 to predominantly urban, underscoring the dependence of urban water body sustainability on surrounding land use changes. These conditions provide a basis for subsequent morphological and driver analyses.

Table 6. Land Cover Area Around the Situ Area in 2025

No	Land Cover Classification	Area (ha)	Percentage (%)
1	Open Area	10.77	2.15
2	Settlement	419.70	83.96
3	Water Body	14.55	2.91
4	Vegetation	54.77	10.96
Total		499.79	100

Morphological transformation analysis employed overlay techniques between the 1901 colonial map and 2025 high-resolution satellite imagery to detect changes in shape, area, and land use dynamics around Situ Cibinong over more than a century. This method enables longitudinal spatial detection by contrasting pre-urbanization water body conditions with current states.

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Overlay results indicate transformations encompassing water body area modifications, perimeter configuration changes, spatial identity shifts, and surrounding landscape evolution.In 1901, Situ Cibinong was documented under a single nomenclature, though it physically comprised two separate basins. The northern water body measured 13.47 hectares and the southern 5.47 hectares, totaling 18.94 hectares. Its shape displayed natural traits with a complex perimeter, encircled by vegetation and open land as an ecological buffer zone. The 2025 conditions reveal substantial landscape reconfiguration. The single nomenclature differentiated into two entities: Situ Citatah (northern) and Situ Gedong (southern). Situ Citatah shrank to 9.42 hectares, a reduction of 4.05 hectares or 30.07%. Situ Gedong decreased moderately from 5.47 to 5.13 hectares, losing 0.34 hectares. Overall, total water body area declined from 18.94 to 14.55 hectares, indicating a 4.39-hectare loss during 1901–2025.

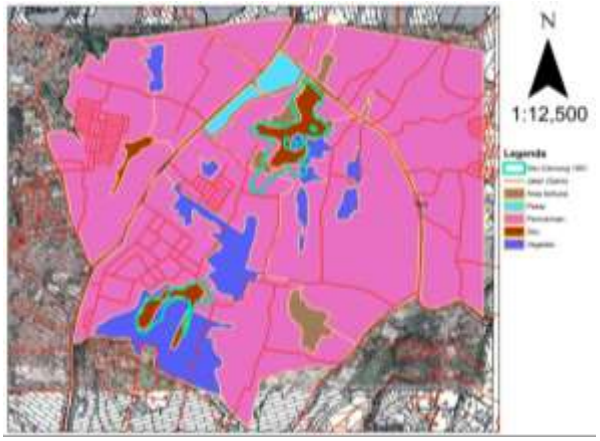


Figure 4. Overlay of Situ Cibinong Morphological Transformation 1901–2025

The most significant morphological change occurred in the northern water body. Overlay analysis indicates that the perimeter of Situ Citatah underwent simplification through the loss of natural indentations. Dense settlements, a complex road network, and a market directly bordering the water body dominate this area, demonstrating that development pressure and local economic activities primarily drive water body shrinkage. This pattern illustrates how built-up area expansion around urban water bodies accelerates boundary changes and reduces hydrological stability (Zhu et al., 2016).

Table 7. Changes in Situ Cibinong Area 1901–2025

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No	Water Body	Area in 1901 (ha)	Area in 2025 (ha)	Area Change (ha)	Change Percentage (%)
1	Northern Situ → Situ Citatah	13.47	9.42	-4.05	-30.07
2	Southern Situ → Situ Gedong	5.47	5.13	-0.34	-6.22
Total		18.94	14.55	-4.39	-23.18

In contrast, Situ Gedong exhibits a distinct transformation pattern. Its area reduction is relatively minimal, yet perimeter changes are evident along several edges. Extensive southern vegetation provides a superior ecological buffer compared to the north, accounting for the lower shrinkage rate. This morphological change is closely tied to Cibinong's role as a growth zone in the Jakarta metropolitan area. The 1966 Metropolitan Regional Master Plan designated Cibinong and Citeureup as industrial zones to support the capital, accelerating land conversion from water catchments to dense settlements and industries (Robbany et al., 2019). Government Regulation No. 6 of 1982 reinforced this by relocating the Bogor Regency government center to Cibinong, boosting settlements, roads, and economic activities that drove land conversion around the situ. The 2025 land cover shows settlements dominating at 419.70 ha, with vegetation at 54.77 ha and open areas at 10.77 ha. This reflects ecological fragmentation from urban expansion, potentially reducing infiltration, increasing runoff, sedimentation, and diminishing ecological capacity (Manjunath & Jagadeesh, 2025). Overall, the 1901–2025 transformation indicates that urban water body degradation involves selective shrinkage, perimeter changes, identity shifts, and land pressures rather than total disappearance, highlighting long-term urbanization as the main driver.

CONCLUSION

This research reveals that Situ Cibinong has undergone substantial spatial changes throughout the 1901–2025 period as a result of ongoing urbanization pressure in the Cibinong area. Based on the reconstruction of the 1901 colonial map, the study area was initially still recorded under a single geographical nomenclature, namely Situ Cibinong, although morphologically it had already been divided into two main basins. The northern water body area at that time reached 13.47 hectares, while the southern part was 5.47 hectares, resulting in a total area of 18.94 hectares. These historical conditions reflect the natural character of the water body, featuring a complex perimeter surrounded by vegetation and open land without significant

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development pressure. The 2025 condition analysis shows that the single nomenclature has transformed into two separate water body entities, namely Situ Citatah in the northern part and Situ Gedong in the southern part. The total water body area has shrunk to 14.55 hectares, indicating a loss of 4.39 hectares over more than a century. The most significant reduction occurred in the northern situ at 30.07%, while the southern situ remained relatively stable with a 6.22% decrease, although it still exhibits changes in perimeter shape.

This transformation was significantly influenced by land use changes tending toward increased built-up areas. Based on the 2025 land cover classification, the study area is dominated by settlements covering 419.70 hectares or approximately 83.96% of the total research area, while vegetation cover remains only 54.77 hectares. This situation indicates that settlement expansion, infrastructure development, and the growth of Cibinong as a government center and buffer zone for the Jakarta metropolitan area are the primary drivers of changes in the water body landscape. This research confirms that urban water body degradation does not always occur through total loss of water bodies but can also proceed through area shrinkage, shape changes, perimeter simplification, and gradual decline in ecological function. The integration of colonial maps and multitemporal satellite imagery has proven effective in reconstructing long-term spatial changes and providing a more comprehensive historical perspective. The findings of this research are expected to serve as a scientific basis for spatial planning, water body conservation, and more sustainable urban situ management in Bogor Regency.

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