

DEVELOPMENT OF GREEN INFRASTRUCTURE ON THE UPPER BOARD OF THE CITARUM RIVER SECTOR 6

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Abstract

Urban development in the Bandung Basin has exerted significant pressure on the function of the Citarum River Basin, particularly along riverbank areas. This study aims to examine the development of green infrastructure along the Upper Citarum River riparian zone in Sector 6 and to assess its integration with physical, social, and economic aspects of local communities. A qualitative descriptive method was employed through field observation and literature review. The study area, approximately 6 km in length, was divided into three segments based on land use characteristics and dominant activities. The results indicate that the implementation of green infrastructure along the Upper Citarum River in Sector 6 remains uneven. Segments 1 and 2 experience high pressure from land use activities, limited protective infrastructure, and greater vulnerability to flooding. In contrast, Segment 3 shows relatively better development, characterized by the presence of embankments and the utilization of riverbanks as public open spaces, although small-scale economic activities still pose potential threats to conservation functions. This study concludes that riparian management in the Upper Citarum River is still predominantly focused on physical interventions and has not fully integrated ecological, social, and economic functions. Strengthening green infrastructure-based riparian planning is therefore essential to support environmental sustainability and improve community quality of life.

Keywords: *green infrastructure, riverbank area, Citarum River, watershed, urban and regional planning*

Introduction

The Bandung Basin (Greater Bandung) is the third-largest metropolitan area in Indonesia after Greater Jakarta (Jabodetabek) and Gerbangkertosusila.

The population of Greater Bandung continues to grow, reaching 8.4 million people, with high levels of mobility and significant individual needs (West Java Province Central Statistics

Agency, 2023). Infrastructure development does have a positive impact on the economy at the individual level, and even the country. However, if this development does not pay attention to ecological balance, negative impacts on the environment await (Heryana et al., 2024). These impacts include reduced green space, declining water and air quality, and the emergence of hotspots in several areas (Sadikin et al., 2025). Therefore, the concept of 'green infrastructure' needs to be implemented in urban development.

Various countries have begun implementing a concept to maintain the sustainability of this system, namely by implementing the concept of green infrastructure in regional development plans (Widyaputra, 2020). Green infrastructure

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is a concept, effort, and approach to maintaining a *sustainable environment* through the arrangement of green open spaces and maintaining natural processes that occur in nature such as the rainwater cycle, soil conditions, and surface runoff. The concept of green infrastructure is to create an environment with maintained natural processes, including rainwater management, water quality management, and flood mitigation (Rachmawati & Jordan, 2022), (Hanna et al., 2024), but often face contradictions between the preservation of biophysical functions and the needs of social or cultural services of the community (Kryukov, 2022).

Real forms of green infrastructure include the development of green belts along rivers and canals, the arrangement of infiltration gardens, biopore wells, and ecologically-minded drainage systems such as *bio-swales* and *rain gardens* (Praja & Asran, 2025), (Khairunisa et al., 2025), management of Green Open Spaces (RTH), functions as a strategic step to support the achievement of *the Sustainable Development Goals* (SDGs) targets (Auliya et al., 2025). The purpose of implementing green infrastructure is to improve environmental conditions and maintain green open spaces, where its implementation is closely related to spatial, social, and economic aspects. In terms of spatial planning, it is physically visible that green infrastructure consists of core areas *as* habitats and connecting corridors (*links*) that facilitate the movement of species and ecosystem services throughout the landscape or function vitally as buffers that connect river ecosystems with the surrounding land areas (Staccione et al., 2022) (Dyadin, 2026) (Esa et al., 2026) to provide various ecosystem services that are beneficial to the environment and humans (Jamil et al., 2024). Green infrastructure integrates various types of Green Open Spaces ranging from functional parks, road corridors, to vertical vegetation as a natural system to provide ecosystem services

while improving the social quality and resilience of the urban environment (Faisal et al., 2022).

Green infrastructure implementation integrates ecosystem services into land use to conserve natural resources, provide recreational benefits, and support sustainable economic growth and climate resilience for communities (Bara et al., 2025). The implementation of green infrastructure in Greater Bandung is currently more focused on the physical aspects of parks and green belts, there has been no treatment for riverbank areas, which is one of the elements in flood control for areas along river basins, which are dominated by residential and industrial activities (Widyaputra, 2020). There has been a lot of conversion of riverbank land into residential and commercial activities that are not in accordance with their original designation (Esa et al., 2026).

The lack of public awareness in maintaining the ecology of river boundaries and the conversion of green open spaces not only reduces the aesthetic value of the environment, but also hinders the potential for increasing economic productivity and the psychological well-being of urban residents. The integration of rivers and their border areas in the spatial organization of architecture and residential landscapes is a crucial issue that occupies a central position in the paradigm of modern urban and landscape design (Liudmyla, 2023). By designing a sustainable concept for green infrastructure planning in urban spatial planning from an amenities perspective, it is hoped that it can change the face of the city so that it has a positive atmosphere that can be used as a place for its people to live.

According to (Sudarwani & Ekasaputra, 2017), the addition of green open space in urban areas can be done in various ways such as using vacant land, critical land, and river borders. Based on (PUPR Ministerial Decree No. 28 of 2015 concerning Determination of River and

Lake Boundary Lines, 2015), river boundaries are protected areas on the left and right of rivers that are determined through precise boundary lines to maintain the sustainability of spatial functions from disturbances from cultivation activities. One classification of green open space that has important benefits is the river border area (Wardiningsih & Salam, 2019). River borders as a fundamental element of Green Open Space (RTH) have a specific function that integrates physical development limitations with vegetation preservation to maintain ecosystem balance and the sustainability of environmental carrying capacity in urban areas (Ministry of Public Works Regulation No. 5 of 2008 concerning Guidelines for the Provision and Utilization of RTH in Urban Areas, 2008). The position of river borders as an integral part of Green Open Space (RTH) which must be integrated into the instrument for controlling spatial use, to ensure that the ecological function of the area is maintained amidst the dynamics of control and ownership of land rights in urban areas (Permen ATR/KBPN No. 14 of 2022 concerning the Provision and Utilization of Green Open Space, 2022). The regulatory synergy through Ministerial Regulation of Public Works No. 05/2008, Ministerial Regulation of Public Works and Housing no. 28/2015, and Ministerial Regulation of ATR/BPN No. 14/2022 forms a legal framework for land tenure and spatial control that requires collaboration and optimization of the roles of all stakeholders to ensure the sustainability of the function of river banks as green open spaces. Furthermore, optimizing river boundary utilization must consider economic and environmental aspects (Westi Utami et al., 2024).

Riverbanks are river areas bordered by water from land that can be developed to meet the community's needs for public green open space (Tomigolung et al., 2018). According to (Santoso et al., 2022), management and

understanding of riverbanks, consisting of the left and right sides of rivers, are essential for maintaining river sustainability, improving river function, and preventing human occupation. The current condition of several watersheds in Indonesia has experienced a significant decline in their function in maintaining water availability and environmental health. The number of critical watersheds in Indonesia continues to grow and worsen despite numerous rehabilitation programs for several watersheds in Indonesia (Fadhil et al., 2021). Green open space in riverbanks functions as an interconnected network of natural systems to maintain the integrity of aquatic ecosystems and mitigate watershed degradation through the process of absorbing and filtering rainwater (Kim & Kim, 2025). The presence of green open space on river banks can reduce the risk of disasters such as floods and landslides (Pelealu et al., 2022), (Erawati et al., 2025), (Wang et al., 2025). Green open space on river banks with certain functions that aim to protect or secure facilities and infrastructure, for example protecting the sustainability of natural resources, pedestrian safety or limiting the development of land use so that its main function is not disturbed (Safaria et al., 2021), (Wang et al., 2025). The green infrastructure strategy is implemented through revitalization of riparian areas and changing the building orientation to active frontage to integrate pedestrian paths with social interaction spaces (Mistoro et al., 2026). Reorganization of river bank areas by referring to the principles of *waterfront city design* and *Human Centered Design*, through the provision of public facilities that support the ecological and social functions of the area in an integrated manner (Dewani et al., 2025). Efforts to improve/rehabilitate green open spaces have been attempted in several watersheds in Indonesia, but are more directed at improving environmental functions such as reducing flooding and maintaining environmental

sustainability, there have been no efforts that lead to a sustainable concept, where there must be synergy between environmental, social and economic conditions.

Population growth and changes in land use in the upstream Citarum River Basin have reduced the quality of land cover and changed the hydrological characteristics, resulting in increased flooding, erosion, and a decrease in the quantity of water resources (Fadhil et al., 2021). Currently, the functions of the upstream, middle and downstream parts of the Citarum River Basin must be given more attention so that they are in accordance with their functions.

The decline in the absorption function in the Upper Citarum Watershed due to deforestation and the expansion of built-up land has increased the frequency of annual flooding, which causes major losses in the residential and agricultural sectors (Fadhil et al., 2021). The smallest damage occurs in the Upper Citarum Watershed in Cisanti, as well as industrial waste pollution in the Bandung Basin, particularly in the Baleendah and Dayeuhkolot areas, which are increasingly densely populated with industrial plants (Andri & Aziz, 2021).

The Citarum Harum Sector 6 program is an integrated river revitalization initiative involving cross-sectoral collaboration between the central and regional governments, as well as elements of the Indonesian National Armed Forces (TNI) and the Indonesian National Police (Polri) to address ecosystem damage in the Baleendah area. Despite having been running for four years, optimizing the roles of all stakeholders remains crucial to effectively address flooding and pollution issues without harming any party (Andri & Aziz, 2021). The Citarum Harum Program has not fully improved the function of the riverbank as one element of the downstream Citarum Watershed planning, therefore through this research will strive to utilize green open spaces in the form of riverbanks in the

downstream Citarum Watershed area to implement sustainable concepts. Integration between *bioengineering*, local materials, communal public spaces, and enforcement of spatial planning regulations is the key to the success of sustainable riverbank management (Bimantara, 2025), (Beni Aulia, 2026). The green infrastructure development strategy is carried out through riparian zone vegetation rehabilitation using local plants to mitigate anthropogenic impacts, strengthen law enforcement, and encourage multi-stakeholder collaboration and community empowerment in maintaining the quality of river ecosystems (Horve et al., 2026). Such riverbank management can be the foundation for the development of sustainable green open space that not only improves ecological quality, but also improves city aesthetics, strengthens social resilience, and opens up ecotourism-based economic opportunities (Sinurat et al., 2025). The development of green open space on riverbanks demonstrates the potential of ecosystem-based design to regenerate dry urban riverbanks, harmonizing environmental sustainability, social inclusion, and cultural identity (Esenarro et al., 2025), as well as a natural landscape that enhances the aesthetics of commercial and high-rise residential areas, thus potentially attracting waterfront development . (Wisudha et al., 2023) and helps reduce the vacancy rate of surrounding buildings (Kim et al., 2023). The principle of developing green open space as a green infrastructure must be directed at urban environmental conservation, integrated and *bionetwork connectivity* , natural disaster mitigation, climate change adaptation, improving health and well-being, and improving urban aesthetics (Sinatra et al., 2022) in order to achieve resilient and sustainable development (Miakhel et al., 2024). The sustainability of green infrastructure planning in urban spatial planning is expected to improve the quality of life of urban communities and can increase the

value of community life, especially in the context of the environment, as well as the socio-economic community within it.

Research Methodology

Tools and Materials

The analysis technique used was descriptive qualitative data collection, namely:

1. Primary data collection through field observations regarding physical conditions (land use, green infrastructure, availability of facilities and infrastructure), social and economic conditions (education, income, and livelihoods).
2. Secondary data collection, namely from literature (policy data and spatial data).

The resulting data was then formulated descriptively by performing data reduction by sorting related data, grouping, and converting it based on physical, social, and economic aspects. Then, it was presented and summarized into

information to compile a profile of green infrastructure development along the riverbank.

Research Location

The study location was conducted in the downstream area of the Citarum Watershed, specifically in the Citarum Watershed in Baleendah and Bojongsoang Districts is in the Upper Citarum River Boundary Sector 6 with a length of 6 km. At this study location, the Citarum Harum program has been running since 2018. Its implementation is carried out in an integrated manner by the central, provincial, district/city governments and all relevant ministries, including the Siliwangi III Military Command and the West Java Regional Police. Actions taken include revitalizing the Citarum Riverbanks by planting avocado trees. This study location has a unique character in that there have been efforts to implement green infrastructure but have not yet reached the sustainability target until 2026.

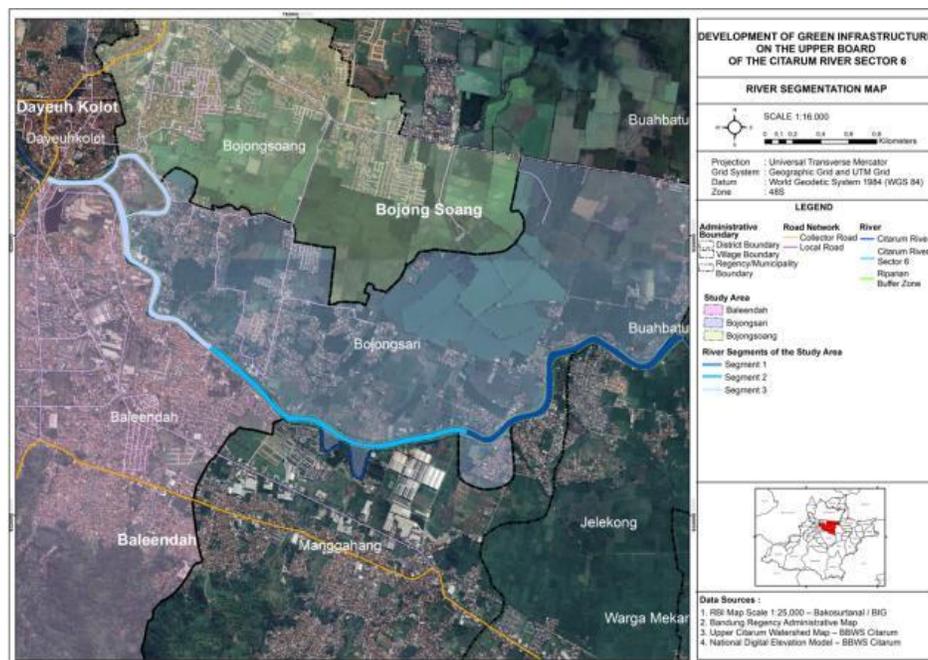


Figure 1. Research Study Area

The development of green infrastructure in the Upper Citarum River Basin Sector 6 will be discussed by dividing it into three segments that pass through the areas of Bojongsoang Village

and Bojongsoang Village (Bojongsoang District), as well as Baleendah Village (Baleendah District).

River segmentation is carried out by dividing the total length of the river of ± 6 km into three segments of ± 2 km each.

Segments are associated with regional characteristics:

1. Segment 1 \rightarrow Settlements and agriculture
2. Segment 2 \rightarrow Residential, industrial and agricultural
3. Segment 3 \rightarrow Residential and industrial

Results and Discussion

The discussion on green infrastructure development in the Upper Citarum River Basin Sector 6 will be divided into three segments. Each segment will address the physical and socioeconomic conditions of the community.

1. Segment 1

Location: Bojongsari Village, Bojongsoang District (northern area)

Segment Length: 2 km

Activities: Settlement and agriculture

a. Physical Condition

Based on field observations in Segment 1, it was identified that the riverbank area is currently used for cassava cultivation. Vegetation along the riverbank is relatively open and lacks protective structures such as embankments or physical barriers. This situation has the potential to increase the risk of river runoff into residential areas, particularly during heavy rainfall, as water can overflow and reach residential areas without adequate barriers.

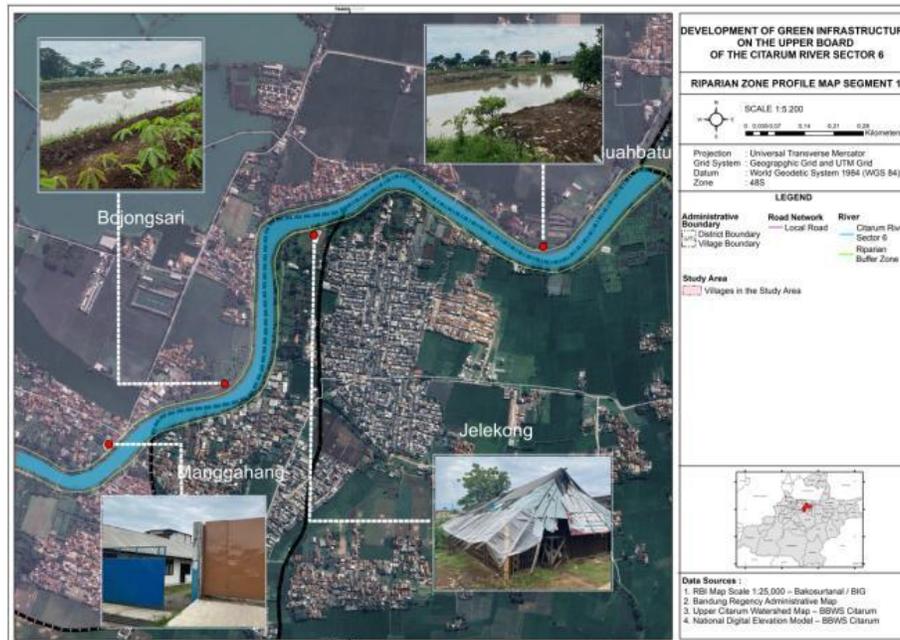


Figure 2. Segment 1

Furthermore, buildings and activities were found that were inconsistent with the riverbank's protective function, including chicken pens, semi-permanent structures such as huts, small stalls, and the use of the land as a drying area for agricultural and food products. These activities indicate a conversion of the riverbank area, which has the potential to reduce the area's ecological capacity and increase environmental vulnerability to hydrometeorological disasters.

In terms of infrastructure, the road network in Segment 1 is considered to be in poor condition, characterized by numerous damages in the form of relatively large potholes and differences in road surface elevation. This damage causes significant pooling of water, especially during the rainy season, which can disrupt community mobility and worsen environmental sanitation. Downstream of the segment, there is also a bridge that serves as a connecting link between

areas and is intensively used by the community to support daily social and economic activities.



Figure 3 . Existing Physical Conditions at River Boundary Segment 1 in 2026

b. Socio-economic conditions

Segment 1 is dominated by residential areas and agricultural land. Settlements generally consist of simple houses spread out along river banks and village roads. The community's education level is relatively middle-class, with the majority having a junior high or high school education. Economically, residents earn an average monthly income of \$63.69 – \$191.08 . This income comes from a combination of agricultural activities, informal employment, several industries and roof tile factories, and small businesses located around the settlement. This indicates that the community is in the lower-middle class. Socially, the community engages in mutual cooperative activities and intense inter-resident interaction within the settlement and agricultural areas.

A rice mill is located in the Bojongsari Village settlement and serves as an economic driver for the community. Agricultural land around the river is used for food crops and horticulture, which are the primary source of livelihood for some residents. A roof tile factory is located in the Bojongsari Village settlement and serves as an economic driver for the community.



Figure 4. Existing Socio-Economic Conditions in River Boundary Segment 1 in 2026

2. Segment 2

Location: Bojongsari Village, Bojongsong District (Northern Region) and Baleendah Village, Baleendah District (Southern Region)

Segment Length: 2 km

Activities: Residential, Industrial, and Agricultural

a. Physical Condition

Based on field observations in Segment 2, the riverbank area is still covered by natural vegetation in the form of grass and wild plants that serve as ground cover. However, in several locations, residential buildings and community activities have been found within the riverbank area, including small stalls and guard posts. This condition indicates that the use of space exceeds the riverbank's protective function and indicates the pressure of cultivation activities on areas whose use should be restricted by law.

This segment also features a makeshift floating bridge that connects the two villages. This infrastructure is intensively utilized by the local community to support daily mobility. The bridge is managed independently by the community, charging a fee of \$0.13 per motorcycle to contribute to maintenance costs. The existence of this floating bridge reflects the community's adaptive response to the limitations of formal infrastructure, but at the same time, it has implications for safety, structural sustainability, and the potential for disruption to river flow, particularly during periods of increased water flow.

From a physical perspective, Segment 2 exhibits varying bank protection conditions. Downstream of the segment, the riverbank is equipped with a barrier embankment that functions to control flow and protect the surrounding area. Conversely, upstream of the segment, the riverbank is still dominated by vegetation without a barrier embankment. The absence of this upstream protection structure makes the surrounding residential areas vulnerable to flooding, especially during the rainy season. Uncontrolled runoff from tributaries often

inundates residential areas, increasing the risk of flooding and reducing the comfort and safety of the community's residential environment.

Overall, the condition of Segment 2 shows differences in the level of physical protection of riverbanks, which directly impacts flood vulnerability in the surrounding areas. This finding indicates the need for a more integrated approach to riverbank management, including strengthening safety structures, controlling land use, and improving coordination of infrastructure planning between village areas.

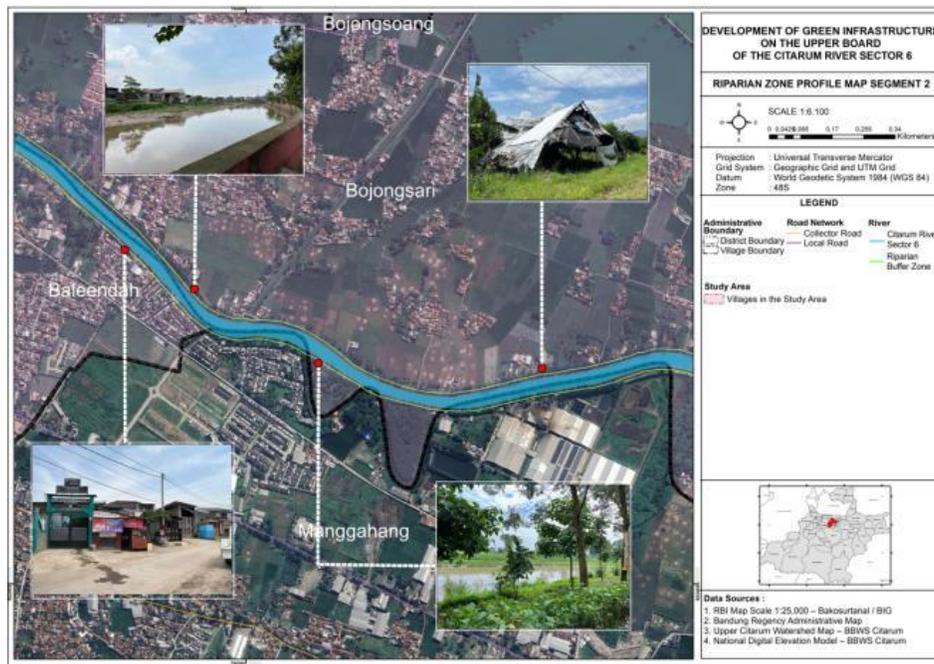


Figure 5. Segment 2



Figure 6. Existing Physical Conditions at River Boundary Segment 2 in 2026

b. Socio-economic conditions

Segment 2 consists of residential areas, industrial areas, and agricultural land. Settlements have developed along riverbanks, while industrial activity has emerged at specific points within the settlements. Agricultural land remains a vital source of livelihood, although some areas are being displaced by residential and industrial development. The community's education level is relatively middle-class, with the majority having completed junior high or high school.



Figure 7. Existing Socio-Economic Conditions in River Boundary Segment 2 in 2026

Their income ranges from \$63.69 – \$191.08 per month, derived from a combination of work in the industrial sector, small businesses,

agriculture, laborers, and private employees. This puts the community in the lower-middle class.

3. Segment 3

Location: Bojongsari Village and Bojongsoang Village, Bojongsoang District (Northern Region) and Baleendah Village, Baleendah District (Southern Region)

Segment Length: 2 km

Activities: Residential and Industrial

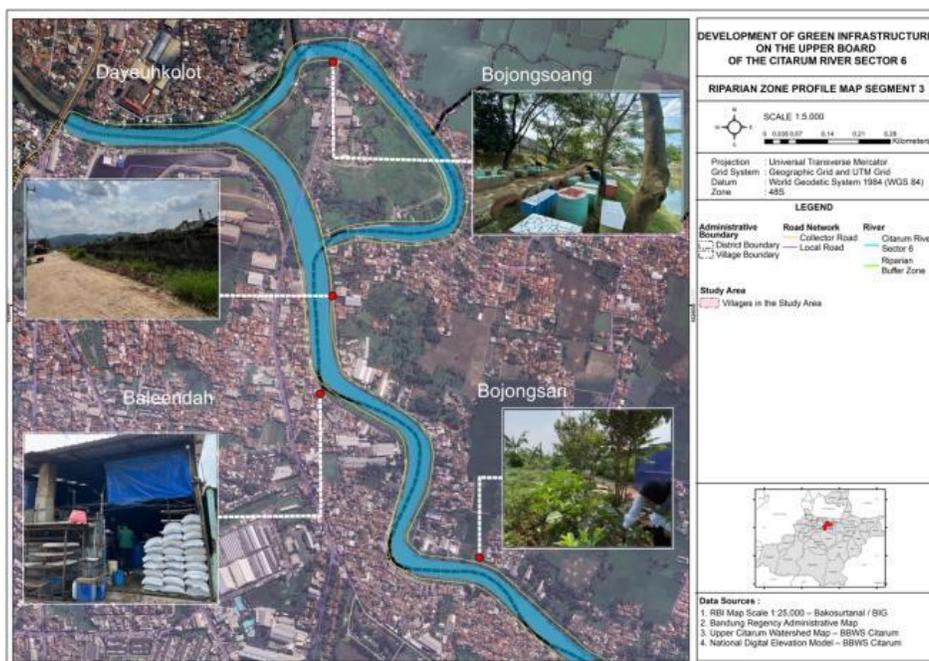


Figure 8. Segment 3

a. Physical Condition

Based on field observations in Segment 3 in Bojongsari Village, the physical condition of the riverbank area is dominated by vegetation that has been equipped with a boundary embankment. The presence of the embankment indicates an effort to control river flow and protect the surrounding area from potential flooding. In the oxbow section, the riverbank area has been developed as an open space that functions as a public facility, equipped with supporting elements such as seating, a children's play area, and a pedestrian path. The open space is surrounded by trees with relatively high

vegetation density, which plays a role in improving the quality of the microclimate, the ecological function of the riverbank, and the comfort of the space for the community.

In terms of accessibility, the road network around the border area of Segment 3 in Bojongsari Village is generally in good condition. However, several sections of the road are still damaged, with relatively large potholes. This condition causes puddles, especially during rainy seasons, which can potentially disrupt the comfort and safety of road users and the public engaging in activities in these open spaces.

Meanwhile, in Segment 3 in Baleendah Village, the physical condition of the riverbank is also dominated by vegetation complemented by a boundary embankment. However, in several locations, small-scale structures used for economic and social activities were found, such as tempeh fermentation facilities, small food stalls, and semi-permanent huts. The presence of these structures indicates limited and functional use of the riverbank space, but they still have the potential to put pressure on the area's protected function if not managed effectively.

This segment also includes the construction of a connecting bridge connecting the Cijeruk and Bojongsoang areas with Mekarsari Village, Baleendah District. This infrastructure plays a strategic role in improving interregional connectivity and supporting social and economic mobility. However, the bridge and surrounding activities need to be integrated with sustainable riverbank management to avoid disrupting the hydrological and ecological functions of the river area.



Figure 9. Existing Physical Conditions at River Boundary Segment 3 in 2026

b. Socio-economic conditions

Segment 3 consists of densely populated residential and industrial areas. Educationally, the majority of residents are junior high and high school graduates. The average monthly income ranges from \$63.69 – \$191.08, reflecting a lower-middle class economy. However, for those involved in the tofu and tempeh industry, monthly income can reach up to \$955.41. The

community generally earns a living in the industrial sector, particularly in the production of tofu and tempeh. This industry is a key economic activity, absorbing local labor and contributing significantly to community income. Some residents in Bojongsari and Bojongsoang Villages (Northern Region) own gardens and operate small businesses such as food stalls and workshops, and are also private sector employees.



Figure 10. Existing Socio-Economic Conditions in River Boundary Segment 3 in 2026

Conclusions

The development of green infrastructure in the Upper Citarum River riparian zone, Sector 6, shows uneven distribution and is not fully integrated with sustainability principles. The study, conducted across three segments, revealed variations in physical, social, and economic characteristics that influence the effectiveness of the riverbank's function as a flood control element, green open space, and support for the community's quality of life.

In Segment 1, the riverbank area is still dominated by agricultural and residential activities with a low level of physical security, characterized by the absence of boundary embankments and land use that is inconsistent with its protective function. This condition results in high vulnerability to river overflows and flooding, as well as a decline in the ecological capacity of the riverbank. The economic activities of lower-middle-class communities also encourage intensive use of the riverbank area without considering environmental sustainability.

In Segment 2, the riverbank conditions demonstrate a transition between protection and cultivation functions. Natural vegetation is still present, but is accompanied by residential and industrial activities, as well as emergency infrastructure such as floating bridges. The differences in physical conditions between the upstream and downstream sections of the segment, particularly related to the presence of boundary embankments, have direct implications for flood vulnerability in residential areas. This indicates that riverbank management in Segment 2 remains partial and has not been comprehensively coordinated across administrative regions.

Meanwhile, Segment 3 demonstrates relatively better green infrastructure development compared to other segments. The more consistent presence of boundary embankments and the utilization of oxbow areas as public open spaces indicates the potential for implementing a more integrated green infrastructure concept. However, pressure from small-scale economic activities and issues with supporting infrastructure, such as road damage and the presence of buildings within the boundaries, remain, potentially reducing the river's protective function if not managed sustainably.

Overall, the results of this study indicate that the Citarum Harum Program, particularly in Sector 6, has contributed to the restoration of the Citarum River, but has not yet optimally restored the riverbank's function as sustainable green infrastructure. Riverbank management still tends to focus on physical aspects and flood control, while the integration of ecological, social, and economic functions has not been fully achieved. Therefore, a more comprehensive planning and spatial planning strategy is needed by making riverbanks part of the city's green infrastructure network, thereby supporting flood risk reduction, improving environmental quality, and strengthening the

socio-economic welfare of communities in the Upper Citarum Watershed area.

References

- Andri, A. & Aziz, YMA. (2021). Environmental Policy Strategy for the Citarum Harum Program in Bandung Regency. *Ministrate*, 32 (3), 167–186.
- Auliya, IH, Raharjo, SE, & Gunaldi, G. (2025). Optimizing Green Infrastructure as a Vehicle for Empowering Generation Z to Support SDGs at UIN Walisongo Semarang. *Environmental Journal*, 1 (1), 1–11.
- Bara, A.A., Cornelis, R., & Lau, D. (2025). Integration of Green – Blue Infrastructure for Climate and Water Resilience in East Nusa Tenggara: A Systematic Literature Review from a Semi-Arid Urban Systems Perspective. *Kridatama Journal of Science and Technology*, 7 (02), 828–838.
- Beni Aulia. (2026). Riparian Zones in Padang City: A Study of Ecological Functions, Degradation, and Conservation Efforts. *Pediaqu: Journal of Social and Humanities Education*, 5 (1), 1332–1338. <https://publisherqu.com/index.php/pediaqu>
- Bimantara, IPG (2025). Revitalization of the Sempidi-Sading River Waterfront Area Through a Green Architecture Approach and Disaster-Adaptive Structural Adaptation. *Wastuloka Journal*, 3 (2), 9–12. <https://ojs.unr.ac.id/index.php/wastuloka>
- Central Statistics Agency of West Java Province. (2023). *West Java Province in Figures 2023*.
- Dewani, NI, Prastiwi, I., & Muljana, M. (2025). Human-Centered Design Approach to the Batanghari River Boundary as a Waterfront City in Jambi City. *Lakar: Jurnal Arsitektur*, 8 (2), 192–209.

- Dyadin, M. (2026). Riparian vegetation structural diversity as an indicator of riparian zone functioning in a rural to urban stream gradient. *Urban Ecosystems* , 29 , 77–84. <https://doi.org/10.33042/2522-1809-2025-3-191-77-84>
- Erawati, NW, Aryastana, P., & Wahyuni, PI (2025). Analysis of the suitability of utilizing the Tukad Pakerisan River boundary in Gianyar Regency in sustainable disaster mitigation. *Proceeding Civil Engineering Research Forum* , 5 (1), 205–213.
- Esa, SA, Helard, D., Aziz, R., Magister, P., & Andalas, PU (2026). Perceptions and Preferences of Residents of Settlements on the Indragiri Riverbanks and the Aspirations of the Community in Tembilahan Hulu District, Indragiri Hilir Regency, Riau. *Rang Teknik Journal* , 9 (1), 108–115. <https://doi.org/http://dx.doi.org/10.31869/rtj.v9i1.6738>
- Esenarro, D., Montenegro, L.K., Medina, C., Cairo, J.V., Israel, A., Terry, L., Garagatti, M.V., Wigberto, G., Delgado, S., María, M., & Lira, E. (2025). Green Corridor Along the Chile River as an Ecosystem-Based Strategy for Social Connectivity and Ecological Resilience in. *MDPI Urban Science* , 9 (488), 1–50. <https://doi.org/https://doi.org/10.3390/urbansci9110488>
- Fadhil, MY, Hidayat, Y., & Baskoro, DPT (2021). Identification of Land Use Changes and Hydrological Characteristics of the Upper Citarum Watershed. *Indonesian Journal of Agricultural Sciences* , 26 (2), 213–220. <https://doi.org/10.18343/jipi.26.2.213>
- Faisal, B, Dahlan, MZ, Chaeriyah, S , Hutriani, IW & Amelia, M. (2022). Analysis of Green Infrastructure Development Policy in Indonesia: An Adaptive Strategy for Sustainable Landscape Development. *IOP Conf. Series: Earth and Environmental Science The 6th International Symposium of Sustainable Landscape Development* , 1092 (012013). <https://doi.org/10.1088/1755-1315/1092/1/012013>
- Hanna, E., Bruno, D., Comín, F. A., & Hanna, E. (2024). The ecosystem services supplied by urban green infrastructure depend on their naturalness, functionality and imperviousness. *Urban Ecosystems* , 27 (1), 187–202. <https://doi.org/10.1007/s11252-023-01442-9>
- Heryana, D., Firmansyah, A., Pembangunan, U., & Veteran, N. (2024). Green Infrastructure Framework: A National Green Infrastructure Development Strategy. *Journal of Law, Administration, and Social Science* , 4 (2), 172–185.
- Horve, Z., Mccall, B. L., & Reisner, M. (2026). Riparian vegetation structural diversity as an indicator of riparian zone functioning in a rural to urban stream gradient. *Urban Ecosystems* , 1–14. <https://doi.org/https://doi.org/10.1007/s11252-025-01864-7>
- Jamil, R., Julian, J.P., Jensen, J.L.R., & Meitzen, K.M. (2024). Urban Green Infrastructure Connectivity: The Role of the Private. *MDPI Land 2024* , 13 (1213). <https://doi.org/https://doi.org/10.3390/land13081213>
- Khairunisa, LA, Indira, SS, & Syam, FH (2025). Riparian Landscape Design with the Riverwalk Concept for the Revitalization of the Deli River in Medan City. *East Asian Journal of Multidisciplinary Research (EAJMR)* , 4 (3), 1209–1228.

- <https://doi.org/https://doi.org/10.55927/eajmr.v4i3.53>
- Kim, J., & Kim, J. (2025). Green Infrastructure for Urban Flooding: Knowledge Domains and Research Evolution (2015 – 2024). *MDPI Land* , 1–33. <https://doi.org/https://doi.org/10.3390/land14050921>
- Kim, Y., Lee, RJ, Lee, T., Shin, Y., Kim, Y., Lee, RJ, Lee, T., & Shin, Y. (2023). Green Infrastructure and Urban Vacancies : Land Cover and Natural Environment as Predictors of Vacant Land in Austin, Texas Natural Environment as Predictors of Vacant Land in. *MDPI Land* , 12 (2031). <https://doi.org/https://doi.org/10.3390/land12112031>
- Kryukov, M. (2022). Riparian vegetation structural diversity as an indicator of riparian zone functioning in a rural to urban stream gradient. *Urban Ecosystems* , 85 , 8–18.
- Liudmyla, R. (2023). Guidelines for "Blue - Green" Urban Infrastructure: Adaptive Model and its Structural Elements. *Scientific Journal of Latvia University of Life Sciences and Technologies Landscape Architecture and Art* , 22 (22), 147–156. <https://doi.org/10.22616/j.landarchart.2023.22.15>
- Miakhel, M., Amjad Ahmad Abdulrahimzai, Ahmadullah Habib, & Mohammad Mukhlis Behsoodi. (2024). Urban Green Infrastructures and Their Impacts on the Urban Environment : A Review. *Journal of Environment, Climate, and Ecology (JECE)* , 1 (2). <https://doi.org/https://doi.org/10.69739/jecce.v1i2.135>
- Mistoro, NH, Yulianto, A., Rahmawati, S., Kholif, M., & Widyo, L. (2026). Green Infrastructure Strategy in Supporting Environmental Resilience. *AJIE - Asian Journal of Innovation and Entrepreneurship* , 10 (1), 55–66. <https://doi.org/10.20885/ajie.vol10.iss1.art5>
- Pelealu, RH, Sembel, AS, & Warouw, F. (2022). Potential Locations for Green Infrastructure Implementation in the Tondano Watershed in Manado City. *Sabua* , 11 (2). <https://doi.org/http://ejournal.unsrat.ac.id/index.php/SABUA>
- Praja, S., & Asran. (2025). Environmentally Friendly City Spatial Planning Strategy: An Ecological Approach in the Introduction. *Journal of Health Quality Development* , 5 (1), 12–22.
- PU Regulation No. 5 of 2008 concerning Guidelines for the Provision and Utilization of Green Open Space in Urban Areas (2008).
- PUPR Ministerial Regulation No. 28 of 2015 concerning Determination of River and Lake Boundary Lines, Pub. L. No. 28/PRT/M/2015 (2015).
- Rachmawati, DP, & Jordan, NA (2022). Evaluation of Green Infrastructure for Flood Control based on Stakeholders' Preferences in Sempaja Selatan Village. *Indonesian Journal of Built Environment* , 11 (September), 143–148. <https://doi.org/http://doi.org/10.32315/jlbi.v11i3|179>
- Regulation of the Minister of ATR/KBPN No. 14 of 2022 concerning the Provision and Utilization of Green Open Spaces (2022).
- Sadikin, GN, Syaharani, RA, Johari, GS, Azizah, SA, Dewi, AM, Naila Salsabila, N., Vadhilah, V., Iryanudin, & Herdiana, D. (2025). The Impact of Infrastructure Development on the Environment and

- Community Life. *Multidisciplinary Scientific Journal* , 3 (5), 377–381. <https://doi.org/10.5281/zenodo.15633132>
- Safaria, F., Gunawan, G., & Susetyaningsih, A. (2021). Utilization of River Boundaries as Green Open Spaces. *Construction Journal* , 19 (1), 179–190.
- Santoso, BA, Rahayu, P., & Istanabi, T. (2022). Potential of Green Open Space (RTH) Along River Boundaries from the Physical Aspect of Revitalization. *Desa-Kota* , 4 (2), 196. <https://doi.org/10.20961/desa-kota.v4i2.53511.196-209>
- Sinatra, F., Azhari, D., Asbi, AM, & Affandi, MI (2022). Principles of developing urban green open spaces as green infrastructure in Bandar Lampung. *Jurnal Planologi* , 19 (1), 19–36. <https://doi.org/http://jurnal.unissula.ac.id/index.php/psa>
- Sinurat, A., Benteng H Sihombing, Rameria Saragih, Ahmad Rizki Setiawan, & Vandelina Pasaribu. (2025). Management of the BAH Bolon Watershed for Sustainable Green Open Space Development. *Journal of Regional Planning* , 7 (2), 98–108. <https://doi.org/10.36985/1ktyrx26>
- Staccione, A., Candiago, S., & Mysiak, J. (2022). Mapping a Green Infrastructure Network : a framework for spatial connectivity applied in Northern Italy. *Environmental Science and Policy* , 131 , 57–67. <https://doi.org/10.1016/j.envsci.2022.01.017>
- Sudarwani, MM, & Ekasaputra, YD (2017). Study of the Addition of Green Open Space in Semarang City (Sampangan Park & Rejomulyo Park). *Civil Engineering & Planning* , 19 (1), 47–56.
- Tomigolung, BA, Rondonuwu, DM, & Rogi, OHA (2018). Spatial Planning of the Tondano Riverbank Area in the Segment from Kampung Tubir to the Miangas Bridge in Manado. *Spatial Journal* , 5 (1), 32–45. <https://ejournal.unsrat.ac.id/index.php/spasial/article/view/18936/18482>
- Wang, K., Wang, Z., & Fan, Y. (2025). A Comprehensive Modeling Framework for Identifying Green Infrastructure Layout in Urban Flood Management of the Yellow River Basin. *MDPI International Journal of Geo-Information* , 14 (414), 1–28. <https://doi.org/https://doi.org/10.3390/ijgi14110414>
- Wardiningsih, S., & Salam, BF (2019). Planning of Green Open Space along the Ciliwung River in the Kampung Pulo Area. *NALARs Journal of Architecture* , 18 (1), 65–74.
- Westi Utami, Novita Dian Lestari, & Rohmat Junarto. (2024). Optimizing the Utilization of Mataram Ditch Boundaries as Green Open Spaces. *Innovation: Journal of Politics and Policy* , 12 (1), 15–25.
- Widyaputra, PK (2020). *Implementation of Green Infrastructure in Various Countries - Supporting Environmentally Based Sustainable Development* (Pe Printing). Widina Bhakti Persada Bandung.
- Wisudha, F., Suryadjaja, R., Santoso, S., & Wipranata, BI (2023). Utilization of River Boundaries as Green Open Spaces with the Waterfront Development Concept. *Stup Journal* , 5 (2), 1933–1944. <https://doi.org/10.24912/stupa.v5i2.24353>