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REDESIGN OF RIVERBANK SETTLEMENT BASED ON ECO-ARCHITECTURE IN THE GAJAH WONG RIVER AREA, YOGYAKARTA

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ABSTRACT

Gajah Wong River is one of the rivers that cross the city of Yogyakarta in the east which is in critical condition. The use of land on the riverbank for settlements continues without regard to environmental aspects. The density of the population and buildings is not under the area's capacity. Riverbank damage occurred in several riverbank areas. Ecological architecture is a holistic design approach, eco-friendly design, and optimizing the utilization of natural potential. This study aims to make the concept of redesigning the Gajah Wong riverbank settlement based on ecological architecture. The analysis was carried out using three approaches: interpretational analysis, structural analysis, and reflective analysis. The results of the study show that the basic problems of the Gajah Wong riverbank can be grouped into the settlement, socio-economic and environmental aspects. The concept of redesigning riverbank settlements based on ecological architecture can be applied by optimizing the use of natural resources, designs that respond to site characteristics, working with climate to get energy efficient, and designs that respond to residents' needs.

Keywords: Redesign, Riverbank settlement, Eco-architecture

1. INTRODUCTION

A total of 63,256 villages in Indonesia are located on the riverside and 26 percent of villages have settlements on the riverbank [1]. Damage to riverbanks in cities in Indonesia is a critical condition. This critical condition also occurs in the Gajah Wong River which crosses the city of Yogyakarta in the east.

The use of space on the riverbank for residential activities continues without regard to environmental aspects. Population density and building density do not match the area's capacity. Violations of river boundaries occur in various riverbank areas. Based on PUPR Ministerial Regulation No. 28/PRT/M/2015, several residential areas along the Gajah Wong River have violated the regulation.

Green Open Space (GOS) is one component to provide a balance in the urban settlement environment. According to Law No. 26 of 2007, at least 30 percent of the area of a city or region must have green open space. Based on this regulation, the city of Yogyakarta has not yet reached the ideal condition, because in 2019 the total area of Yogyakarta GOS is only 18.8% of the city area of 35 Km2. Riverbanks have great potential in providing urban green open space, but this area is increasingly being pushed by urban development. This condition is caused by the lack of integrated planning and development approaches in critical urban areas [2].

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The need for healthy housing is a fundamental problem in the city of Yogyakarta. The factor of limited land and expensive land prices make marginal land used as residential areas. The dense urban area causes the riverbank area that should have functioned as a flood catchment area to turn into a residential area. Occupancy located in such conditions has a high level of vulnerability to flooding disasters [3]. However, this condition occurs in the area along the Gajah Wong River.

The development of the city that is increasingly widespread but the land area does not increase has an impact on the environment because the growth of new community habitats always requires natural resources. Based on the UN Environment Global Status Report 2021, buildings and construction contribute more than 36% of global final energy use and almost 37% of CO2 emissions related to energy, and the residential sector contributes 22% of global final energy use [4]. Therefore, sustainable development is needed to maintain environmental balance. Ecological architecture is an approach to planning and designing buildings based on a balance between humans, buildings, and the environment. Therefore, the ecological architecture approach is important to be applied to residential areas on critical lands such as the Gajah Wong riverbank.

Ecological architecture is a holistic design approach, eco-friendly design, and optimizing the utilization of natural potential. The dimensions of ecological architecture include nature, space, time, sociocultural, and building techniques [5]. Ecological architecture is not only a matter of specific design choices that lead to certain high-tech building products but the right way of thinking in responding to nature in building design [6].

This study aims to determine the problems of settlements in the Gajah Wong riverbank and to redesign riverbank settlements based on ecological architecture. Based on this research, it is expected to get the concept of the right approach to managing the residential environment located on the riverbank, especially in the DIY area.

2. MATERIALS AND METHODS

2.1. Location of Study

The research location is in the Gajah Wong riverbank area in the city of Yogyakarta. The boundaries of the research area are the southern part of Laksa Adisucipto street (East of UIN Yogyakarta). The observation area covers the area of RT 12 Ambarukno village and RT 14 and 15 RW 6 Gowok village, Sleman Yogyakarta.

2.2. Methods

This research is divided into several stages, the first stage is collecting data from physical, social, economic, and environmental aspects. Data was collected through survey techniques and community aspirations interviews. The second stage is to map the problem from various aspects and the third stage is to analyze the determinants of environmental degradation in the riverbank area. The fourth stage is to approach the area arrangement based on ecological architecture.

The analysis was carried out using three approaches: interpretational analysis, structural analysis, and reflective analysis. The interpretive analysis is directed at constructing data and creating themes and patterns that can be used to explain and explain the symptoms that occur in the riverbank area. Structural analysis is used to process incoherent data to give meaning to these patterns. The reflective analysis is used to evaluate the existing findings [7]. The findings are explained in a descriptive narrative that seeks to construct the reality (phenomenon) that exists in the field. Aspects of ecological architecture are used as the basis for conducting the analysis.

2.3. Research Variable

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Several principles in designing ecological buildings: (a) utilization of natural resources around the area as a building system, such as the use of materials, energy sources (lighting and ventilation), and building utilities; (b) paying attention to and maintaining environmental resources (air, land, and water); (c) adapt to the conditions of the natural environment; (d) reduce dependence on the use of centralized energy sources (electricity and water); (e) Save the use of non-renewable natural energy sources and save energy use and (f) allow residents to provide for their own needs [5].
The concept of ecological design includes several aspects: (a) meeting human needs; (b) towards the sustainability of natural resources; (c) maintaining ecological integrity; (d) imitating natural ecosystems; (e) eliminating natural debt and (f) protecting natural habitats. Applications to architectural design include: (a) land use can be optimized by designing multi-story buildings and designing efficient spatial plans for various needs; (b) energy use can be reduced by using passive designs; (c) the use of plants and trees to create an environmental microclimate; (d) utilization of waste as a power plant; (e) efficient use of building materials and furniture from renewable, durable but also recyclable resources; (f) traditional local (vernacular) design elements can be incorporated into buildings to improve energy and material efficiency, aesthetics, and comfort while respecting cultural heritage. (g) reduce waste [8].
There are 6 principles in designing green architecture: (a) Conserving energy; (b) Working with climate, namely buildings designed by applying the principles of working with climate and energy sources; (c) Minimizing new resources, namely buildings designed to minimize the use of new natural resources; (d) Respect for users, namely the building design responds to the needs of the occupants; (e) Respect to Site, namely the building responds to the site characteristics and (f) Holistic, namely designing the building as a whole [9].
Based on these theories, it can be identified that the parameters of resettlement based on the ecological architecture in this study are: (a) optimizing the use of natural resources in the design; (b) the design responds to site characteristics; (c) working with the climate to achieve energy efficiency and (d) respond to the needs of residents.

Table 1 Research Variables

No	Variable	Prinsip	Sumber	Elemen Desain
1	Optimizing the use of natural resources	Optimization of land use by designing multi-story buildings	Fridman, et all	Land use, Site Plan, Infrastructure
		Minimizing new resources	Robert dan Brenda	
		Pay attention to and maintain environmental resources	Heinz Frick	
2	The design responds to site characteristics	Respect to Site	Robert dan Brenda	Site Plan, Building design
		Adapting to the conditions of the natural environment	Heinz Frick	
3	Working with the climate to save energy	Working with climate	Robert dan Brenda	Building design, layout, lighting and ventilation systems, landscape
		Utilization of natural resources as a building system (lighting and ventilation)	Heinz Frick	
		Use of passive design	Fridmann, et all	
		Using vegetation to create a microclimate	Fridmann, et all	
4	**Respect for users**	**Residents allowed to provide for their own needs**	Heinz Frick	Site plan, spatial arrangement, infrastructure,
		Fulfilling human needs	Fridmann, et all	

3. RESULTS AND DISCUSSION

3.1. The Problems of the Riverbank Area

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The discussion of problems in the Gajah Wong riverbank area is grouped into the human settlement, socio-economic and environmental aspects. Analysis of the determinants of environmental degradation in the riverbank area is related to these aspects.

3.2. Human settlement aspect

Based on the settlement aspect, the problem that stands out from this area is the high density of buildings and the distance between adjacent buildings. Due to the small area of land (site), the community tries to optimize land use, so that it exceeds Building Coverage (60%), violates river boundaries, and lacks green open space.

The streets that connect people's houses are very narrow with a road width ranging from 1 to 2.5 m. The existing streets are informal streets that are agreed upon between residents called "rukunan streets". In some areas, the streets network was discontinued and residents parked their vehicles on the edge of the streets. The drainage network is not completely available, there is no infiltration or biopore so rainwater does not absorb properly. The lack of infrastructure and sanitation system results in settlements in poor conditions that are uninhabitable.

Most of the buildings are 1-story and have a rectangular floor plan with walls made of clay bricks or concrete bricks. Some of the buildings are of wooden construction with asbestos or zinc roofs. The composition of the building is irregular, giving the impression of a slum area. Building structures generally use bearing walls and frame structures made of reinforced concrete, but many houses do not meet the rules of earthquake resistance.

The orientation of the building generally does not respond to the river, avoiding the direction of the river and turning the river into the rear. Some residents even throw their waste directly into the river, resulting in river pollution.

3.3. Socio-Economic Aspect

Residents of the Gajah Wong riverbank generally have low incomes. They work as informal city workers such as factory or construction workers, daily workers, online motorcycle taxi drivers, and small entrepreneurs (warung). Some houses are rented out as boarding houses for students, students, and workers. Social relations between community members are very close, they often hold meetings together in socio-religious activities.

3.4. Physical and Environmental Aspects

The condition of the Gajah Wong River experienced significant silting, but the river water flow was still smooth. The condition of river water is polluted by household water waste. Based on observations, houses located on the riverbank generally dispose of their wastewater into the river. The results of water measurements in the Gajah Wong River for in situ pH and DO parameters were below the required quality standards, namely 5.52 for pH and 4.76 for DO (Dissolvent Oxygen) [10]. Garbage is piled up in several locations along the river.

Some of the banks of the river have a construction of permanent dams. In the area west of the river bordering the UIN Sunan Kalijaga plot, the bearing wall is made with gabion stones with a slope of 45 degrees. In the riverbank area of Gowok hamlet, the canal is made vertically and the construction does not meet the standards.

The riverbank area has mostly been built with houses and very little green open space. There is very little vegetation in this riverbank area even though the riparian vegetation on the riverbank has many functions, including as a buffer zone, improving soil properties, maintaining river water quality, preventing riverbank erosion, regulating water management, and as a habitat for wildlife. and various fauna [11]. Rainwater infiltration is still very poor both from environmental roads and residential plots. Environmental drainage has not been implemented properly, so rainwater is directly discharged into the river.

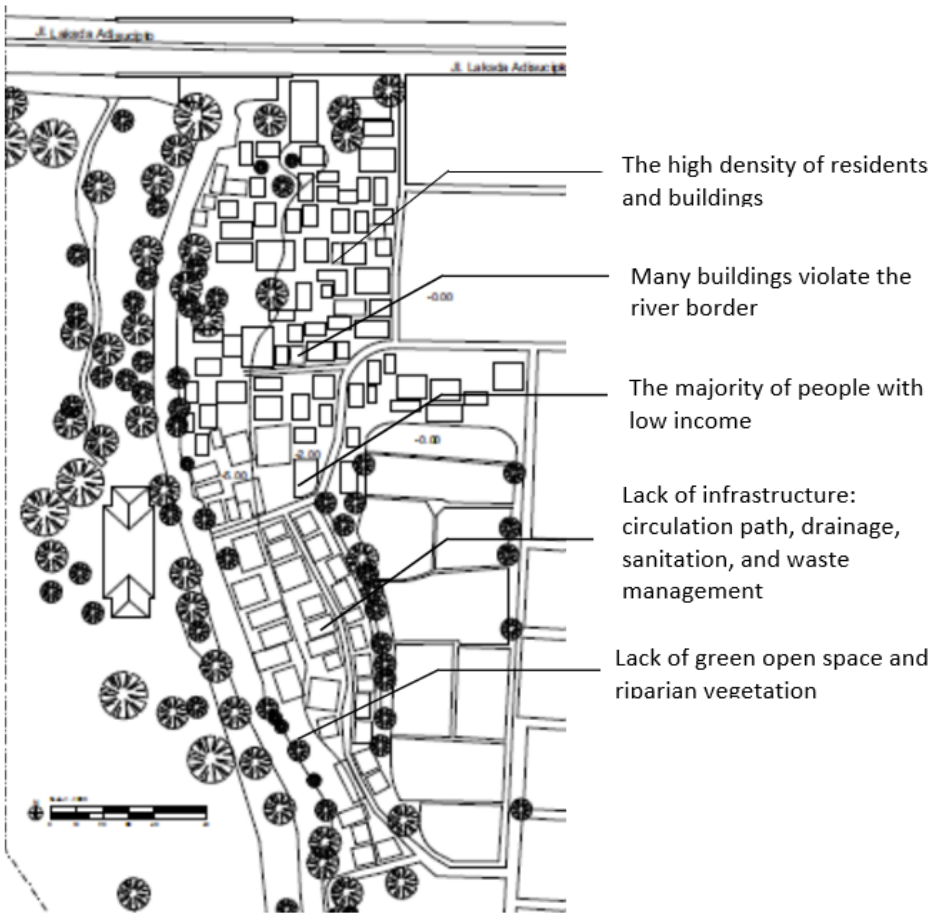

Figure 2 Riverbank area problems

3.5. Redesign of riverbank settlements based on ecological architecture

3.5.1. Optimizing the use of natural resources

Optimizing the use of natural resources is more focused on reorganizing land use. The current condition of the area's land use is an ecological crisis due to changes in land use.

At the beginning of the 1930s, the land was still natural as a riverbank with various kinds of plants and no buildings. In 1975 the population began to be inhabited. In 1985 Ledok Gowok changed to Gowok hamlet due to the increasing population and in 1987 there was a flash flood that inundated people's houses. In 1990 the number of dwellings increased, and even the lower area adjacent to the river began to be inhabited by residents. In 2010 the construction of the

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UIN Sunan Kalijaga campus which is located in the west of Gowok hamlet and borders the Gajah Wong River. Riverbanks bordering UIN are built the bearing walls. Some of the houses affected by the bearing walls project moved to the east side of the river in Gowok hamlet. As a result of uncontrolled land use changes, the Gowok riverbank has experienced an ecological crisis.

Based on these conditions, land use planning is intended to restore the ecological function of the river. The land use arrangement in the research area is divided into several zoning based on the proximity to the riverbed. Zone A is a core buffer zone that is directly adjacent to river water. Zone B is a secondary buffer zone that is bordered by zones A to C above. Zone C is the zone above which is a safe zone for residential activities.

In zone A, it is directed to minimize changes in land use. The bearing walls are designed to continue to support the ecological function of the river and can accommodate the overflow of water in the event of a flood. Construction materials with river stones are arranged without spaces and plastering so that microorganisms can live on the banks of the river. Planting riparian vegetation is expected to prevent erosion as a habitat for various fauna and wildlife and to create a microclimate in the area.

In Zone B, some areas are still possible to be used for cultivation activities: agricultural activities, public green open spaces, or for housing. According to PP no 2015, the minimum limit of the embankment area is at least 3 m. The use in zone A of residential building designs must strictly follow the ecological architecture and meet the requirements of the legislation.

There are two models for the revitalization of riverbank settlements, namely the Vertical Revitalization Model and the Horizontal Revitalization Model [12]. The use of the vertical revitalization model in the Gajah Wong riverbank area is more appropriate. Land can be optimized with multi-story buildings, so there is a lot of green open space. The composition of a minimum of 60 percent of green open land and a maximum of 40 percent for buildings will make the area greener and function as a water catchment. To minimize new natural resources and preserve environmental resources, existing infrastructure, such as roads and existing drainage networks, is considered in site planning. Street and drainage patterns are used as determining factors in the design. So that the spatial zoning arrangement for the use of residential space is based on the existing infrastructure.

3.5.2. Responds to site characteristics

The analysis is focused on site morphology, existing drainage patterns, and site vegetation which is used as the basis for determining the concept of settlement patterns, road network patterns, and drainage patterns that are integrated with regional green spaces. The focus of this analysis is also on researched strategies for designing sustainable housing areas with a water-sensitive urban design approach in the North Bandung area [13].

The use of the site is based on differences in the slope of the site, so riverbanks can be grouped into 3 zones. Zone A is the lowest zone directly adjacent to the river which is used as a zone to preserve the river. In this zone vegetation and trees are used to maintain river ecology and must be free from buildings.

Zone B is a relatively flat land that can be used for residential zones with 2 -3 story buildings with stage construction due to the consideration that this zone is often

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flooded when flooded with a height of 50 cm to 1 meter. Maximum building coverage (BC) is 40% to increase the area of green open space. The orientation of the buildings in zone A is directed towards the river so that the river becomes the face of the view of the existing houses. This orientation is important so that the community pays attention to the condition of the river and does not throw waste and garbage into the river. Buildings on the banks of the river are directed to retreat at least 3 meters from the riverbank to meet the requirements of government regulations.

In Zone C, it is safe from flooding but to maintain the ecological function of the river, this zone needs to be set up as a buffer zone for the riverbanks. This zone can be used for limited residential and commercial functions. Residential buildings need to be redesigned vertically for efficient land use.

The pattern of the existing circulation network is used as the basis for determining the new pattern of the circulation network. The use of the existing circulation is intended to reduce conflicts with existing land ownership. However, to increase the quantity and quality of circulation, it is directed to widen the street to a width of 3 meters. If the vertical development model is applied, it is very possible to widen the street and add green open public spaces.

The vegetation and trees on the site are relatively few because the existing land is maximized by residents for buildings. Therefore, the existing vegetation and trees must be maintained and it is necessary to add new vegetation and trees to maintain the ecology of the river. New vegetation can be planted beside the river or in green open public spaces. The recommended tree riparian vegetation is bamboo, breadfruit, jackfruit, cherry, Terminalia catappa, tamarind, teak, Hibiscus tiliaceus, Parkia speciosa, and banana according to the findings of Sholikhati et all [14] in the study of riparian vegetation in the Gajah Wong River sub-watershed area. Rivers and riverbanks are expected to provide maximum benefits for the life of flora and fauna as well as human welfare continuously if the river ecosystem is improved.

3.6. Working with the climate to save energy

The passive design strategy is applied in the design of residential buildings to reduce the negative impact of buildings on the environment. The strategy implemented includes the use of passive lighting and ventilation. Natural lighting is used as the main source of maximum room lighting. The application of passive lighting principles is expected to reduce or even eliminate the need for artificial lighting in residential spaces. The use of electric lights is only placed in rooms where natural light is not sufficient. The natural lighting strategy is carried out by (a) designing the shape and form of the building; (b) orienting the building and (c) maximizing side lighting.

3.6.1. Designing Building Form and Shapes

Three alternative building shapes can be applied, namely rectangle, equivalent rectangle, and core. Of the three alternatives, the shape of the rectangle and the equivalent rectangle is more appropriate because of the condition of the site shape and the characteristics of the site adjacent to the river. Another consideration is that the shape of the residential building will affect the pattern of airflow around the building so that it directly affects the ventilation of the building. The width of the building (depth) determines the need for artificial lighting where the wider / deeper, the more artificial lighting is needed.

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Therefore, it is recommended that the maximum building width is 8 m so that the interior spaces still get sufficient natural light.

3.6.2. Residential Building Orientation

Residential buildings are oriented to benefit from passive lighting strategies. The orientation of the building and building materials also facilitates the creation of a microclimate and natural lighting.

The ideal orientation for areas with hot and humid climates is to maintain a long building axis from East to West, as this will reduce heat gain. On the other hand, buildings that have a long axis from North to South will have a higher cooling load and require larger cooling equipment, resulting in higher energy costs. Therefore, based on the characteristics and shape of the riverbank footprint, the orientation of residential buildings is directed to the East and West with a tolerance of 30 degrees adjusted to the site conditions. The building minimizes the placement of glass facing East-West.

3.6.3. Optimizing Natural Lighting

Optimizing the use of natural lighting has the advantage of saving energy, creating an attractive environment, and improving the health of its occupants. Window design, placement, shape, and size determine the successful use of natural light. The window will effectively pass natural light into the room up to a distance twice as long as the window height.

Natural light is different from direct sunlight. Natural light is the light of the sky, namely the light that comes from the reflection of the skylight due to the reflection of sunlight on air particles. The relative light of the sky does not cause many problems because the light entering the building does not carry heat. Therefore, the bright sky on the north and south sides of residential buildings is optimally utilized by incorporating natural light from the bright sky to the maximum into the house by making wall openings or holes (windows, jalousies, partially open walls) on the south side and north of the building.

Optimizing natural ventilation has the advantage of saving energy and improving the health of its occupants. The design of ventilation openings either through windows, bouvens, roosters, or lattices is the key to the successful use of natural ventilation. The placement and size of the hole are considered to get an optimal natural ventilation. The movement of the wind on this riverbank generally moves from south to north in the morning to evening and at night changes from north to south. Therefore, ventilation openings are placed on the walls of the building in the north and south positions, so that the space will always get flowing air. Thus there will be an exchange of air inside with outside air. The application of this method has fulfilled three main functions: (a) meeting the need for clean air for residents (health ventilation); (b) increasing the level of heat loss sufficient and can evaporate from the body (comfort ventilation) and (c) cool the indoor space through the exchange of indoor air with outdoor air.

3.6.4. Vegetation to create a microclimate

Trees can help form shade so that the ambient temperature can be reduced, especially in hot climates. Therefore, wide-titled trees are planted in several locations to provide environmental coolness.

Trees on the south side of residential buildings will be useful for entering cold air during the day until the afternoon so that the airflow entering the building is cooler. Meanwhile, the trees on the north side of the building help to be a barrier from the afternoon and evening sun. Besides that, planting a diversity of plant species has an ecological function

provided by plants which are very important for the health of the ecosystem [15]. The recommended tree species are asam jawa (Tamaracus indica), gayam (Inocarpus fagifer), kedawung (Parkia timoriana), rain tree (Samanea saman), beringin (Ficus benjamina), preh (Ficus ribes Reinw), randu (Ceiba pentandra), jambu air (Syzygium aqueum) and bamboo (Bambusa Sp).

Shrubs are one of the constituents of vegetation that have very important ecological functions. The shrub vegetation area shows the formed canopy. Shrub thickness affects the surrounding conditions such as temperature and humidity. Based on these data, planting shrubs for residential landscaping must be an integrated part to optimize the ecological functions of riverbank areas. The recommended shrub vegetation is shrubs that have comfort value and support ecological functions but still have aesthetics, such as vegetation of the Combrataceae, Cassia Sp., Sauropus Sp., Ficus Fariegata, and Ficus fistulosa categories because these types of vegetation can drastically change the microclimate.

3.7. Respect for users

The aspirations of the community agreed to redesign the riverbank area on the condition that the design results will provide benefits and improve the quality of life of the community. At this time some of the dwellings are used as boarding houses and some of the space is rented out. This is related to the very strategic location of Gowok Hamlet because it is close to the State Islamic University. Based on this, the idea of redesigning residential buildings is the co-living concept. Each residential building unit is arranged with a division of private space zones for housing and some for rent or as student boarding rooms.

The location of the site is on the edge of the river, so the concept of building mass uses 3 approaches: facing the river, backing away from the river border, and building with more than 1 floor so that land resources are more efficient. The 1st floor is used for semi-public spaces such as parking spaces or sharing spaces with the consideration that this location is often flooded every rainy season up to a height of 0.5 m to 1 m. While the 2nd floor is for residential and the 3rd floor is for boarding or renting.

The basic consideration for determining a 3-story residential building is that some of the building space can be rented out or as a workspace to increase people's income to improve people's living standards. The existence of two mosques in the location can be used as a basis for arranging the mass and space of the building so that there is social integration for the community. The existence of a large enough green open space can be used for urban farming which is useful for meeting the vegetable needs of the community.

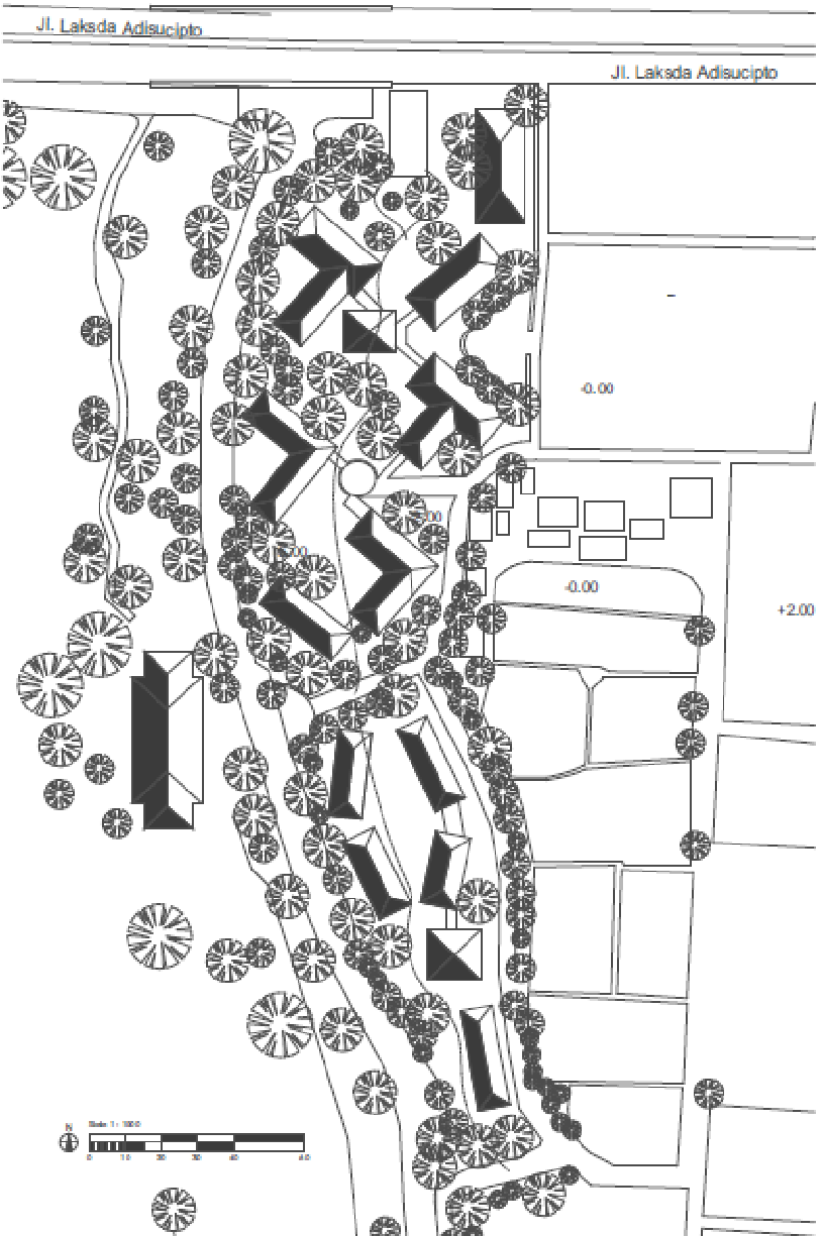

Figure 1. Redesign of Riverbank Settlement Based on Eco-Architecture

4. CONCLUSION

The Eco-Architecture approach can be applied to the redesign of riverbank settlements in the Gajah Wong River. The results obtained that the settlement conditions are much better than the existing settlement conditions. Utilization of natural resources to respond to site characteristics is carried out by rearranging land use, restoring repatriated vegetation zones, increasing green open space zones, and limiting a maximum of 40% for buildings. Working with Climate is applied by designing energy-efficient buildings through passive design and the use of vegetation as a source of microclimate. Responding to residents' needs is implemented by designing co-living so that people can get additional income. Urban farming is applied to meet the needs of vegetables for the community.

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