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Optimizing The Roundabout as Green Infrastructure: A Case Study at ITERA

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ABSTRACT

Limited green space due to urbanization causes problems such as rising micro-temperatures, declining air quality, and increased surface runoff, which increases the risk of flooding. This condition is worsened by the dominance of gray infrastructure. In fact, these problems could be addressed by applying green infrastructure. An open space that can implement green infrastructure is a roundabout. This study aims to explore and optimize the GKU roundabout at ITERA as part of the city's green infrastructure. The research employs a qualitative-descriptive method and is divided into two stages: the pre-design and the design stage. The pre-design stage involves collecting both primary and secondary data necessary for designing the GKU roundabout. The design stage consists of three steps: site inventory, analysis, and design. During this stage, the software used includes AutoCad, SketchUp, and Adobe Photoshop. Green infrastructure that can be applied includes stormwater planters, rain gardens, and permeable concrete. These strategies can help absorb run-off water, prevent flooding, and filter pollutants from run-off water. The seating can also be designed with raised legs, thereby increasing the water infiltration areas. Furthermore, introducing a greater variety of plant species would not only enhance the site's visual appeal but also promote biodiversity and strengthen its ecological value. The results of this research are expected to serve as a guideline for local authorities in designing a more sustainable campus landscape.

Keywords: green infrastructure, green space, rain gardens, run-off water, stormwater planters

INTRODUCTION

Modern cities face increasing environmental pressures due to urbanization, residential expansion, increased traffic intensity, and climate change. Limited green open space causes problems such as rising micro-temperatures (urban heat islands), declining air quality, and increased surface runoff, which increases the risk of flooding. Floods can occur due to high-intensity rain accompanied by piles of garbage, a lack of water catchment areas, building density, inappropriate land use, or floods sent from higher areas[1], [2], [3]. This situation is worsened by the fact that the infrastructure we know, much of which exists in Indonesia today, is gray infrastructure. Gray infrastructure includes various physical infrastructure, such as roads and drainage systems, which are mostly focused solely on the economic aspects because of their low cost, but pay little attention to environmental aspects[4], [5]. The concept of infrastructure that takes environmental and sustainable aspects into account is known as green infrastructure.

Green infrastructure is a network of interconnected green open spaces, such as city parks, greenways, and riverbanks. Green infrastructure is key to maintaining food security, regulating microclimates, conserving water, and providing inclusive social interaction and recreation spaces[6]. Green infrastructure can be defined as infrastructure that utilizes vegetation and natural open spaces to collect rainwater, capturing runoff during rainfall, so that the water is not simply wasted and turned into waste, but can instead become a new resource. Furthermore, green infrastructure can improve water quality, as soil and plants are key components[7]. Green infrastructure focused on the main issues, such as increasing pollution, urban flooding, loss of natural habitat, and vulnerability to disasters[8]. The green infrastructure approach has many advantages, providing more sustainable land use alternatives, such as water catchment areas[9]. Therefore, support and investment in green infrastructure are crucial for creating sustainable, healthy, and livable cities for all their inhabitants[10]. Some examples of green infrastructure applications are: green roofs, green lanes, rain gardens, bioswale, utilization of trees, vegetated terrain, permeable pavement, reservoirs, bioretention systems, infiltration well/trench, infiltrating wetland, and rain barrel, which can be designed to fit its site characteristics[7], [11], [12],[13]. Green infrastructure can be applied to urban forest, urban park, cemetery, green lanes, river banks, railway buffer green space, roadside vegetation, road medians, and roundabouts[14].

Roundabouts are a type of traffic control system widely used in several Indonesian cities[15]. They are used to minimize conflict and streamline traffic flow[16]. Street island parks such as roundabouts, intersections, road medians are part of urban green lanes[17]. As green open spaces, roundabouts, in addition to their aesthetic appeal, also serve as water conservation and dust barriers[18]. Roundabouts have the potential to reduce surface temperatures, absorb particle pollutants, slow down rain runoff flow, thereby increasing local infiltration, and improve the aesthetics and quality of spatial experience for users. However, many roundabouts still serve solely as aesthetic elements dominated by pavement, such as monuments or landmarks. Whereas, roundabouts have the potential to be optimized as spaces that contribute to water conservation, pollutant filtration through vegetation, and flood risk prevention. Therefore, this research aims to explore and optimize the role of roundabouts as part of the city's green infrastructure.

RESEARCH METHODS

1. Time and Location

The research was conducted over a period of two months, from July to September 2025. The study was undertaken at Institut Teknologi Sumatera (hereafter referred to as ITERA) in South Lampung (see Figure 1). The roundabout, which is the object of the research, is commonly referred to as the GKU roundabout. It has a diameter of 40 meters and a total area of 1,256 m^2.

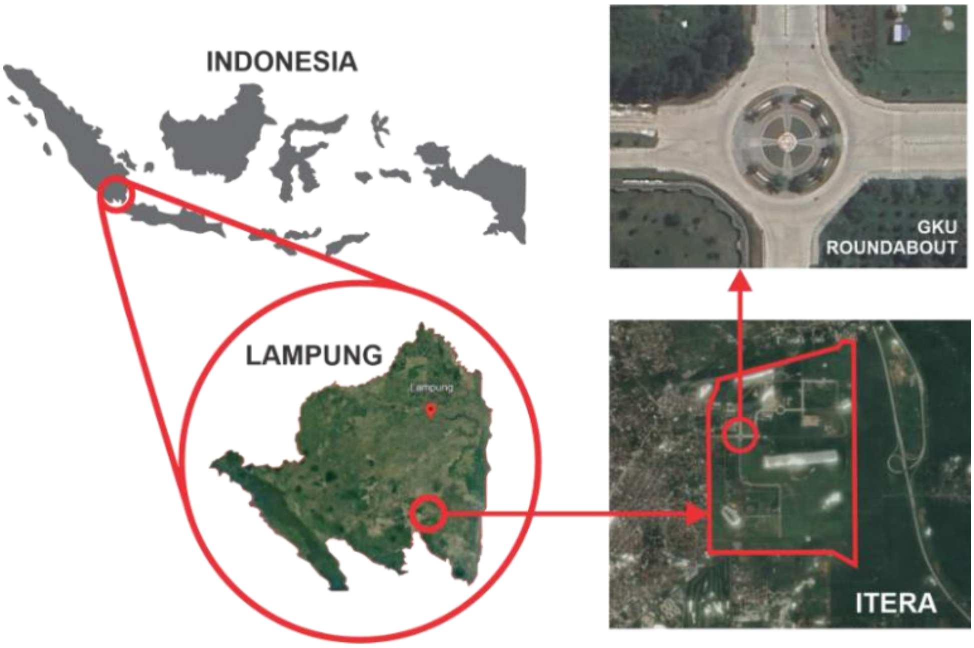

Figure 1. Map of the research location
Source : google Earth, 2025. Modified by author.

2. Data Collection

This research uses the qualitative-descriptive method with a landscape planning and design approach. The methods used in designing the GKU roundabout are shown in Figure 2.

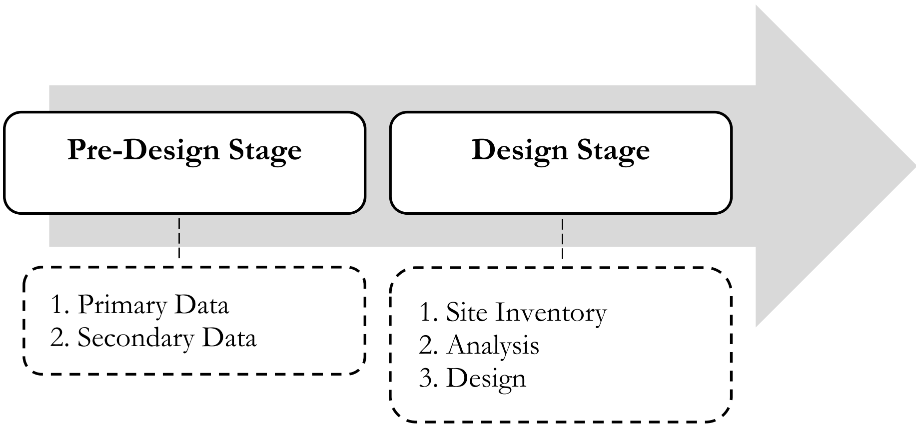

Figure 2. The method stages
Source : Author, 2025

2.1. Pre-Design Stage

Pre-design is conducted by collecting the data required for designing the GKU roundabout. The data is categorized into two types; primary data and secondary data[19]. Primary data is gathered by three steps: survey and site measurement to obtain accurate spatial information, on-site observation to understand the physical, environmental and social conditions and the last step is documentation in the form of photographs and field notes. Secondary data is obtained by reviewing numerous literature sources, including national and international journals related to the discussed topic.

2.2. Design Stage

The collected data is processed to support every step of the planning and design process, from site inventory, where all existing conditions are documented, followed by site analysis to identify opportunities and constraints. The next process is development of concept and final visualization[20]. This stage uses several software tools, such as AutoCAD for precise technical drawings, SketchUp for three-dimensional modelling, and Adobe Photoshop for presentation and visual enhancement of design output

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RESULTS AND DISCUSSION

1. Site Inventory and Analysis

The GKU Roundabout primarily serves as a social space designed to facilitate interaction among ITERA students. This is reflected in the expansive paved area, complete with an amphitheater and seating area, which is designed for gatherings, discussions, performances, art practice, and simply relaxing (Figure 3). However, conditions on the ground indicate a shift in function. Instead of being used by students, the roundabout is more often used as a resting place and a hangout for online motorcycle taxi drivers waiting for orders. Even the motorbikes are parked inside the roundabout. As a result, students are rarely seen utilizing the facilities within the roundabout, so the potential of the planned social space is not optimally achieved.

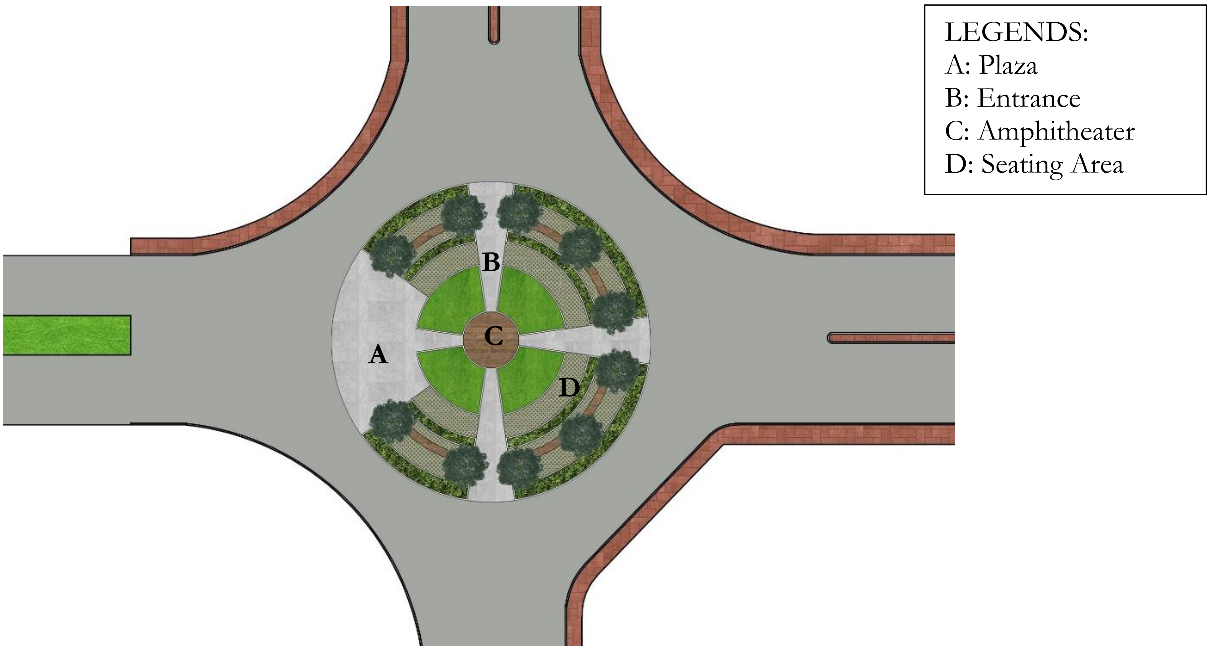
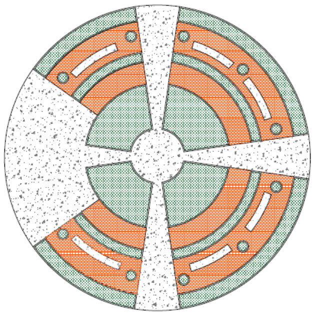
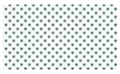
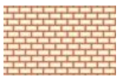


Figure 3. Existing Plan
Source : Author, 2025

The GKU roundabout features three types of surface material categories: non-permeable surfaces, ground cover, and grass blocks. This material serves both functional and aesthetic purposes. The non-permeable surfaces (about 480 m^2), such as concrete and tiles, serve as activity spaces like seating areas, walkways, and the amphitheater. These areas are intended for human circulation and social interaction. Ground cover includes grass, low shrubs, and tree planting zones. These areas (about 383.5 m²) enhance the space's visual appeal and play an ecological role by allowing water to naturally seep into the ground. Grass blocks, covering approximately 392.5 m², facilitate rainwater infiltration and create pathways connecting walkways to seating areas.

Table 1. Surfaces Map

	**Materials**		**Area**
		Non-permeable surfaces	517,5 m²
		Ground cover	383,5 m²
		Grass block	355 m²

Even though the area covered by the grass block is quite large, the conditions were bad. Soil and fallen leaves cover the surface, blocking the infiltration of runoff water. Additionally, some parts were damaged due to their proximity to tree roots. The ground cover area is also pretty big; however, it can't take in runoff from the road because it is elevated and bordered by concrete. Furthermore, even though the road slope is lower towards the roundabout, there is no drainage, so the roundabout cannot receive road water runoff. The area under the seating area can be optimized as a place to absorb water (Figure 4).

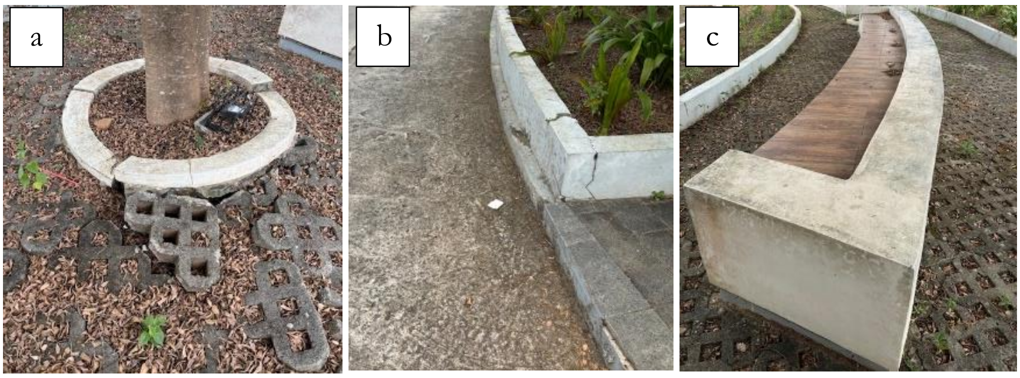


Figure 4. (a) Grassblock, (b) concrete curbs, (c) seating area
Source : Author, 2025

The vegetation within the site consists of three species, namely: *Terminalia mantaly*, *Hymenocalis speciosa*, and *Pennisetum purpureum* (Figure 5). There are 10 *Terminalia mantaly* trees that function as pollution absorbers and shade, making them suitable for students to carry out activities[21]. A 179.5 m2 grass area around the amphitheater accommodates spectators or users during performances or art rehearsals. *Hymenocalis speciosa* can prevent soil erosion and absorb lead[22], [23]. The softscape map can be seen in Table 2. Trees on the roundabout must provide a clear view for drivers because the tree branches are 2 meters above the ground[24]. On the roundabout, only shrubs/bushes with a height of less than 0.5 meters can be planted[25].

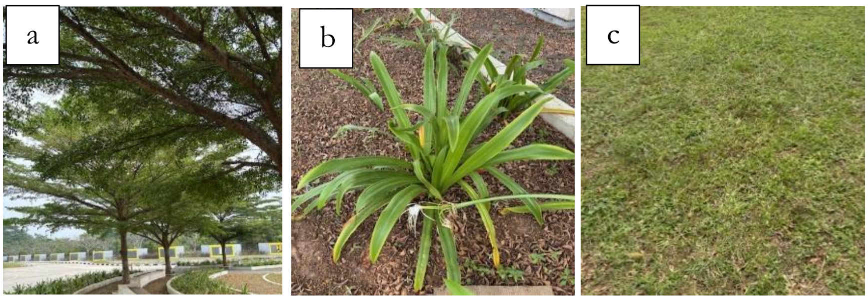
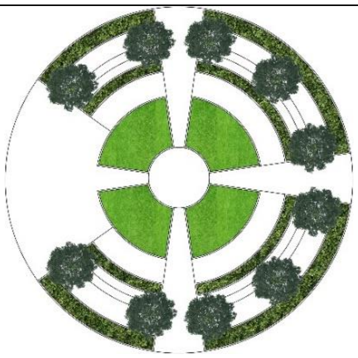


Figure 5. (a) *Terminalia mantaly*, (b) *Hymenocalis speciosa,* (c) *Pennisetum purpureum*
Source : Author, 2025

Table 2. Softscape Map

	Vegetation		Area
		*Terminalia mantaly*	10 trees
		*Hymenocalis speciosa*	190 m²
		*Pennisetum purpureum*	179,5 m²

2. Green Infrastructure Design

Trees can be altered with broadleaf trees, such as *Terminalia catappa* and *Ficus lyrata*, for easy maintenance and to prevent falling leaves from covering the grass block. *Terminalia catappa* is also known to be effective in absorbing Total Suspended Particulate (TSP)[26]. TSP is one of the air pollution parameters that contributes to various health problems and diseases in humans[27]. *Ficus lyrata* is known to absorb lead and sulfur[28]. This alteration to the tree species will increase the number of vegetation types within the site. The higher the number of tree species and the value of tree species diversity in an area, the greater the diversity of ecological functions[29]. To increase water absorption, non-permeable surfaces can be replaced with permeable paving blocks, which consist of three main layers: permeable concrete paving blocks, bedding layers, and open-grade bases (OGB) (Figure 6). The OGB layer serves as a temporary reservoir for rainwater before it infiltrates into the subgrade[30]. Seating can be designed with chair legs, thereby increasing the water absorption areas.

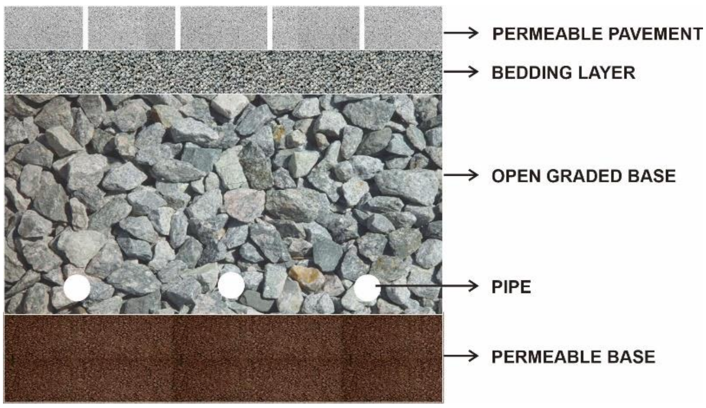


Figure 6. Permeable paving block
Source : Author, 2025

Green infrastructure that can be implemented at these locations includes stormwater planters and rain gardens. Stormwater planters and rain gardens utilize vegetation that can accelerate rainwater absorption, absorb nutrients, and filter pollutants contained in rainwater. Examples of such vegetation include *Pennisetum setaceum, Canna indica, Loropetalum chinense, Lantana camara, Galphimia glauca, Nephrolepis sp., Costus spicatus,* and *Hymenocalis speciosa.* Rain gardens are designed on the grassy areas surrounding the amphitheater. Previously unused grassy areas can now be used as water catchment areas (Figure 7). Rain gardens reduce potential flooding, promote groundwater recharge, enhance aesthetic value, support biodiversity, and improve the overall environmental quality of the amphitheater's surroundings.

Figure 7. Rain gardens
Source : Author, 2025

Stormwater planters are designed in roundabout areas adjacent to roads to accommodate runoff-water from the road. Runoff-water from the road and pedestrian path flows into the stormwater planters through curb cut and designated inlet. Once the water enters the inlet, it is channeled toward a domed riser, which helps spread it evenly across the planter. Inside the planter, the water slowly soaks into the soil, where it gets naturally filtered and cleaned as it passes through the layers. If there's more water than the soil can absorb, the extra is carried away by an underdrain and directed into the existing sewer system. This process helps reduce flooding while also improving the quality of stormwater (Figure 8).

Figure 8. Stormwater planters
Source : Author, 2025

CONCLUSION

1. Conclusion

Several areas at the GKU roundabout could be improved as green infrastructure. These include converting grassy areas into rain gardens and installing stormwater planters in the roundabout area adjacent to the road. These strategies can help absorb run-off water, prevent flooding, and filter run-off water. The seating area can be designed so that it is not completely concrete at the bottom and alter the non-permeable surfaces to permeable pavement, thereby increasing the water absorption area. Finally, introducing a greater variety of plant species would not only make the area more attractive but also boost biodiversity and strengthen the ecological value of the space.

2. Suggestion

The conceptual recommendations in this study can be used as a reference in planning sustainable campus landscape areas. It encourages designer to consider environmental aspects such as conserving water, increasing green coverage, preventing flood and supporting biodiversity, while also creating outdoor space that are comfortable for students and staff.

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