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DESIGN OF A RAINWATER UTILIZATION SYSTEM IN AN URBAN AREA: A CASE STUDY OF GRAHA ENVIRONESIA BUILDING, SLEMAN REGENCY

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Abstract:
Water resource management in urban areas requires sustainable strategies, particularly in regions facing increasing pressure on groundwater use and rising rainwater runoff. This study aims to design a rainwater utilization system at the Graha Environesia Building, Sleman Regency, as an alternative source to partially meet clean water demand and support groundwater conservation. The study was conducted through an analysis of rainwater quality, rainfall data, building clean water demand, rainwater harvesting system calculations, pipeline network planning, water quality treatment, and estimation of system costs and environmental benefits. The Graha Environesia Building has a clean water demand of 2,750 liters per day, with a total of 90 users. The results show that most rainwater quality parameters met the required standards, except for hexavalent chromium (Cr^{6+}), which requires treatment through an adsorption system using zeolite. The designed system is capable of collecting 5.8 m³ of rainwater per day, with a utilization efficiency of 47% of the building's total water demand. The system requires an adsorption tank with a capacity of 0.0203 m³ using 3 kg of zeolite, with an estimated treatment efficiency of 90%. The estimated construction cost of the system is IDR 38,446,000.00. The implementation of this rainwater utilization system has the potential to reduce groundwater use by 870,000 liters per year, making it a technical and ecological solution to support groundwater conservation in urban areas.

Keywords: Rainwater; Groundwater Conservation; Rainwater Harvesting; Water Quality; Zeolite Adsorption; Urban Area.

INTRODUCTION

Water resource management has become one of the strategic issues in urban development, particularly in areas experiencing population growth, increased economic activity, and land-use change. Urban development is generally followed by increasing demand for clean water for domestic, commercial, office, and industrial activities. At the same time, the expansion of built-up areas often reduces water infiltration zones, making it increasingly difficult to maintain a balance between water availability, groundwater recharge, and surface runoff control. This condition indicates that water management in urban areas should not only focus on clean water supply, but should also consider conservation, resource-use efficiency, and environmental risk reduction.

Sleman Regency, as part of the Special Region of Yogyakarta, is one of the areas facing serious challenges in water resource management. In recent years, Sleman has experienced two interrelated problems, namely groundwater level decline and increasing flood risk. The decline in groundwater levels is caused by excessive groundwater extraction for domestic and business activities, while the increase in surface runoff is influenced by high rainfall intensity and reduced infiltration areas due to land conversion. Groundwater levels in this area have reportedly decreased by approximately 1–1.5 meters per year, while the average annual rainfall exceeds 2,500 mm, with several extreme rainfall events contributing to floods and inundation. This condition is further aggravated by the

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limited capacity of drainage systems to accommodate rainwater volume and the conversion of green open spaces into residential and commercial areas (Yulianto et al., 2019; BMKG, 2023; Pratama et al., 2022).

These problems indicate the need for a more adaptive and sustainable approach to water management. One alternative that can be implemented is a rainwater harvesting system (RWHS). Rainwater harvesting is a method of collecting, storing, treating, and utilizing rainwater for various purposes, both domestic and non-domestic. This system can be applied by using building roofs as catchment areas, after which the collected rainwater is conveyed through gutters or pipes to storage and treatment units. In urban areas, rainwater harvesting has two main functions: as an alternative source of clean water and as an instrument for controlling surface runoff. Therefore, rainwater that would otherwise flow directly into drainage channels can be reused to reduce dependence on groundwater.

Previous studies have shown that rainwater harvesting systems have significant potential to support water resource management. Abdulla et al. (2009) stated that rooftop rainwater harvesting systems can be used as an alternative household water supply when supported by adequate filtration systems. Campisano et al. (2017) also emphasized that the implementation of rainwater harvesting systems in urban areas can reduce surface runoff and decrease water consumption from primary sources. Meanwhile, Liuzzo et al. (2016) showed that the reliability of rainwater harvesting systems is influenced by rainfall, catchment area, storage capacity, and user water demand patterns. Another study by Yulistyorini (2011) explained that rainwater harvesting can serve as an alternative approach to water resource management in urban areas because it can reduce groundwater consumption and utilize rainfall that falls on building surfaces.

From an environmental conservation perspective, rainwater harvesting plays an important role in reducing pressure on groundwater reserves. Continuous groundwater extraction without adequate recharge efforts can lead to declining groundwater levels, deteriorating water quality, and potential long-term environmental damage. Conversely, rainwater utilization can reduce groundwater abstraction, particularly for purposes that do not require drinking-water quality. Collected and treated rainwater can be used for activities such as plant watering, building cleaning, certain sanitation needs, and other operational purposes. Therefore, rainwater harvesting systems are not only technically valuable but also ecologically important in maintaining the sustainability of water resources.

Graha Environesia Building in Sleman Regency is one of the urban buildings considered relevant for the implementation of a rainwater harvesting system. The building is occupied by PT Environesia Global Saraya and PT Green Lab Indo Global, with approximately 90 employees. The building's daily clean water demand reaches approximately 2,750 liters and is currently supplied through groundwater extracted from a drilled well. This condition indicates a dependence on groundwater as the main source of the building's water supply. In the long term, this dependence should be reduced through the implementation of more sustainable alternative water sources. Rainwater harvesting is a potential option because it can utilize local rainfall while supporting groundwater-use reduction and electricity savings.

The implementation of a rainwater harvesting system in urban buildings needs to be designed based on site-specific conditions. Several aspects must be considered, including rainwater quality, catchment area, rainfall intensity, user water demand, storage capacity, piping system, treatment technology, and cost feasibility. In addition, the use of rainwater and groundwater should be managed in an integrated manner so that the designed system is not only technically feasible but also operationally effective. The selection of appropriate technology is strongly influenced by economic conditions, user needs, and local regulations. With proper planning, a rainwater

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harvesting system can improve water-use efficiency, reduce operational costs, and support more responsible environmental management.

Based on this background, this study aims to design a rainwater utilization system at Graha Environesia Building, Sleman Regency, as an alternative to partially meet clean water demand. This study focuses on rainwater quality analysis, rainwater harvesting system design, integrated management of rainwater and groundwater use, and the calculation of system costs and benefits. The findings of this study are expected to provide practical contributions to the development of rainwater harvesting systems in urban buildings, as well as serve as a reference for building managers, business actors, and policymakers in promoting sustainable groundwater conservation.

Rainwater rainwater is one of the water resources that can be utilized as an alternative source to meet clean water needs. In urban areas, rainwater is often not optimally used and is mostly discharged into drainage systems before flowing into rivers or the sea. In fact, when properly managed through appropriate collection, filtration, and storage systems, rainwater can be used for various purposes, such as bathing, washing, plant watering, cleaning activities, and even as a source of clean water after meeting the required quality standards. The utilization of rainwater is important because access to clean water is a crucial issue in supporting public health and environmental sustainability (Hunter et al., 2010; Waseem et al., 2023).

In planning rainwater utilization, rainfall is a key aspect that must be considered. Rainfall refers to the amount of water that falls to the earth's surface within a certain period, while rainfall intensity indicates the amount of rainfall occurring within a specific unit of time. Information on rainfall and rainfall intensity is required to calculate the potential volume of water that can be collected, storage capacity, and the requirements of the conveyance system. Rainfall also plays an important role in hydrological studies and water resource management, particularly in areas affected by climate change and increasing extreme weather events (Barry & Chorley, 2009; Curtis et al., 2017).

In addition to quantity, rainwater quality must also be considered. Initially, rainwater is relatively clean because it originates from atmospheric precipitation. However, its quality may decline when it comes into contact with roof surfaces, conveyance channels, filters, and storage tanks. Contaminants that may be carried by rainwater include physical particles, chemical compounds, and microorganisms. Therefore, rainwater intended for use as clean water must be tested according to applicable water quality parameters. In Indonesia, water quality for hygiene and sanitation purposes refers to the Regulation of the Minister of Health Number 2 of 2023, which includes microbiological, physical, and chemical parameters, such as Escherichia coli, total coliform, TDS, turbidity, color, pH, nitrate, nitrite, iron, manganese, and hexavalent chromium ($Cr6+$) (Radaideh et al., 2009; Gwenzi et al., 2015).

Groundwater Reserves groundwater is one of the main sources of clean water supply in urban areas. However, continuous and uncontrolled groundwater use can lead to groundwater level decline and disrupt the hydrological balance. This condition becomes more serious in urban areas due to population growth, commercial area development, and increasing water demand for both domestic and non-domestic activities.

In the context of Mlati District, Sleman Regency, groundwater reserves are part of the Yogyakarta–Sleman Groundwater Basin system. The dynamic groundwater reserve in Mlati District is reported to be 135,464,219,120 liters per year. Although this reserve is relatively large, groundwater management must still be carried out carefully to prevent overexploitation. One strategy that can be implemented is reducing dependence on groundwater through the use of alternative water sources, such as rainwater. Thus, rainwater harvesting can function as a form of

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groundwater conservation, particularly for meeting water needs that do not necessarily require drinking-water quality (Manny et al., 2016).

Rainwater Harvesting rainwater harvesting is a method or technology used to collect rainwater from building roofs, ground surfaces, roads, or other catchment areas so that it can be utilized as an alternative source of clean water. This system is highly relevant for areas experiencing limited clean water availability, declining groundwater reserves, or increasing surface runoff. Abdulla et al. (2009) explained that rainwater harvesting can serve as an alternative water supply, particularly when supported by appropriate collection, filtration, and storage systems.

In general, a rainwater harvesting system consists of several main components, namely the rainwater catchment area, conveyance system, filter, storage tank, first flush device, and pump. The catchment area functions as the surface that receives rainwater and is commonly in the form of a building roof. The conveyance system, such as gutters or pipes, is used to channel water from the catchment area to the storage tank. The filter functions to remove debris such as leaves, twigs, dust, and other particles in order to maintain water quality. The storage tank is used to store rainwater, while the first flush device functions to discard the initial rainwater flow, which may contain contaminants from the roof surface. A pump is required when water from the tank needs to be distributed to the water network or specific points of use.

The selection of materials and system design strongly influences the efficiency and quality of the collected rainwater. Catchment surface materials should be non-toxic and should not degrade water quality. In addition, pipe size, channel slope, tank capacity, and ease of maintenance must be considered to ensure that the system operates optimally. In urban areas, rainwater harvesting systems not only function as an alternative water supply but also contribute to reducing surface runoff and pressure on drainage systems (UNEP, 2001; Campisano et al., 2017).

Rainwater Harvesting Calculation rainwater harvesting calculations are required to determine the technical feasibility of the designed system. Several key aspects in the calculation include rainfall intensity, rainwater discharge, catchment area, pipe diameter, storage capacity, and rainwater utilization efficiency. Rainfall intensity calculation is used to convert daily rainfall data into a time unit that is more suitable for system design requirements. In addition, rainfall projection can also be used to estimate rainwater potential in future periods.

Rainwater discharge can be calculated based on the relationship between runoff coefficient, rainfall intensity, and catchment area. This calculation is important to determine the volume of water that can be collected from roof surfaces or other catchment areas. Chow et al. (1988) explained that this hydrological approach can be used in planning runoff discharge and water conveyance systems. After the discharge is determined, pipe diameter can be calculated based on discharge, cross-sectional area, and flow velocity. According to Mays (1999), pipe size must be properly designed to convey water according to flow capacity without causing unnecessary installation costs.

Rainwater utilization efficiency indicates the ability of the system to meet water demand from the volume of collected rainwater. This efficiency is calculated by comparing the volume of collected rainwater with the total water demand. The greater the proportion of water demand that can be supplied by rainwater, the higher the effectiveness of the system in reducing groundwater use. Therefore, efficiency calculation becomes an important indicator in assessing the performance of a rainwater harvesting system (Haris et al., 2016).

This section also needs to consider the possible presence of hexavalent chromium ($Cr6+$) in rainwater. $Cr6+$ is a toxic chemical compound that may occur due to contact between rainwater and certain materials, such as roofs or galvanized components. Lindström et al. (2010) explained that chromium-treated galvanized steel can release chromium into the environment under certain

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conditions. Therefore, if the concentration of Cr6+ exceeds the quality standard, special treatment is required.

One method for treating Cr6+ is adsorption using zeolite. Zeolite has a porous structure and is capable of adsorbing contaminants from water. Kouli et al. (2020) showed that both natural and modified zeolites can be used to adsorb Cr6+ from aqueous solutions. The effectiveness of adsorption is influenced by contact time, pH, initial Cr6+ concentration, and adsorbent characteristics. Therefore, zeolite can be considered an efficient and environmentally friendly treatment alternative in rainwater utilization systems.

Management of Rainwater Utilization management of rainwater utilization is required to ensure that the system operates effectively and sustainably. Rainwater is not always available evenly throughout the year because it is influenced by seasonal patterns and rainfall distribution. Therefore, rainwater utilization needs to be managed alongside other water sources, particularly groundwater. During the rainy season, rainwater can be optimally used to meet part of the building's water demand. Meanwhile, during the dry season or when rainwater reserves are insufficient, groundwater can be used as a supporting source.

The management of a rainwater utilization system is not only related to water quantity but also to the quality of stored water. Water stored in tanks for a certain period may experience quality degradation if not properly managed. Therefore, the system needs to be equipped with filtration mechanisms, tank maintenance, distribution control, and water quality monitoring. Amos et al. (2020) explained that the integration of rainwater harvesting systems and groundwater use can improve water supply resilience, particularly when supported by proper operational management.

Costs and Benefits of Rainwater Harvesting Cost and benefit aspects are important considerations in the implementation of a rainwater harvesting system. System costs include component procurement, installation, operation, and maintenance. Components that commonly require costs include pipes, filters, storage tanks, pumps, treatment units, and other supporting equipment. The total cost is strongly influenced by system capacity, material type, pipeline network complexity, and water treatment requirements.

Although it requires an initial investment, a rainwater harvesting system has potential long-term benefits. These benefits may include reduced groundwater use, operational cost efficiency, energy savings from groundwater pumping, and contributions to environmental conservation. Amos et al. (2020) stated that the construction cost of a rainwater harvesting system is influenced by tank capacity and supporting system components. Meanwhile, Vialle et al. (2015) explained that rainwater harvesting systems have relatively low environmental impacts compared with full dependence on conventional water sources. Therefore, a rainwater harvesting system can be viewed as an environmental investment that supports water-use efficiency and groundwater conservation.

METHODS

This study employed a descriptive-quantitative approach with a technical planning research design. The study was conducted to design a rainwater utilization system as an alternative source to partially meet clean water demand in an urban building. The research location was the Graha Environesia Building, located at Jati Mataram Street No. 284B, Karangjati, Sinduadi Village, Mlati District, Sleman Regency. This location was selected because the building still uses groundwater from a drilled well as its main source of clean water, while the roof area has the potential to be utilized as a rainwater catchment area.

The research data consisted of primary and secondary data. Primary data were obtained through field observations, building area measurements, identification of roof conditions and the existing piping system, interviews with the building manager, field documentation, and rainwater

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sampling. The rainwater samples were tested in the laboratory to determine their quality based on physical, chemical, and microbiological parameters. Water sampling for physical and chemical parameters referred to SNI 8995:2021, while sampling for microbiological parameters referred to SNI 9063:2022.

Secondary data were obtained from rainfall, humidity, and wind speed data, building technical data, location maps, and supporting documents from relevant institutions. Rainfall data were used to calculate rainfall intensity and the potential volume of rainwater that could be collected. Meanwhile, building technical data were used to determine the catchment area, clean water demand, piping routes, and the placement of rainwater harvesting system components.

Data analysis was carried out through several stages, including the analysis of the building's clean water demand, rainwater quality analysis, calculation of rainwater potential, design of the rainwater harvesting system, planning of the water treatment system, and estimation of system costs and benefits. Clean water demand was calculated based on the number of building users and the standard daily water requirement. Rainwater potential was calculated based on the catchment area, rainfall intensity, and runoff coefficient. The results of these calculations were used as the basis for determining storage capacity, pipe diameter, distribution system, and rainwater utilization efficiency.

The system design focused on the use of rainwater for non-consumptive purposes, such as cleaning, sanitation, and plant watering. If the water quality test results indicated that certain parameters exceeded the quality standards, an appropriate treatment unit was designed before the water could be used. Cost estimation was conducted by calculating the required system components, including pipes, filters, tanks, pumps, and treatment units. The system benefits were analyzed based on the potential reduction in groundwater use and its contribution to water resource conservation.

RESULT AND DISCUSSION

Existing Conditions Building Condition the Graha Environesia Building is located in Sinduadi Village, Mlati District, Sleman Regency, Special Region of Yogyakarta. The building is used by PT Environesia Global Saraya and PT Green Lab Indo Global. Based on the existing conditions, the building consists of several functional spaces, including offices, laboratories, meeting rooms, storage rooms, toilets, a front office, and other supporting areas. The roof area that can be utilized as a rainwater catchment area is 117.48 m². This area serves as the main basis for planning the rainwater harvesting system in the building.

Existing Clean Water Distribution System the existing clean water supply system at the Graha Environesia Building uses a ground tank and roof tank system. Water from the ground tank is pumped to the roof tank and then distributed to points of use, such as toilets, washbasins, and other operational needs. The existing ground tank has a capacity of 1,000 liters, while the roof tank has a capacity of 600 liters. This system serves as a key consideration in integrating the rainwater harvesting system with the existing clean water network.

Rainwater Quality the rainwater quality test results showed that most parameters met the quality standards for water used for hygiene and sanitation purposes. Physical parameters such as TDS, color, and odor were still within acceptable conditions. Chemical parameters such as nitrate, nitrite, iron, and manganese were also below the quality standards. Microbiological parameters, namely Total Coliform and Escherichia coli, showed results of 0 CFU/100 mL. However, hexavalent chromium or Cr^{6+} showed a concentration of 0.014 mg/L, exceeding the quality standard of 0.01 mg/L based on the Regulation of the Minister of Health Number 2 of 2023. Therefore, rainwater has the potential to be used as an alternative water source, but it requires specific treatment to reduce Cr^{6+} concentration.

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Table 1. Rainwater Quality Test Results

No	Parameter	Unit	Result	Quality Standard
1	TDS	mg/L	154	<300
2	Color	TCU	9,30	10
3	Odor	-	Odorless	Odorless
4	Nitrate	mg/L	1,41	20
5	Nitrite	mg/L	0,004	3
6	Cr6+	mg/L	0,014	0,01
7	Iron	mg/L	0,023	0,2
8	Manganese	mg/L	0,009	0,1
9	Total Coliform	CFU/100 mL	0	0
10	*Escherichia coli*	CFU/100 mL	0	0

Source: Processed by the researcher, 2026.

Clean Water Demand the clean water demand of the Graha Environesia Building was calculated based on the number of building users and supporting activities. PT Environesia Global Saraya has 40 users with a water demand of 1,200 liters/day, while PT Green Lab Indo Global has 50 users with a water demand of 1,500 liters/day. In addition, the water requirement for cleaning activities is 50 liters/day. Therefore, the total clean water demand of the building is 2,750 liters/day or 2.75 m³/day.

Table 2. Water Consumption Composition of Graha Environesia Building

No	Component	Number of Users	Requirement	Total Liters/day	m³/day
1	PT Environesia Global Saraya	40	30 L/orang/hari	1.200	1,20
2	PT Green Lab Indo Global	50	30 L/orang/hari	1.500	1,50
3	Cleaning activities	-	50 L/hari	50	0,05
	Total	**90**		**2.750**	**2,75**

Source: Processed by the researcher, 2026.

Building Roof Area the roof area that can be used as a rainwater catchment area is 117.48 m². This area was used as the basis for calculating the discharge and volume of rainwater that could be collected. Since the rainwater harvesting system was designed within the land and building area of Graha Environesia, the roof area became the main component in the catchment area design.

Rainfall data were obtained from the BMKG Sleman Geophysical Station for the 2019–2023 period. The analysis showed that the highest maximum daily rainfall occurred in March 2019, reaching 170.6 mm/day. Based on the average monthly rainfall, the wet months occurred in January, February, March, November, and December, while the dry months occurred from April to October. The highest rainfall intensity based on the daily average occurred in March, reaching 91.36 mm/day or 3.81 mm/hour. The five-year rainfall intensity projection showed an average value of 2.45 mm/hour.

Rainwater Collector the calculation of the rainwater collector was carried out using a rainfall intensity of 0.0000006361 m/second, a roof area of 117.48 m², and a runoff coefficient of 0.9. Based on this calculation, the rainwater discharge that could be collected was 0.0000672595 m³/second. When converted into daily volume, the collected rainwater reached 5.8 m³/day. This volume is greater than the building's clean water demand of 2.75 m³/day, indicating that rainwater has the potential to serve as an alternative water source during the rainy season.

Table 3. Rainwater Collector Calculation

Description	Value	Unit

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Rainfall intensity	0,0000006361	m/second
Roof catchment area	117,48	m²
Runoff coefficient	0,9	-
Rainwater discharge	0,0000672595	m³/second
Rainwater volume	5,8	m³/day

Source: Processed by the researcher, 2026.

Determination of Collector Pipe Diameter based on the rainwater discharge of 0.0000672595 m³/second and an assumed flow velocity of 2 m/second, the minimum required pipe diameter was 6.54 mm. After adjustment to standard pipe sizes, the system uses a nominal ¾-inch pipe or DN 20. This size was selected by considering safety factors, rainfall discharge variation, potential sediment accumulation, flow pressure, and ease of maintenance.

Treatment of Hexavalent Chromium (Cr6+) since the Cr6+ concentration in rainwater exceeded the quality standard, the system was designed using an adsorption method with zeolite as the adsorption medium. The rainwater discharge to be treated was 5.8 m³/day or 241.67 L/hour. With a contact time of 5 minutes, the required adsorption tank volume was 20.14 liters or 0.0203 m³. The treatment unit was designed as a cylindrical tank with a height of 0.833 m, a diameter of 0.176 m, 10 kg of zeolite, a zeolite thickness of 0.342 m, and an estimated treatment efficiency of 90%.

Table 4. Design Criteria of the Cr6+ Treatment Unit

Design Criteria	Value	Unit
Vessel shape	Cylindrical	-
Vessel volume	0.0203	m³
Vessel height	0.833	m
Vessel diameter	0.176	m
Cross-sectional area	0.0243	m²
Vessel material	PVC/HDPE pipe	-
Zeolite mass	10	kg
Zeolite thickness	0.342	m
Contact time	5	minutes
Superficial flow rate	10	m³/m²
Treatment efficiency	90	%

Source: Processed by the researcher, 2026

Distribution Pipeline Planning the distribution pipeline was planned to convey rainwater from the roof to the filter, then to the storage tank and points of use. The planned gutter pipe is ¾ inch or DN 20, with PVC or HDPE material. The storage tank was planned with a capacity of 15 m³ or 15,000 liters. This capacity was selected by considering the rainwater potential of 5.8 m³/day and the assumption of rainfall occurring three days per week.

Management of Rainwater Utilization the management of rainwater utilization was designed through a combination of rainwater and groundwater use. During the rainy season, the collected rainwater of 5.8 m³/day can meet the building's water demand of 2.75 m³/day. On days without rainfall, groundwater from the drilled well remains the main water source. On rainy days, rainwater is used to fill the lower tank, while the excess water is directed to the upper tank with a capacity of 15 m³ as a reserve. Based on the comparison between clean water demand and the volume of rainwater that can be collected, rainwater utilization efficiency reaches 47%.

Costs and Benefits of Rainwater Harvesting Required Cost the total construction cost of the rainwater harvesting system is IDR 38,445,830.05 and is rounded to IDR 38,446,000.00. The largest cost component is the water tower structure work, amounting to IDR 25,436,134.04, followed by installation and piping work of IDR 9,270,000.00 and foundation work of IDR 3,691,108.46.

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Table 5. Summary of the Budget Plan for the Rainwater Harvesting System

No.	Work Component	Total Cost
1	Earthwork	IDR 48,587.55
2	Foundation work	IDR 3,691,108.46
3	Water tower structure work	IDR 25,436,134.04
4	Installation and piping work	IDR 9,270,000.00
	Total	**IDR 38,445,830.05**
	Rounded	**IDR 38,446,000.00**

Source: Processed by the researcher, 2026

Electricity Use Calculation and Proportion of Groundwater Reduction the cost efficiency analysis focused on electricity use for water pump operation. Based on a water demand of 2,750 liters/day and a pump capacity of 20 liters/minute, the pump operating time reached 68.75 minutes/day. The use of two pumps with a power rating of 790 watts resulted in electricity consumption of 1.81 kWh/day. With an electricity tariff of IDR 1,699.53/kWh, the pump electricity cost is IDR 3,076.15/day, IDR 92,284.50/month, or IDR 1,107,414.00/year. From an environmental benefit perspective, rainwater utilization has the potential to reduce groundwater use by 870,000 liters/year.

DISCUSSION

Existing Conditions the existing condition of the Graha Environesia Building indicates that the building has technical potential for the implementation of a rainwater harvesting system. The roof area of 117.48 m² can be utilized as a catchment area without requiring additional land development. In addition, the existing clean water system, which already uses a ground tank and a roof tank, allows the rainwater system to be integrated into the existing distribution network. However, the capacity of the existing tanks is still limited; therefore, an additional tank is needed so that the collected rainwater volume can be optimally utilized.

Rainwater Quality the test results indicate that rainwater at the study location is feasible to be considered as an alternative water source for non-consumptive purposes. This is supported by most physical, chemical, and microbiological parameters meeting the required standards. However, the $Cr6+$ concentration exceeding the threshold is an important finding, as it indicates that rainwater quality may be affected by contact with catchment surface materials or the conveyance system. Therefore, rainwater utilization still requires a treatment unit before it can be used for hygiene and sanitation purposes.

Clean Water Demand clean water demand of 2.75 m³/day indicates that the building's water consumption is still at a scale that allows partial substitution by rainwater. Compared with the rainwater potential of 5.8 m³/day, rainwater is quantitatively capable of meeting the building's daily water demand during rainfall events. However, because rainwater availability strongly depends on season and rainfall intensity, groundwater is still required as a supporting water source.

Building Roof Area the roof area is an important factor in the success of a rainwater harvesting system. In this study, the 117.48 m² roof area was able to generate a rainwater potential of 5.8 m³/day. This finding shows that the building roof does not only function as a protective architectural element, but can also be utilized as water conservation infrastructure in urban areas.

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Rainfall the rainfall pattern from 2019 to 2023 shows that rainwater harvesting is most potential during the wet months, particularly January, February, March, November, and December. This condition indicates that the storage system is an important component to ensure that rainwater captured during the wet period can be used during rainless periods. Therefore, the system design should consider not only daily volume but also rainfall distribution patterns and water reserve requirements.

Rainwater Harvesting System Design the design results show that the rainwater harvesting system is capable of producing a water volume greater than the building's daily water demand. The use of a nominal ¾-inch pipe is also considered adequate because it takes into account technical calculation results and operational safety factors. Meanwhile, the zeolite adsorption unit is an important component because the rainwater quality still contains Cr6+ above the quality standard. With this treatment unit, the system is not only oriented toward water quantity but also considers the safety of the water quality used**.**

Management of Rainwater Utilization the hybrid management of rainwater and groundwater use is a realistic approach for urban buildings. During the rainy season, rainwater can be used as the main source to reduce groundwater use. On days without rainfall or when rainwater reserves are insufficient, groundwater remains a supporting source. The utilization efficiency of 47% indicates that the system makes a tangible contribution to reducing the building's dependence on groundwater**.**

Costs and Benefits of Rainwater Harvesting the construction cost of IDR 38,446,000.00 indicates that implementing a rainwater harvesting system requires a relatively large initial investment, particularly for the water tower structure and piping installation components. When viewed from the electricity savings of IDR 1,107,414.00 per year, the purely financial payback period would be relatively long. However, the main benefit of this system lies in its environmental aspect, namely the reduction of groundwater use by 870,000 liters/year. If similar systems are implemented in many urban buildings, the cumulative impact could support groundwater conservation and reduce pressure on urban drainage systems.

CONCLUSION

Based on the research results, the rainwater utilization system at the Graha Environesia Building, Sleman Regency, has the potential to be implemented as an alternative source to partially meet clean water demand in an urban building. The roof area of 117.48 m^2 can generate a rainwater potential of 5.8 m^3/day, while the building's clean water demand is 2.75 m^3/day. This indicates that, quantitatively, rainwater can support the building's water demand, particularly during the rainy season.

The rainwater quality test results showed that most physical, chemical, and microbiological parameters met the quality standards for water used for hygiene and sanitation purposes. However, the hexavalent chromium (Cr6+) concentration of 0.014 mg/L exceeded the quality standard of 0.01 mg/L; therefore, treatment is required before the rainwater can be utilized. Accordingly, the system was designed with an adsorption unit using zeolite media, supported by a ¾-inch collector pipe, a 15 m^3 storage tank, and a distribution network to the points of use.

The implementation of this rainwater harvesting system resulted in a utilization efficiency of 47% of the building's water demand. The total construction cost of the system is estimated at IDR 38,446,000.00, with the potential to reduce groundwater use by 870,000 liters per year. Therefore, the rainwater utilization system at the Graha Environesia Building can serve as both a technical and

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ecological solution to support groundwater conservation, efficient water resource utilization, and sustainable water management in urban areas.

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