

Yağmur Suyu Hasadı ile Sürdürülebilir Su Yönetimi: Samsun Üniversitesi Balıca Kampüsü Örneği

Sustainable Water Management Through Rainwater Harvesting: A Case Study at Samsun University Ballica Campus

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ÖZET

Günümüzde artan su ihtiyacı ve iklim değişikliğinin etkileri, alternatif su kaynaklarının değerlendirilmesini zorunlu hale getirmektedir. Bu bağlamda yağmur suyu hasadı, hem ekolojik sürdürülebilirlik hem de ekonomik verimlilik açısından öne çıkan yöntemlerden biridir. Bu çalışma, Samsun Üniversitesi Balıca Kampüsünde bulunan hangar yapıları üzerinden yağmur suyu hasadı potansiyelini incelemeyi ve kampüs dinamiğine en uygun depolama stratejisini belirlemeyi amaçlamaktadır. Çalışmada örnek olarak seçilen bir hangarın çatı alanı dikkate alınmış, bölgenin yıllık yağış verileri kullanılarak toplanabilecek yağmur suyu miktarı hesaplanmıştır. Elde edilen suyun kullanım potansiyeli, sağlayacağı yıllık tasarruf miktarı ve bu tasarrufun Türk Lirası cinsinden ekonomik karşılığı ortaya konulmuştur. Buna ek olarak, elde edilecek suyun yönetimi için merkezi depolama sistemi ile hangarlar çevresinde konumlandırılan lokal depolama sistemi; 11 adet kapsamlı sürdürülebilirlik ve fizibilite kriterleri açısından karşılaştırmalı olarak değerlendirilmiştir. Sonuçlar, kampüs ölçeğinde uygulanacak yağmur suyu hasadı sistemlerinin hem su kaynaklarının korunmasına hem de maliyetlerin azaltılmasına katkı sağlayabileceğini ve seçilecek altyapı modelinin kampüsün fiziksel koşullarına göre optimize edilmesi gerektiğini göstermektedir.

Anahtar Kelimeler: Yağmur suyu hasadı, Sürdürülebilirlik, Su Yönetimi, Kampüs Ölçeğinde Su Tasarrufu, Yeşil Kampüs Uygulamaları

ABSTRACT

Today's growing demand for water and the effects of climate change make it imperative to explore alternative water sources. In this context, rainwater harvesting is one of the leading methods in terms of both ecological sustainability and economic efficiency. This study aims to examine the potential for rainwater harvesting from the hangar structures located at the Ballica Campus of Samsun University and to determine the storage strategy best suited to the campus dynamics. The roof area of a hangar selected as a sample in the study was considered, and the amount of rainwater that could be collected was calculated using the region's annual precipitation data. The potential uses of the collected water, the annual savings it would provide, and the economic value of these savings in Turkish Lira were presented. In addition, a centralized storage system and a local storage system located around the hangars were comparatively evaluated based on 11 comprehensive sustainability and feasibility criteria. The results indicate that rainwater harvesting systems implemented on a campus scale can contribute to both the conservation of water resources and the reduction of costs, and that the selected infrastructure model must be optimized according to the campus's physical conditions.

Keywords: Rainwater harvesting, Sustainability, Water management, Campus-scale water conservation, Green campus practices

Başvuru: 04.08.2026 Kabul: 20.10.2026

Doi: 10.51764/smutgd.2010775

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1. INTRODUCTION

Water, one of the most fundamental building blocks of life, has become a serious problem for the entire world due to emergence of the possibility of depletion for various reasons such as urbanisation, population growth and industrialisation, accelerating search for solutions to the problem. With increasing population growth and climate change, the importance of water is increasing day by day, and it is stated that it may become a scarce resource in coming periods (Mengü & Akkuzu, 2008; Republic of Turkey Ministry of National Education & WWF Turkey, 2020). This situation has made effective water management a vital issue for countries, which is not among the water-rich countries and experiences water stress (Kirtorun & Karaer, 2018). Within the scope of sustainable freshwater management, there are two main solution approaches: the efficient use of existing water resources and discovery of water resources in addition to centralised traditional systems. Rainwater harvesting, evaluated within the scope of this second approach, is an ancient method that has been used for centuries and has been important in terms of reducing flood risk and increasing existing water resources (Yannopoulos et al., 2018). In rainwater harvesting systems, water can be collected from surfaces such as ground and roofs. The collected water is then utilised for secondary uses such as irrigation and toilet cisterns, and when appropriate treatment methods are applied, it can even be used for bathing and drinking water (Sustainable Technologies, n.d.). Rainwater harvesting, an important alternative for increasing available freshwater resources, is a flexible method that can be applied in different types of structures and settlements. In this context, university campuses, with their intensive use and settlement characteristics, large roof surfaces and green areas, offer significant potential for rainwater harvesting. Within the scope of this topic, literature contains many studies with different characteristics and approaches regarding rainwater harvesting in universities (Almeida et al., 2023; Anchan & Prasad, 2021; Arda-ergen & Ergen, 2024; Kılıç & Kılıç, 2025; Mısırlı & Şişman, 2025; Ravelo-García et al., 2023; Şimşek & Demir, 2023). The studies examined show that physical characteristics of campuses, size of their areas, and types of construction have a significant impact on the forms and quantities of rainwater harvesting. This study aims to assess the rainwater harvesting potential specific to the Samsun University campus, located in Turkey's Black Sea region, which receives high levels of precipitation. In addition to the quantity and economic benefit calculations specific to Hangar-1, determining the most suitable storage strategy for implementation across the entire campus is also among the primary objectives. Accordingly, within the scope of this study, a central storage system to be installed at the endpoints of the main water collection lines was compared with a local storage system to be positioned around the independent hangar units. Both system approaches were evaluated in terms of system definitions, infrastructure requirements, number and capacity of storage tanks, ecological impact (surface/land relationship), energy consumption, filtration requirements, initial investment cost, operation and maintenance processes, on-campus implementation challenges, water quality and loss, and long-term efficiency with the goal of identifying the most optimal solution for the campus.

2. METHODOLOGY

In this study aimed at assessing rainwater harvesting potential at Samsun University's Ballica campus, the architectural and plumbing plans of buildings and area were first examined, and assessments were made by identifying the existing infrastructure lines on site. To provide a comprehensive assessment of the site's rainwater harvesting potential in terms of both quantitative capacity and practical applicability, quantitative calculations and a criterion-based comparative assessment were used together. Significant rainwater harvesting potential was identified on the ground and roof surfaces of old tobacco warehouses, which have been converted into a university campus. Based on the results of the assessments, which took into account the campus's existing drainage infrastructure, roof and ground surfaces, and areas where rainwater could be collected and stored, the study was conducted using two different rainwater harvesting approaches:

1. Rainwater harvesting from the main drainage lines on campus and the centralized storage of the water at the end of the main collection lines,

2. Rainwater harvesting from each hangar and the surrounding storage tanks located in the area
were carried out under two headings.

Under the second heading, Architecture Faculty Hangar-1 structure was selected as a sample hangar unit from the campus, which consists of hangars similar in size and roof shape, and rainwater harvesting analyses were carried out on the structure. Calculations were made for Hangar-1 building regarding amount of rainwater to be collected from the roof surface using rainwater data for the province of Samsun, the storage volume required for the harvested water, and economic gains of system. The calculation of amount of rainwater to be harvested in area

where the system's installation was evaluated was carried out taking into account meteorological data for that area. This calculation method is given below (Helmreich & Horn, 2009) (equation 1);

$$V_y = A \times Y \times \frac{e}{1000} \quad (1)$$

- V_y : Amount of rainwater collected (m^3)
- A : Rainwater collection area (m^2)
- Y : Monthly or annual rainfall amount (mm)
- e : Rainwater harvesting surface efficiency coefficient

Along with the amount of rainwater to be harvested, the nature and size of reservoirs that will store the water are also important. The storage volume of system to be designed has been calculated based on data for November, when rainfall is highest (83.5 mm per month), according to equation (equation 2) given below (Hacısalıhoğlu, 2022).

$$V_d = A \times Y \times \frac{e}{1000} \quad (2)$$

The study calculated the quantities of water harvested and used, conducted a cost analysis based on 2025 water sales prices of the Samsun Water and Sewerage Authority and determined the amounts of financial savings. In addition, the calculated annual amount of rainwater harvested was compared with the annual amount of water consumed in the hangar. In addition to these quantitative calculations, two different rainwater harvesting approaches developed for the campus were evaluated comparatively to determine the site's existing technical and physical conditions, as well as the potential advantages and disadvantages that might arise if they were implemented. In this context, two systems were compared based on criteria such as drainage infrastructure, roof and ground surfaces, infrastructure requirements, the number and capacity of storage tanks, impact on the surface/land, water conveyance from storage to the point of use and associated pumping needs, filtration requirements, system components affecting initial investment costs, operation and maintenance needs, implementation challenges within the campus, water quality, the risk of water loss during conveyance, and the long-term potential of rainwater harvesting. The two alternatives were evaluated comparatively, taking into account the existing characteristics of the hangars as well as the site and infrastructure conditions, and their relative advantages and limitations were identified. The results of the criteria-based comparative evaluation are presented in Table 2.

2.1. Case Study Area

Samsun University Ballica Campus is located within the boundaries of 19 Mayıs District, Samsun Province. This region receives an average annual rainfall of 721.8 mm per square meter (Turkish State Meteorological Service, n.d.). The large area where the Tekel Factory was located was divided into two after the factory was privatised in 2008, and ownership of the factory section was transferred to private sector. The section where the tobacco warehouses were located was first allocated to Ondokuz Mayıs University in 2009 and then to Samsun University in 2019. There are 60 hangar structures with a floor area of $1,000 m^2$ in this allocated area. There are also three warehouse/hangars with a floor area of $5,000 m^2$ and three social hangars (Düzenli et al., 2024; Mimarmimarlik.com.tr, n.d.). Within the scope of this study, analyses were conducted on 60 hangar structures, one of which has a floor area of $1,000 m^2$. This part of the campus area has great potential for water harvesting due to its large ground area and large roof areas covering the hangars. Although Ballica Campus is located in Black Sea Region, where rainfall is high, there is a need for water sources to meet basic water requirements in hangars where educational activities take place, and especially for irrigation of landscaped areas during the summer months. One of the most important alternatives for meeting these needs is the use of rainwater harvesting methods in this region, where rainfall is high (Figure 1).

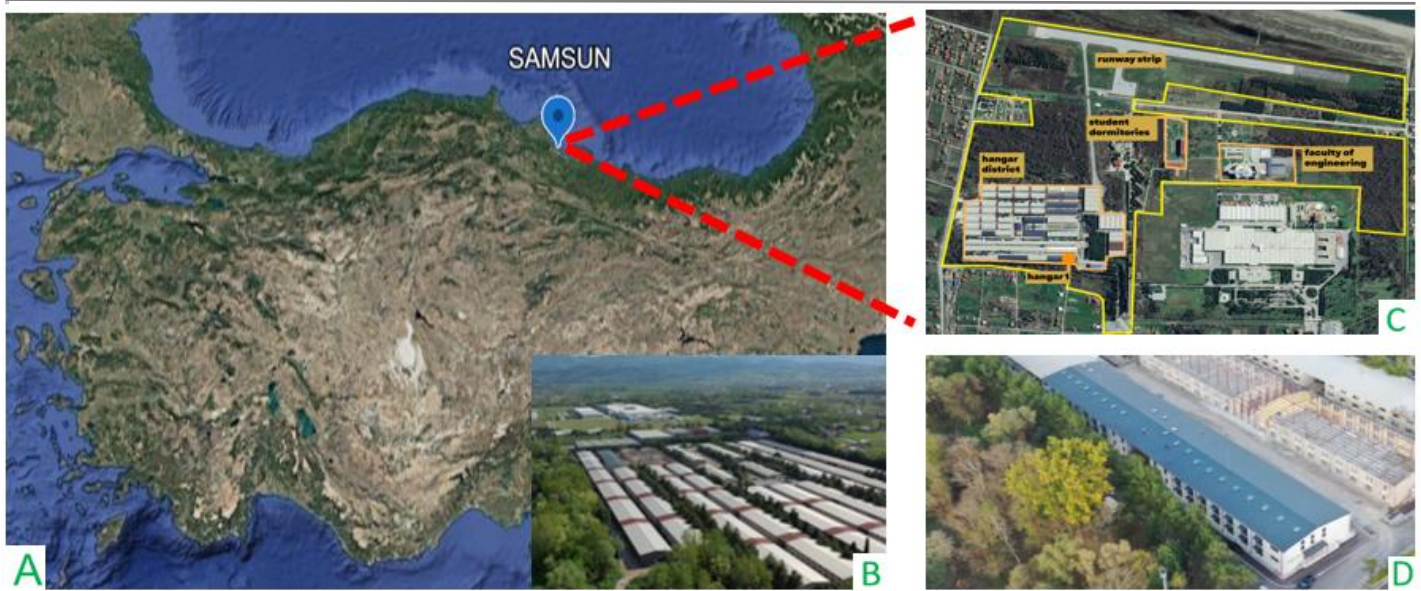


Figure 1. (A) Showing the area on the map of turkey (B) (C) Ballica campus general view (Google, n.d.) (D) Faculty of architecture and design Sources: Google Earth, modified by the Authors; Mimar Mimarlık; Google Earth, modified by the Authors; Preparation by the Authors

Roof gutters and ground water can be collected using different design approaches and made reusable. The collected water can be reused for landscape irrigation, as wastewater in toilets, or in firefighting systems using simpler treatment systems. This water can even be subjected to more advanced filtration processes and used for hand washing. Here, maintenance and cost factors come into play. It has been determined that when systems appropriate to the area are designed, there are areas where a significant amount of rainwater harvesting can be achieved. In this context, investigations carried out in area reveal significant potential in terms of rainwater harvesting.

3. RESULTS AND DISCUSSION

The aim of this study is to identify suitable structures and areas for rainwater harvesting at Samsun University Ballica Campus, to determine the potential amount of rainwater that can be harvested, and to evaluate design approaches that can be developed in this direction. In this regard, there are various design approaches and methods that can be applied at the area and structure scale. In this study, two different design approaches were evaluated and their rainwater harvesting potentials analysed. These approaches are based on directing rainwater collected in area in a manner suitable for area planning, thereby accumulating water at the end points of the main collection lines or integrating it into the surroundings of hangar structures using treatment systems.

3.1. Infrastructure-Based Campus Water Harvesting

Rainwater collected from the roofs of hangar structures located in campus area and from the ground in this area is collected using concrete pipes in accordance with the general layout decisions for the area and discharged in two lines into the stream on the eastern side (Figure 2).

The collected water, including pollutants containing petroleum waste and oil from the area, is also discharged into channels. In these sections where the collected water flows into stream, the water collected from campus area can be utilised using treatment systems and appropriate water storage facilities. Here, due to the location of existing lines, the positioning process can only be carried out below ground level by excavation. In these areas, 50,000-litre water storage tanks can be positioned at the ends of rainwater lines coming from the area. However, as the ground structure where water storage tank will be positioned is wet, it must be levelled by digging to a depth appropriate for size of the tank and pouring concrete material underneath. The concrete material used must be resistant to water on ground and must be properly secured to ground. Along with the installation of the tanks, another important issue is treatment of waste collected from area. Water filtration systems are important here. Caps that can filter petroleum and oil waste without allowing water to enter the buried tanks must be installed (Figure 3).

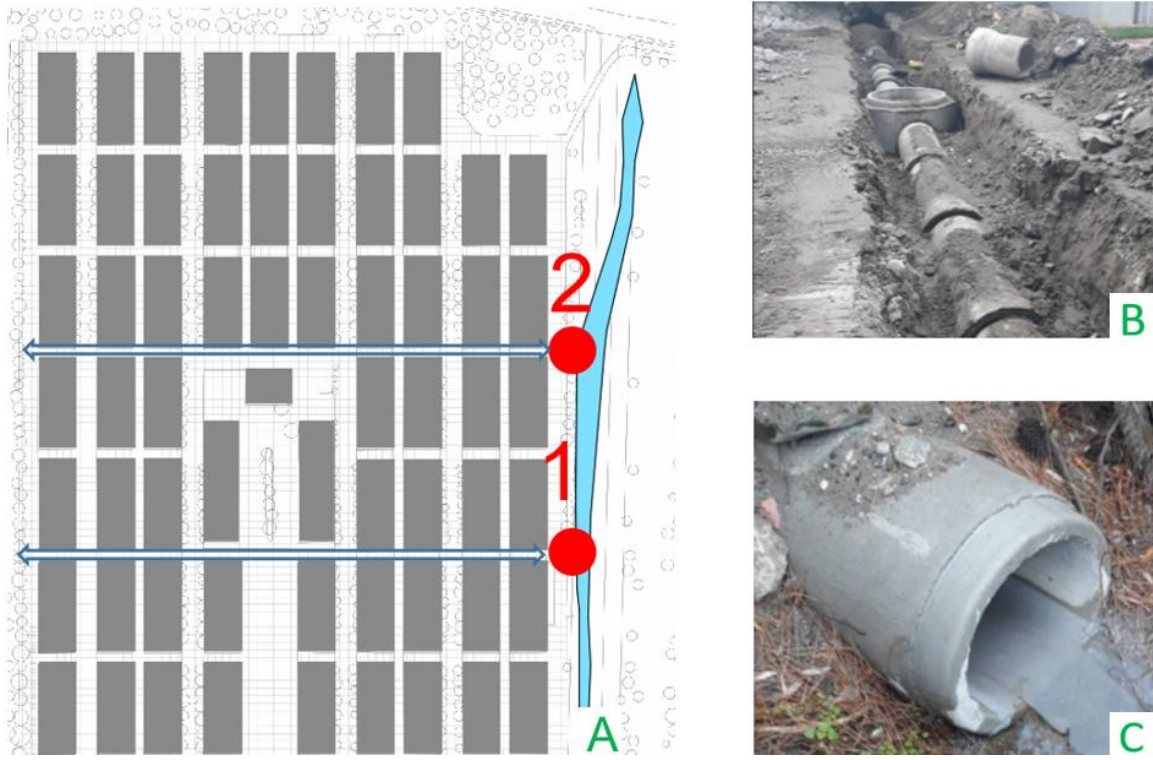


Figure 2. (A) Main lines collected from the campus area, discharge lines of water collected from the area to the river (B) (C) Rainwater drainage pipes within the campus. Source: Taken from Mimarmimarlık and modified by the Authors; Preparation by the Authors.

Following the positioning process, these waters, which have been placed underground, can be used by transferring them to the water tanks of tractors via submersible pump systems. Alternatively, separate landscape water channels can be designed, with sprinklers installed at their ends to provide landscape irrigation. Some water tanks also contain water pump units within them. In hangars where project is being carried out on campus, the clean water lines to the toilet lines and water lines used in sinks and taps have been designed together. Here, the plumbing systems need to be separated so that harvested water can be used in toilets. This will incur an additional cost. However, in the newly built hangars, these plumbing systems are separated, and harvested water can be used in toilets. When the water in harvesting tanks runs out for toilet use, the plumbing details for using water from normal pipes must be resolved.

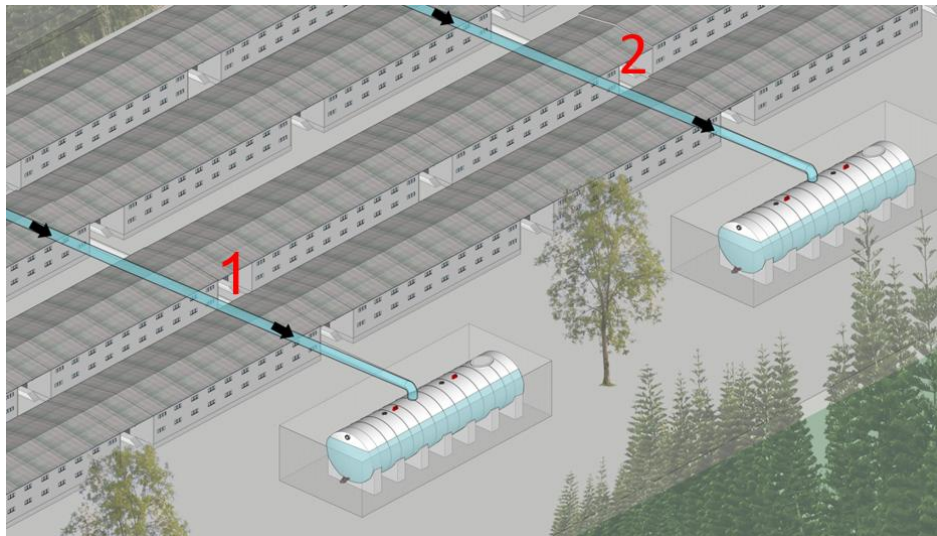


Figure 3. Rainwater harvesting tank proposal at the end of the campus main water drainage lines. Source: Preparation by the Authors.

3.2. Harvesting Water Collected From Hangar Roofs From Individual Hangars

The Ballica campus has 60 hangar units covering 1,000 square meters. The roofs of these hangars are all interconnected and designed as pitched roofs. These roofs, with their large surface areas, offer significant potential

for the collection and utilisation of rainwater (Figure 4).

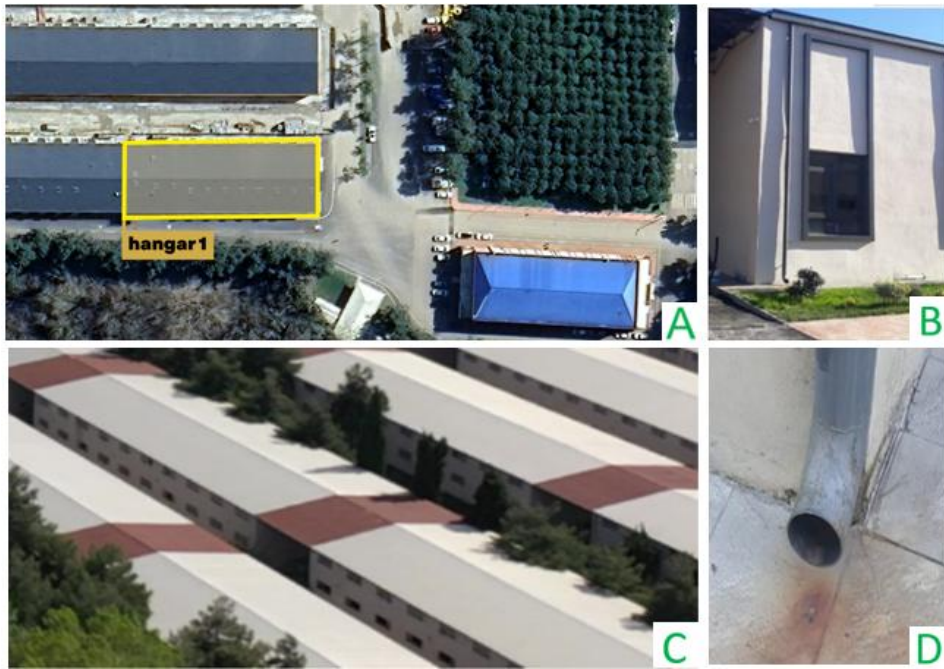


Figure 4. (A) Hangar-1 building (Google, n.d.) (B) water collection systems in hangars (C) roof (D) gutters. Source: Google Earth, modified by the Authors; Preparation by the Authors; Taken from Mimar Mimarlık and modified by the Authors; Preparation by the Authors.

In this approach, rainwater harvesting can be achieved by using smaller, fragmented storage tanks instead of large tanks placed at the ends of main lines. Furthermore, as the water is stored on roof before reaching ground, rainwater can be stored using simpler filtration systems. The location of water storage tanks is also functionally important in conjunction with collection and storage of rainwater. Rainwater can be used for irrigating landscaped areas located between hangars and for meeting the water needs of wet areas. It is important that the storage tanks are located close to landscaped areas between hangars and toilet facilities in hangars. Water tanks can be positioned in areas between the hangars, with lines adjusted on the campus roofs and necessary directions provided according to need, with one tank for two hangars or one tank for each hangar. Recommendations for tank positioning, considering these areas, are outlined in Figure 5.



Figure 5. Places where rainwater tanks can be located in plan. Source: Preparation by the Authors.

In this context, along with the positioning of storage tanks, the equipment used for collecting and draining water and appropriate positioning and design of this equipment are also important. Gutter systems are used to drain water collected from the roof. Gutter systems should be designed in appropriate shapes and positions for efficient collection and utilisation of water. Water flowing down from the rain gutters can be directed into a single gutter and then directed to tanks located under floor in a suitable corner of the hangar. This will allow water to be used in smaller tanks. In addition, water can be stored with a simpler filter that does not contain oil or petroleum waste(Figure 6).

Stored water can be used for garden or landscape irrigation, as well as for waste water in toilet drains. However, as the clean water plumbing for hand washing and toilets in hangars is combined, these systems must be separated again in projects implemented. In new hangars, these systems can be separated so that rainwater or harvested water can be used inside the building.

When reviewing the literature, rainwater storage tanks can be implemented in various forms, either above ground or below ground. In this context, two different methods can be used for above-ground and below-ground tank placement (Temizkan ve Kayılı, 2021). Architectural harmony is important when using above-ground water tanks. There are different design forms here. The literature includes solutions in form of units located on the outside of hangar, as well as solutions located inside by digging into ground (Hacısalıhoğlu, 2022). In above-ground methods, water tanks can be located adjacent to hangar walls or within the structure. Architectural harmony is important when locating them outside the structure. Here, water tanks can be designed to be architecturally appropriate in areas that affect external appearance, or they can be located at points that do not affect the external appearance. Inside the building, tanks can be constructed in interior by creating a technical room and directing gutter systems. However, due to the structural problems of water, it may cause problems within the structure. For this reason, technical aspects must be resolved along with insulation in this system. Above-ground storage systems have disadvantages as well as advantages. For example, with appropriate height choices, harvested water can be used without need for a water pump, utilising the potential energy it holds. The use of underground water storage tanks does not affect the external appearance of surrounding architecture, thus avoiding design issues.

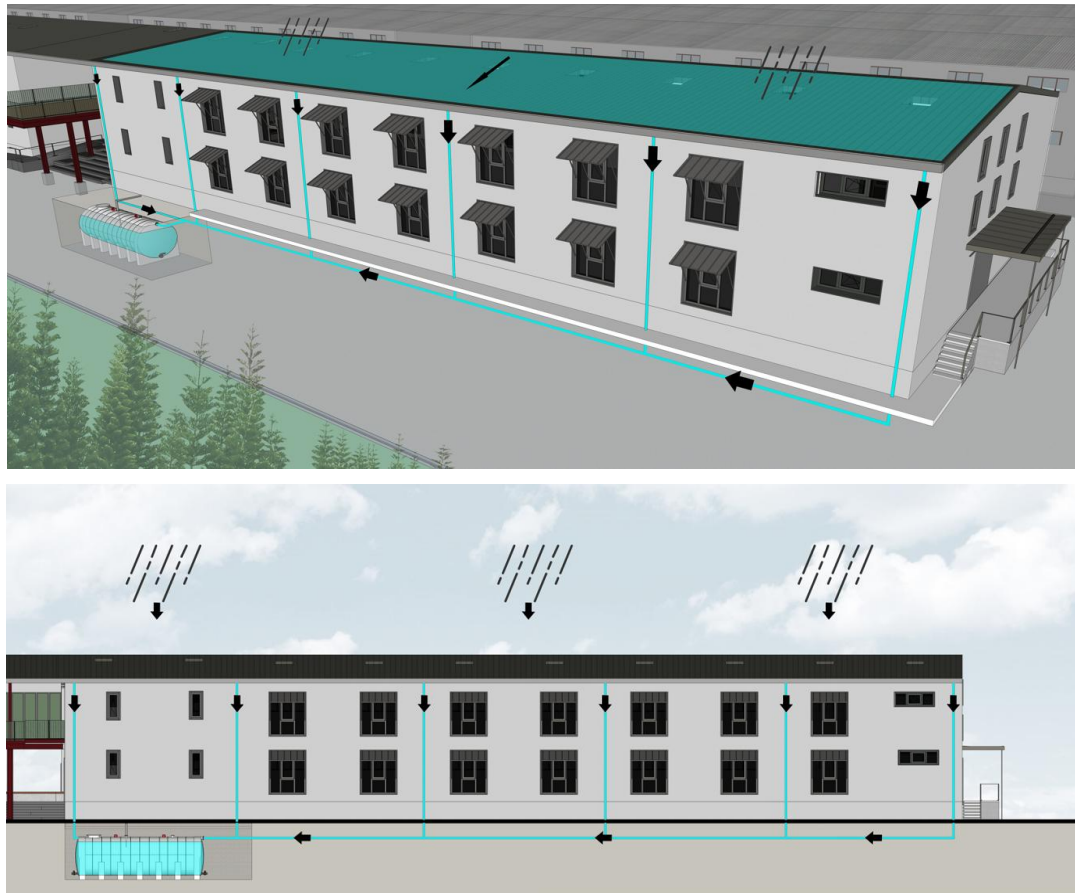


Figure 6. Places where rainwater tanks can be located and water lines. Source: Preparation by the Authors.

In the system designed specifically for hangar structures, measures have been taken to prevent rainwater storage

tank overflows in the event of heavy rainfall. Accordingly, direct discharge connections from the storage tanks to the campus's main stormwater drainage network have been established to ensure the structural safety of the system and prevent localized flooding (Figure 7).

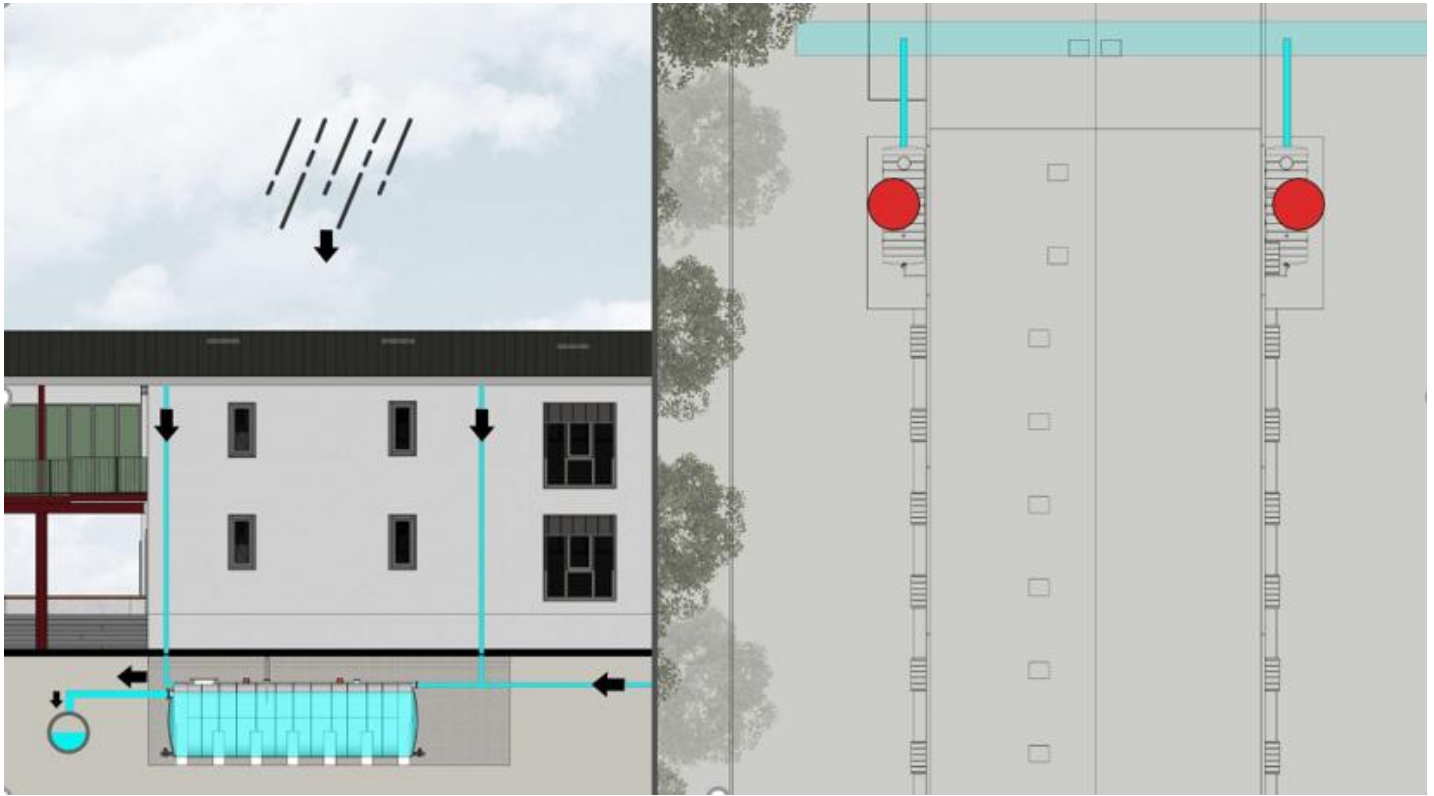


Figure 7. Flood prevention system for reservoirs used to collect rainwater

In conclusion, as seen from the studies conducted, there are design alternatives supporting different approaches specific to the campus. In this section, different design solutions have been presented, taking into account the existing design and physical characteristics of hangar structures, roof and gutter systems, and storage areas.

3.3. Rainwater Harvesting Calculations

In applications based on collecting rainwater from roof surfaces, the most important data for calculation are the size of roof area and capacity of tank in which harvested water will be stored. If the amount of rainwater planned to be collected as a result of rain harvesting meets a significant portion of requirements, implementing this system will be economically efficient.

As indicated in Samsun Annual Average Rainfall Table, the value determined by taking the average of rainfall data over many years for the study area is 721.8 mm per year (Turkish State Meteorological Service, n.d.). (Table 1).

Table 1. Samsun Annual average rainfall amount table. Source: The authors

Months	Fireplace	February	March	April	May	June	July	August	September	October	November	December	Annual Total (mm)
Monthly Total Rainfall Average (mm)	72.5	58.9	67.4	56.7	49.2	46.9	34.9	37.0	55.0	79.2	83.5	80.6	721.8

The hangar building to be analysed has a total roof surface area of 1,000 m² with dimensions of 20 m. x 50 m. According to data obtained from German Standards (DIN), the efficiency coefficient is accepted as 0.8 (DIN, 2016). In light of all this data, the total amount of rainwater has been calculated as follows:

$$V_y = 1000 \text{ m}^2 \times 721.8 \text{ mm} \times (3) / 1000$$

$$V_y = 577.44 \text{ m}^3/\text{year}$$

The Hangar-1 building of the Department of Architecture, Faculty of Architecture, Balıca Campus, Samsun University, was opened for use in September 2022. Peak usage hours occur between 08:30 in the morning and 17:00 in the evening. The building's water usage values have been tracked since the day it was put into use. An analysis of these values shows that a total of 2,108 m³ of water has been used in 3 years. This value indicates that an average of 702.6 m³ of water has been used annually throughout the building. According to rainwater harvesting calculation, the 577.44 m³ of rainwater that can be harvested annually from the roof surface corresponds to 82.18% of the reference hangar's total annual water consumption. Water is used in various areas within the hangar units, such as sinks, restrooms, and kitchens. While it is not appropriate to use the harvested rainwater in areas requiring potable water such as kitchens, it can be used in areas like toilet tanks. Any rainwater remaining after these uses can be utilized to irrigate other landscape and garden areas on campus. For this reason, the value of 82.18% represents the ratio of the annual rainwater harvesting potential to the reference hangar's current total annual water consumption (Figure 8).

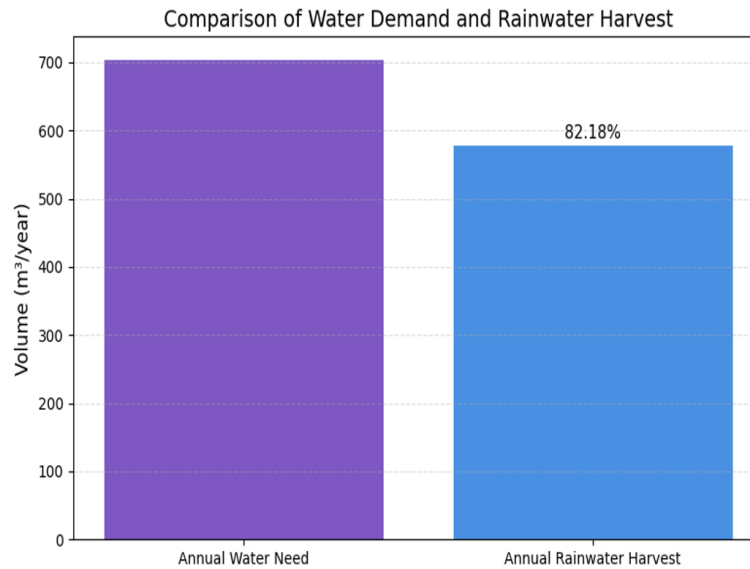


Figure 8. Comparison of Water Demand and Rainwater Harvest. Source: Preparation by the Authors.

It is planned to use polyethylene storage tanks to collect rainwater harvested from the roof of the faculty building currently under construction. According to the study by Kayalı and Temizkan (2021), the month with the highest precipitation was the determining factor in the process of calculating the volume of the storage tank to be used for rainwater harvesting. In the study, M_{max} in the equation used to calculate the storage tank volume represents the precipitation amount for the month with the highest rainfall, expressed in mm/m². Thus, it is understood that the calculations in the storage tank volume determination process were based on the month with the highest precipitation. In Hacısalıhoğlu's (2022) study, the storage volume of the designed system was also calculated based on the month with the highest rainfall. In light of this information, the storage capacity of the system to be designed in this study was calculated based on data from November the month with the highest rainfall (83.5 mm per month). The required storage capacity for the tank to be used in Hangar-1 can be calculated using the following equation.

$$V_d = A \times Y \times e / 1000$$

$$V_d = 1000 \text{ m}^2 \times 83.5 \text{ mm} \times 0.8 / 1000 \quad (4)$$

$$V_d = 66.8 \text{ m}^3$$

According to this calculation, the volume of water tank to be used in area has been determined as 70 tonnes, taking into account exceptional circumstances. If the water saving amount is calculated, the amount of water harvested in area is 577.44 m^3 per year. The average annual water requirement of the building is 702.6 m^3 . In this case, the annual rainwater harvesting potential from a hangar structure can be expressed as 577.44 m^3 . To calculate the monetary value of this saving in Turkish Lira, the 2025 water sales price of the Samsun Water and Sewerage Authority (Samsun Water and Sewerage Administration [SASKİ], n.d.) has been used as a basis.

According to the data in table, the Hangar-1 structure can be considered a public building. When calculated including the wastewater rate and VAT rates applied to water and wastewater, the unit price of water is calculated as 51.06 TL/m^3 . Annual savings = $577.44 \text{ m}^3 \times 51.06 \text{ TL/m}^3 = 29,484.08 \text{ TL}$ (Figure 8).

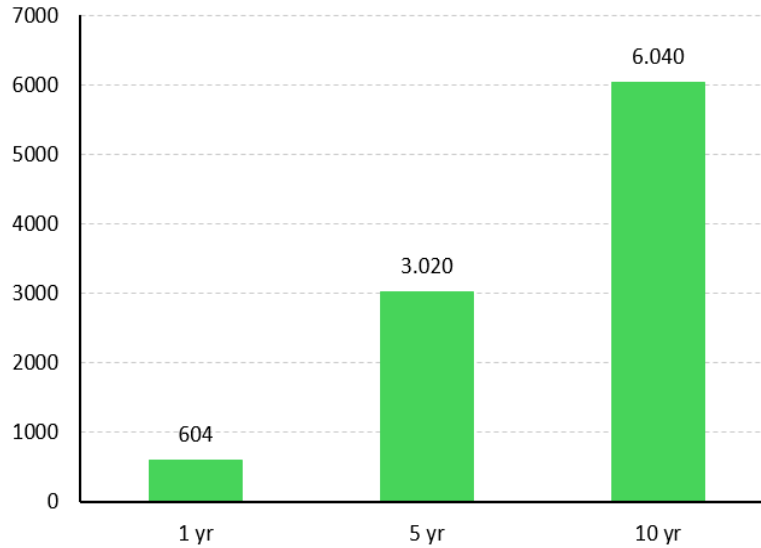


Figure 9. Economic Savings from Rainwater Harvest (Converted to USD). Source: Preparation by the Authors.

In the field study, the annual rainwater harvesting potential was estimated to correspond to 82.18% of the total water consumption in the faculty building, provided that the harvested rainwater is used for suitable non-potable purposes, such as toilet flushing and other applicable uses. Additionally, an annual water saving of approximately 29,484 TL (604 USD) can be achieved. These findings can be discussed in relation to previous studies on rainwater harvesting conducted on university campuses. Studies conducted by Şimşek and Demir (2023), Ravelo-García et al. (2023), and Mısırlı and Şişman (2025) share a strong common ground with this study in that they examine the potential for rainwater harvesting on university campuses and focus on strategies to reduce dependence on municipal water in line with a vision for sustainable campuses. Şimşek and Demir (2023) calculated the amount of water that could be collected specifically at the Ondokuz Mayıs University Library Building in the Black Sea Region, which receives high rainfall; Ravelo-García et al. (2023) examined applications at the Valle de las Palmas campus, while Mısırlı and Şişman (2025) assessed the potential for rainwater harvesting and reuse at the campus level. According to Mısırlı and Şişman (2025), the amount of rainwater that can be captured using various materials on campus is sufficient to meet the irrigation needs of reservoirs and plants to a certain extent. They also emphasized that it is possible to develop solutions such as rain gardens that enhance visual quality while also being sustainable and functional. Furthermore, Mısırlı and Şişman (2025) highlighted that water can be harvested not only from rooftops but also from other hard surfaces and green spaces. A significant proportion of the studies in the literature focus on roof areas. This study, which examines water harvesting in the campus buildings at Samsun University and across the entire campus, whilst showing parallels with the work of Mısırlı and Şişman (2025) in this respect, distinguishes itself from the existing literature on this subject through its site-specific solution approaches. Within the scope of this study, a central storage system designed to be installed at the ends of the main water collection lines was compared and analyzed against local storage systems positioned around independent hangar units. Accordingly, both infrastructure models were evaluated based on multiple sustainability criteria including system and infrastructure requirements, ecological impact (surface/land relationship), energy consumption, operation and maintenance processes, on-campus implementation challenges, water quality, and long-term efficiency to identify the most optimal solution strategy for the campus.

4. CONCLUSION

Water is one of the most fundamental components of life. This study aimed to evaluate the rainwater harvesting potential specifically for the Balıca Campus. To this end, the technical condition of the water lines on campus and the potential for water use were analysed. Based on the findings, the rainwater harvesting potential and applicability of systems in area were analysed. The current state of campus and characteristics of the area allow for implementation of different rainwater harvesting methods in area. However, different methods have different design and technical details, advantages and disadvantages. The advantages and disadvantages of two different rainwater harvesting methods that can be implemented in area, within the framework of defined principles, are presented in Table 2.

Table 2. The advantages and disadvantages of two different rainwater harvesting methods Source: Preparation by the Authors.

Definition of Criteria/Systems	Central storage system placed at the end of the main water collection lines	Model with Storage Positioned Around the Hangars
Definition	A large capacity storage system to be placed at the ends of the main water collection lines within the campus	Storage systems to be implemented around independent hangar units
Infrastructure Requirements	Existing drainage lines can be used to bring water to the tanks, but long transmission lines will be needed to direct the harvested water to the hangars .	Because the storage systems are located near the hangars, short transmission lines will be sufficient. With less transmission infrastructure, the system can be more easily integrated into existing infrastructure .
Number and Capacity of Storage Tanks	Considering campus-wide applications, a small number of high-capacity storage tanks are needed. Extensive landfills at the ends of water drainage channels require significant land interventions.	When considering campus-wide applications, multiple, smaller-capacity storage tanks can be used. Local and smaller-scale land interventions are required.
Ecological impact (surface/land relationship)	Greater storage capacity is required to collect more runoff from roof and ground surfaces, which may increase land intervention and excavation. .	Less soil excavation is required, as it requires smaller storage capacity and less land intervention.
Energy Consumption	More energy will be needed to route water through pipelines over longer distances.	With shorter pipeline designs, less energy will be needed to convey the water.
Filtration Requirement	Many more types of waste, such as oil and petroleum waste, need to be filtered.	Simpler filtration systems are sufficient for rooftop water harvesting.
Initial Investment Cost	The initial investment cost may increase due to the collection of water from ground surfaces and roofs, the need for large storage tanks, advanced filtration systems, and long transmission pipelines	Because water harvesting is done solely from the roof, smaller storage solutions result in potentially lower initial investment costs. Smaller pipe systems and less elaborate filtration systems may also reduce initial investment costs.
Operation and Maintenance	Storage tanks designed at a central point can provide ease of maintenance as they are located at a single location, but a malfunction can affect the entire system.	Individual units require separate maintenance. However, local failures do not affect other systems.
Campus Implementation Challenges	Requires application at a single location. Construction space on campus is limited. However, larger systems may be required compared to small storage systems per hangar.	Requires intervention at multiple locations across the campus and may involve local excavation or removal of pavement around individual hangars.
Water Quality and Loss	Longer conveyance distances may increase the risk of leakage and water quality deterioration.	Shorter conveyance distances may reduce leakage risk and help preserve harvested water quality.
Long-Term Rainwater Harvesting Potential	It provides the opportunity to harvest and store more rainwater from both roof and ground surfaces.	A smaller amount of water can be harvested by just harvesting from the roof.

As can be seen from the table, different systems have various advantages and disadvantages. Applications in the field should be implemented taking these advantages and disadvantages into consideration. Furthermore, in

systems to be established within the campus, the technical infrastructure should be arranged according to where the rainwater will be used. For example, in a scenario where harvested water is only intended for use in toilets, the plumbing systems in the hangars should be designed accordingly. The sewage pipes and clean water pipes within the buildings should be separated. In this context, the plumbing systems in the new hangar units to be built on the campus under construction can be arranged to be suitable for rainwater harvesting.

Calculated analyses conducted on a single hangar unit have revealed significant water savings. The amount of water that can be saved is particularly important in heavily used areas such as university campuses, especially at a time when clean water sources are becoming scarce. Furthermore, the systems implemented in educational institutions will contribute to raising awareness among young people about the environment and sustainability. Samsun University's Ballica campus also has significant rainwater harvesting potential due to its current location. The rainwater harvesting projects to be implemented will mark an important step towards the university's goal of becoming a green campus.

As part of this study, rainwater harvesting a key measure in achieving green campus objectives in campus buildings was assessed; the annual financial savings were calculated alongside the volume of water harvested. However, the initial investment costs of the systems and their payback periods were not assessed as part of this study. In future studies, the inclusion of investment, operating and maintenance costs in the calculations will contribute to a more comprehensive economic assessment of the systems.

Conflict of Interest Statement

The authors declare that there is no conflict of interest between them.

Authors' Contributions

The authors have contributed equally to all stages of preparing the article.

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