

Technical and economic analysis of rainwater harvesting in farm buildings

Umut KILIÇ¹ , İlker KILIÇ^{1*} 

¹Bursa Uludağ University, Faculty of Agriculture, Department of Biosystems Engineering, Bursa, Türkiye

*Corresponding author e-mail: ikilic@uludag.edu.tr

Received: 26.03.2025

Accepted: 30.04.2025

Abstract: This study assessed the capacity of rainwater harvesting, an alternative water conservation strategy, in animal enterprises with a total roof area of 5625.4 m² to fulfill the water requirements of the animals housed therein, alongside doing an economic analysis of the system. Results indicated that 2868 m³ of water harvesting is carried out annually from all building groups. While the annual water needs of ostrich houses are fully met, the water needs of hen houses can be met in all seasons except summer. In the case of cattle and sheep barns, the saving rate is lower due to the high-water requirement. The rainwater harvesting method achieves an annual economic gain of 86301 TL from the water fee. For the installation of the systems at the research center, there is an initial investment cost of 974556 TL. The payback period for the initial investment costs with the economic gain from the water fee is a process of 11.6 years.

Keywords: Animal barns, farm buildings, rainwater harvesting, sustainability, water

Çiftlik binalarında yağmur suyu hasadının teknik ve ekonomik analizi

Öz: Bu çalışmada, toplam 5625.4 m² çatı alanına sahip hayvancılık işletmelerinde bulunan hayvanların, su ihtiyacını karşılamak amacıyla alternatif bir su tasarrufu stratejisi olan yağmur suyu hasadı yönteminin su toplama kapasitesi değerlendirilmiş ve sistemin ekonomik analizi gerçekleştirilmiştir. Çalışma sonucuna göre, tüm bina gruplarından toplamda yıllık olarak 2868 m³ su hasadı gerçekleştirilmektedir. Deve kuşu kümeslerinde yıllık su ihtiyacının tamamı karşılanırken, tavuk kümeslerinde Yaz mevsimi dışında tüm mevsimlerde su ihtiyacı karşılanabilmektedir. Büyükbaş ve küçükbaş barınaklarında ise gerekli su ihtiyacının yüksek olması nedeniyle karşılama oranı daha düşük seviyededir. Yağmur suyu hasadı yöntemi ile yıllık olarak 86301 TL su ücretinden ekonomik kazanç elde edilmektedir. Sistemlerin araştırma merkezine kurulması için 974556 TL'lik bir ilk yatırım masrafı söz konusudur. Su ücretinden elde edilecek ekonomik kazanç ile bu ilk yatırım maliyetlerinin amorti süresi 11.6 yıllık bir süreçtir.

Anahtar kelimeler: Hayvan barınakları, çiftlik binaları, yağmur suyu hasadı, su, sürdürülebilirlik

1. Introduction

Although freshwater constitutes 2.5% of Earth's total water resources, hardly 1% is accessible for use, as a significant amount consists of glaciers (Yeniçeri, 2018). The limited availability of water resources is being exacerbated by causes such as population growth, industrial demands, and climate change, leading to a depletion of current resources. Countries are considered water-rich when they possess an average of 8,000 to 10,000 m³ of water per capita. Among all the nations globally, only six are classified as water-rich. By 2025, an estimated 2.5 billion individuals globally may have water shortage challenges (Dünya Su Forumları, 2009;

WWF-Türkiye, 2011; Firidin, 2015). As the impacts of the drought intensify daily, it is essential to employ alternative strategies to save existing resources or create new ones.

The rainwater harvesting method is one of the methods that creates a new water source while reducing the consumption of existing resources. The rainwater harvesting method can be defined as a technique that involves collecting and storing rainfall and then filtering this water for reuse for various purposes (TEMA, 2025). Thirty (30) percent of the present precipitation infiltrates groundwater, whereas the remaining 70% is lost (Eren et al. 2016; Yalılı Kılıç and Abuş, 2018).

Therefore, the use of rainwater harvesting methods can lead to a significant amount of water savings.

Agriculture and livestock farming are among the sectors with the highest water usage. The inadequate use of water in these sectors causes harm to living beings and, correspondingly, leads to a decrease in productivity. Therefore, water is of vital importance for enterprises to continue their sustainability. Rainwater harvesting method is widely preferred in livestock farms due to large roof areas. Large roof areas also increase the amount of water collected. Therefore, a high level of water savings is achieved with the amount of water obtained, and an additional economic benefit arises for enterprises.

There are studies aimed at using the rainwater harvesting method in the livestock sector to meet the needs of animals and enterprises. Boyacı and Atılğan (2023) aimed to determine the extent to which the amount of water obtained from rainwater harvesting in two different cattle barns, one for dairy cattle and one for beef cattle, located in the Kırşehir province with a continental climate, would save the water needs of the enterprises. There were 80 animals in the dairy cattle barn and 70 animals in the beef cattle barn. They have used buildings with roof areas, such as barns, feed storage, and employee houses, in enterprises for the purpose of storing rainwater. In the dairy cattle barn where the study was conducted, the total roof area of the buildings is 1750 m², while in the beef cattle barn, the total roof area of the buildings is 2680 m². In the dairy cattle enterprise, they have determined that the average rate of saving the water needs of the animals is 18%. In beef cattle enterprise, the average rate of saving water requirements for the animals is 59%.

Boyacı (2023) determined the rainwater storage potential of a sheep and a goat barn located in Kırşehir. There were 250 sheep in the sheep barn and 100 goats in the goat barn. The total roof areas of the sheep and goat barn were 365 m² and 210 m², respectively. With the rainwater harvesting method, the amount of water needed in the sheep barns an average of 8.8% can be saved. In the goat barn, 18% of the water needs can be saved.

This study determined whether the amount of water obtained through rainwater harvesting from the animal enterprises at the Agricultural Faculty Farm of Bursa Uludağ University meets the water requirements for the care of different animal species in the enterprises and to conduct an economic analysis.

2. Materials and Methods

2.1. Work area

This study was conducted in the animal barns at the Agricultural Faculty Farm of Bursa Uludağ University. The study aims to determine the amount of water obtained using the rainwater harvesting method from the barns of cattle and sheep and hen and ostrich houses in the farm center and from the surrounding buildings. The image of the animal barns and surrounding buildings where the rainwater harvesting method is applied is provided in Figure 1 (Google, 2025).



Figure 1. Image of the animal barns where the study was conducted. O.H.= Ostrich House, C. B.= Cattle Barns, S.B.= Sheep Barns, H. H.= Hen Houses

The dimensions of animal barns and surrounding buildings were measured using a laser meter (Extech DT300, USA) to determine the amount of rainwater harvesting and calculations of the roof areas were carried out. The cattle and sheep barns and hen and ostrich houses, as well as the buildings used for various purposes around the farm center, have been grouped in four different ways, and separate calculations have been made for each group of buildings. The total roof areas of the building groups where the study was conducted are given in Table 1.

Table 1. Roof areas of the buildings where the study was conducted

Building Groups	Roof Areas (m ²)
Ostrich House	268.39
Cattle Barns	2323.73
Sheep Barns	1587.41
Hen Houses	1445.87

2.2. Calculation of collected and consumed water amount

To determine the monthly and seasonal rainwater storage potential from all buildings in the study area

and the storage volume to be used for system design for all building groups, equations 1 and 2 have been utilized (TEMA, 2025).

$$\text{Rainwater quantity}(m^3) = A \times RA \times RC \times FEC \quad (1)$$

$$\text{Tank volume}(m^3) = MRA \times A \times RC \times FE \quad (2)$$

A: The area (m^2) of the roof.

RA: The average monthly rainfall amount (mm) in the province

RC: It is the coefficient that indicates the amount of precipitation falling on the roof cannot be fully collected. It is given as 0.8 in DIN1989.

FEC: It is the coefficient that indicates the losses experienced by the amount of water collected through the rainwater harvesting method during the filtration stage. It is given as 0.9 in DIN1989.

Tank volume: It determines the storage volume (m^3) for use in the system based on the highest annual rainfall amount.

The potential amount of water that can be collected monthly and seasonally was determined by using the roof areas of the buildings, the roof coefficient and the filter efficiency coefficient. The average monthly rainfall data for Bursa province from 1928 to 2024 was obtained from the General Directorate of Meteorology website. The tank volumes for the system designs were determined using data from December, the month with the maximum rainfall in Bursa province, which recorded 98.7 mm of precipitation per square meter annually (MGM, 2025).

The rainwater harvesting method aims to filter and store the collected water for immediate use. Consequently, calculations were conducted considering the month with the maximum annual precipitation during the design of the systems to be implemented in the building groups.

2.3. Statistical analysis of the amount of water collected

Analysis of variance was conducted on the amounts of water to be collected using the rainwater harvesting method to determine the importance between months and animal barns. Statistical analyses were conducted using the SPSS 23 statistical software (IBM, USA 2019).

2.4. Water consumption of animals

Following the categorization of the farm center's buildings into four groups according to animal types and building operations, the water requirements for drinking and serving the animals in each group were

assessed. The possibility of fulfilling the agricultural center's monthly and seasonal water requirements was assessed by comparing the volume of water obtainable through rainwater collection with the volume of water needed. In addition, the economic gains and payback periods to be achieved from implementing the systems were calculated. In the final stage of the study, system designs were carried out separately for each group. The number of animals in the farm center and their average daily drinking and service water needs are provided in Table 2 (Chapagain and Hoekstra, 2003; Esen and Özdemir, 2004).

Table 2. Daily average water requirements of the animals in the farm center

Animal Species	Number of Animals	Daily Total Water Consumption (L/day.animal)
Hen	3000	0.45
Goat	55	8.8
Sheep	244	12.6
Cattle	49	92
Goose	20	0.35
Ostrich	9	18

3. Results and Discussion

3.1. Amounts of water collected from barns

Seasonal comparisons of water collected from the barns at the farm center indicate that the largest volume occurs in the Winter season in Bursa province, coinciding with peak precipitation levels. Simultaneously, the minimum water was collected during the summer season, characterized by lowest precipitation. The extensive roof areas of the cow barn construction groups facilitated the most water collection in this category. The volume of water accumulated in the sheep barns and hen house structures was similar. Figure 2 illustrates the seasonal water volumes collected for all groups.

Temporal analysis revealed that the highest amount ($165.13 m^3$) was collected in the cattle barn groups during December. Due to decreased rainfall, the water collected from the cattle barn groups drops to $30.12 m^3$ during summer. From the groups of cattle, sheep, and chicken buildings, an average of $112.71 m^3$ of water is stored monthly during the winter months, while in the summer months, the average amount of water collected per group drops to $32.48 m^3$. The monthly water collected for all groups is given in Table 3.

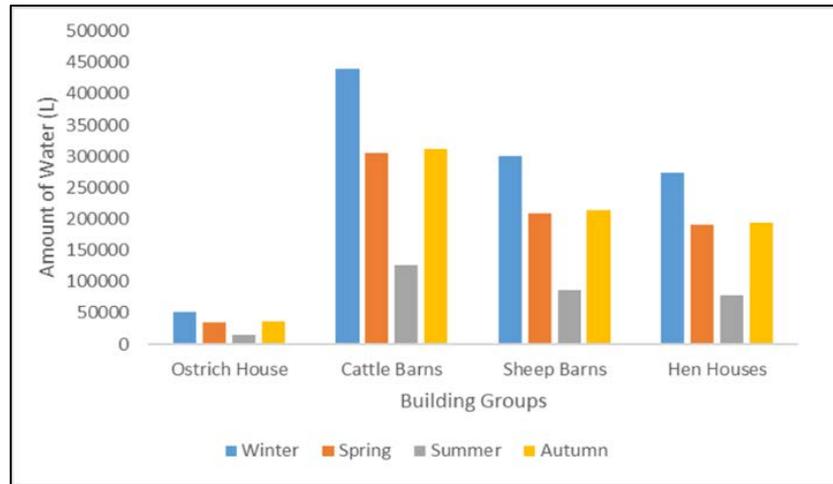


Figure 2. The amount of water collected seasonally from the building groups

Table 3. The amount of water collected monthly from the building groups in the farm center

Months	Amount of Water Collected (m ³)			
	Ostrich House	Cattle Barns	Sheep Barns	Hen Houses
January	17.18	148.74	101.61	92.55
February	14.57	126.15	86.18	78.49
March	13.58	117.62	80.35	73.18
April	11.94	103.40	70.63	64.34
May	9.76	84.49	57.72	52.57
June	6.86	59.39	40.57	36.96
July	4.31	37.31	25.49	23.21
August	3.48	30.12	20.57	18.74
September	8.33	72.11	49.26	44.87
October	12.62	109.25	74.63	67.98
November	15.13	131.00	89.49	81.51
December	19.07	165.13	112.81	102.75

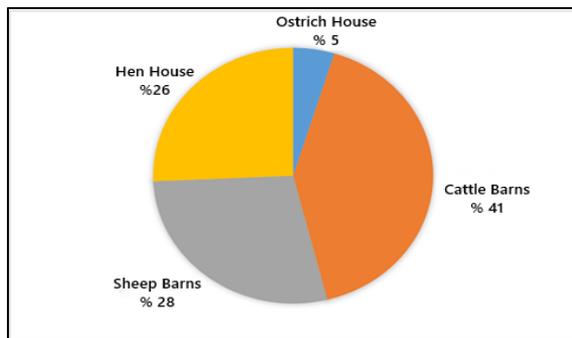


Figure 3. Distribution of the annual water amount to be harvested by building groups

The total amount of water saved annually using the rainwater harvesting method from all building groups in the farm center was 2868 m³. The cattle barn building group constituted 41% of the total water harvested annually, which is 1184.71 m³. The ostrich building group had the lowest water harvesting capacity with 136.83 m³ (5%). The distribution of the annual water amount to be harvested by building groups is shown in Figure 3.

3.2. Statistical analysis

The variance analysis of the differences in the amounts of water collected using the rainwater harvesting method was conducted on a monthly and building group basis. When the differences in the amounts of water collected monthly were examined, they were significant ($P < 0.01$). The statistical analyses of the monthly differences in the amount of water collected are presented in Table 4. The statistical differences in the amounts of water collected between the building groups are presented in Table 5.

3.3. System design

The system is basically planned to store the water collected from the roof after it is filtered and then sent back to the animal barns with the help of a pump for use. A tank drain valve was added to the system so that the stored water can be used directly from the tank without being sent to the animal barns. All building groups were designed to add drainage and overflow pipes to the system to prevent the storage of excess

rainfall or to discharge the existing water in the reservoir if rainfall exceeds expectations. The connection between the tanks has been established to transfer the water in the tanks used in the systems to other tanks in case of any malfunction. It was decided to install the systems above ground to find suitable

empty spaces on the land where the animal barns are located and to reduce the cost somewhat. The locations of the reservoirs in the systems have been determined by considering the slope of the land, wind direction, and intensity. Four different building groups in the farm center have been designed separately (Figure 4, 5, 6, 7).

Table 4. Statistical analyses of the monthly differences in the amount of water collected

Months	Total	Average	Minimum	Maximum	Std. Deviation	P
January	360070.6	90017.7 ^a	17179.1	148737.3	54449.2	0.01
February	305391.7	76347.9 ^b	14570.4	126150.7	46180.8	
March	284735.2	71183.8 ^b	13584.8	117617.9	43057.2	
April	250307.8	62576.9 ^c	11942.3	103396.7	37851.1	
May	204539.5	51134.9 ^d	9758.7	84490.8	30930.1	
June	143785.2	35946.3 ^f	6860.0	59394.5	21743.0	
July	90321.4	22580.4 ^g	4309.3	37309.8	13658.2	
August	72905.2	18226.3 ^g	3478.3	30115.5	11024.6	
September	174567.4	43641.9 ^e	8328.7	72110.0	26397.8	
October	264483.8	66121.0 ^c	12618.6	109252.5	39994.8	
November	317137.6	79284.4 ^b	15130.8	131002.6	47957.0	
December	399763.4	99940.9 ^a	19072.9	165133.5	60451.5	

^{a-g} Means expressed with different letters are statistically significant (P<0.05).

Table 5. Statistical analyses of differences in the amount of water collected by building groups

Barns/House	Total	Average	Minimum	Maximum	Std. Deviation	P
Ostrich	136833	11402 ^c	3478	19072	4941	0.000000072
Cattle	1184711	98725 ^a	30115	165133	42780	
Sheep	809312	67442 ^b	20572	112807	29224	
Hen	737150	61429 ^b	18738	102749	26618	

^{a-d} Means expressed with different letters are statistically significant (P<0.05).

While most of the area where the ostriches are located is open to the sky, there is one building where rainwater harvesting can occur. In the building groups where ostriches are located, considering the amount of water to be collected in December when the most rainfall occurs, it has been decided to use a modular galvanized steel water tank with a volume of 20 m³. The system design for the ostrich house is presented in Figure 4.

Water collection is conducted from the clusters of buildings housing large cattle, comprising the animal shelter and two additional structures serving diverse functions. In the Bursa region, it has been determined to utilize three modular galvanized steel water tanks with a cumulative capacity of 172.5 m³, including one tank of 100 m³, one of 50 m³, and one of 22.5 m³, based on the expected water harvest in December, the month with the highest precipitation. Figure 5 illustrates the system design for the livestock barns.

While the rainwater collection potential of the building where the sheep are located is high due to the large roof area, the amount of water collected in total is lower than the cattle barn groups due to the small size of the other buildings around it. In the system design of the sheep building groups, it was decided to use two

modular galvanized steel water tanks, one 100 m³ and one 10 m³, with a total volume of 110 m³. The system design of the sheep buildings is given in Figure 6.

In the hen house building groups, there are two buildings of similar sizes. In the hen house groups, the amount of water collected monthly and annually is like that of the sheep barn groups. For this reason, it was decided to use two modular galvanized steel water tanks, one 100 m³ and one 10 m³, with a total volume of 110 m³ in the hen building groups. The system design for the hen buildings is presented in Figure 7.

3.4. Water consumption amounts in building groups

The number of animals in each group where the study was conducted and the daily average water needs per animal were considered, and the water consumption amounts for each building group in the farm center were calculated. Due to the high-water needs of cattle, the highest water consumption occurs in cattle barns. The number of animals in ostrich houses is low, and the daily water requirement is not high, resulting in low water consumption. The daily, monthly, and seasonal water consumption amounts for all groups are provided in Table 6.

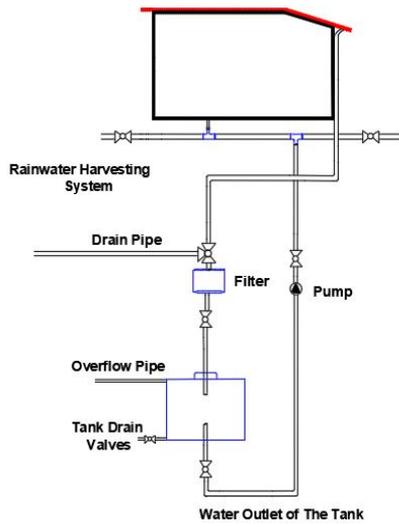


Figure 4. System design of ostrich house

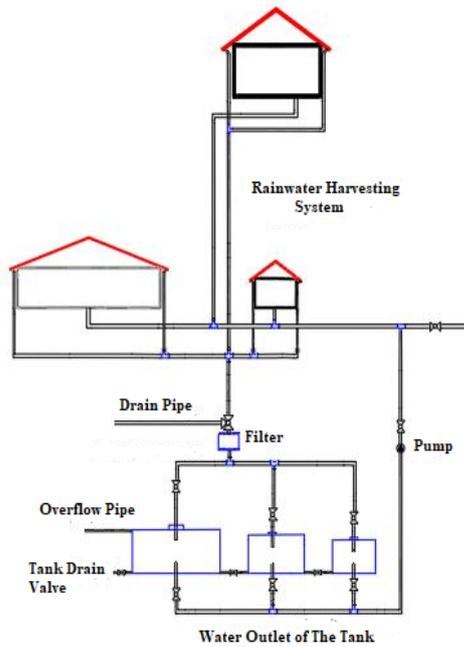


Figure 5. System design for cattle barns

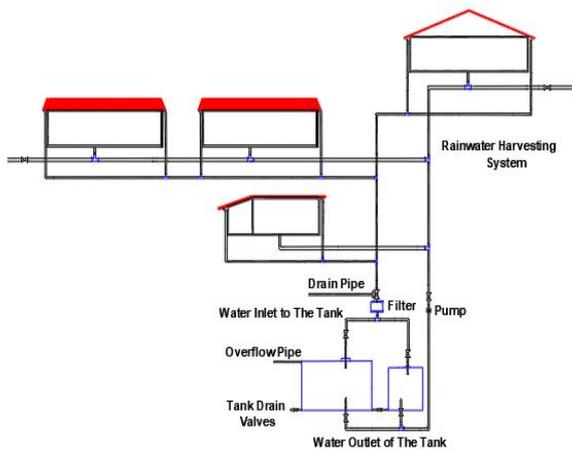


Figure 6. System design for sheep barns

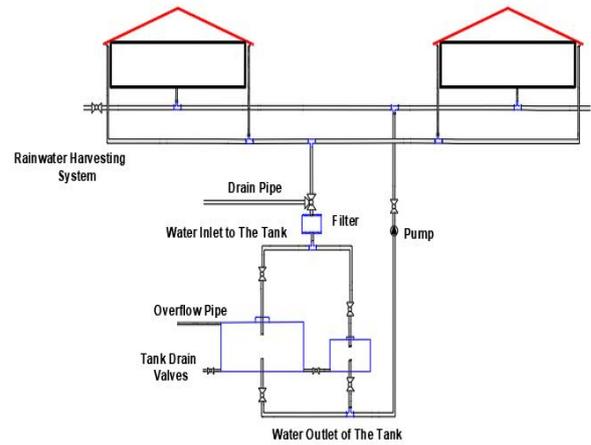


Figure 7. System design for hen houses

Table 6. Water consumption amounts in the building groups at the farm center

Building Groups	Average daily water consumption in buildings groups (L/day)	Average monthly water consumption in building groups (L/month)	Average season water consumption in building groups (L/season)
Ostrich House	162	4860	14580
Cattle Barns	4508	135240	405720
Sheep Barns	3358.4	106752	320256
Hen Houses	1357	40710	122130

3.5. Saving rate

The rainwater harvesting method has determined the potential for meeting the monthly and seasonal water needs for drinking and servicing animals in building groups. Due to the large number of buildings and the extensive roof areas, the water collected is high. In ostrich house groups, the water needed in all seasons can be met due to the low number of animals. In the cattle barns and hen houses groups, all the water needed during the winter months is met by the rainwater system, while 93.86% of the total water needs of the sheep barn groups are met. Due to the decrease in the water level collected during the summer months, the rate of meeting the needs of all building groups outside the ostrich house building group has also decreased. In the spring months, the needs of the ostrich and hen house building groups are fully met, while a large portion of the needs of the cattle and sheep barn groups can be met. The seasonal potential for meeting the water needs of the building groups is shown in Figure 8.

In the ostrich house group, the amount of water obtained through rainwater harvesting will meet 88.6% and 71.5% of the water required for the animals in July and August, respectively, while in the remaining months of the year, it will meet the entire water requirement. In the cattle barn groups, although the

amount of water collected is much higher than that of the ostrich house group, the consumption level is also high, so the entire need can only be met in December and January when the rainfall is at its highest. The water supply ratios obtained from the ostrich house and cattle barn groups through the rainwater harvesting method are provided in Table 7.

Boyacı and Atılgan (2023) determined the potential for saving annual water needs by utilizing rainwater harvesting methods in two cattle shelters in Kırşehir in their study. Using the rainwater harvesting method, 482 m³ of water is collected annually from the dairy cattle barn, while 738.1 m³ of water is collected from the beef cattle barn. The amount of water collected from dairy and beef cattle barns can save 18% and 59% of their annual water needs, respectively. The study we conducted has a higher saving rate of 72% annually in the cattle barn. The main reason for this situation is that the Bursa region has a higher average annual rainfall compared to Kırşehir province.

Due to the high number of sheep and goats in the sheep barn groups, the monthly water consumption in this

building group is at a high level. Therefore, in the sheep barn groups, while the entire need can be met in December when the most rainfall occurs throughout the year, the rate of meeting the need in other months is lower. In the buildings where the hen and goose are located, the water needed can be fully met except for the summer months due to the low number of animals. The water supply rates that will meet the needs of the sheep barn and hen house groups obtained through the rainwater harvesting method are provided in Table 8.

Boyacı (2023) determined the potential of the amount of water to be obtained through rainwater harvesting to save the water needs of the enterprises in a study conducted in a sheep barn and a goat barn in Kırşehir. While 100.5 m³ of water is harvested annually from the sheep barn through rainwater harvesting, 57.8 m³ of water is harvested from the goat barn. When looking at the ratio of the harvested water amount to the water needs, they found that 8.8% of the sheep barn's needs could be save, while 18% of the goat barn's needs could be saved. The saving rate values they obtained have fallen short of the saving rate in our study (%63).

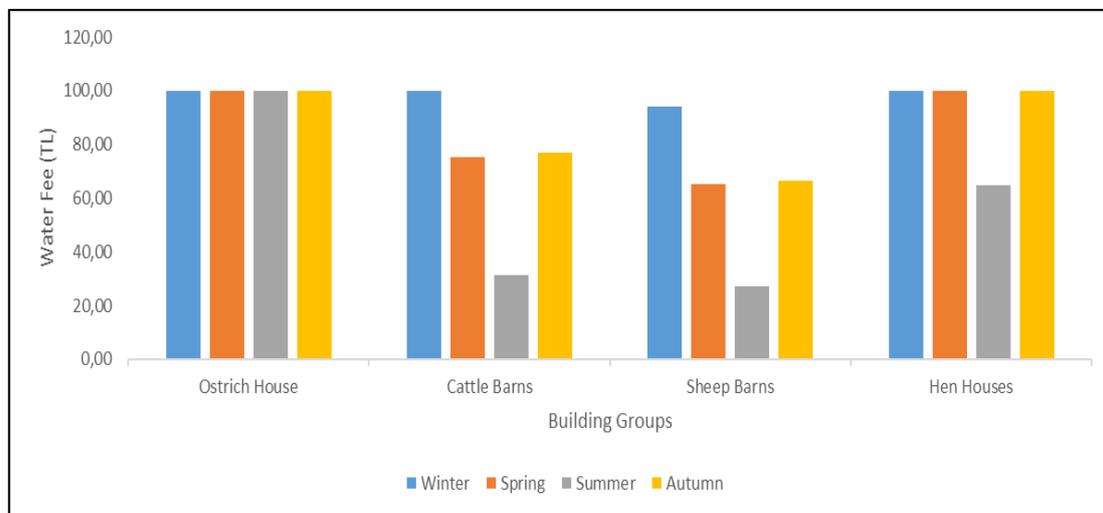


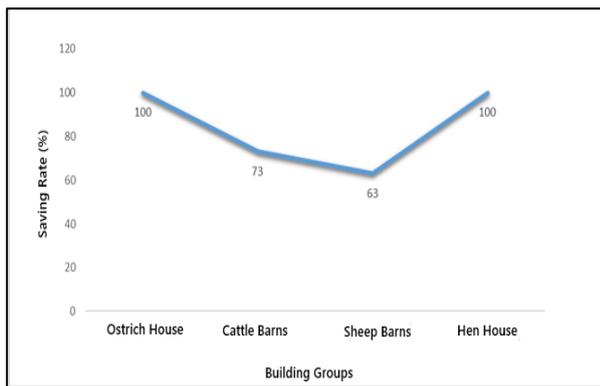
Figure 8. The potential of building groups to saving ratio to the seasonal water demand

Table 7. The rate of saving of the monthly water needs of ostrich house and cattle barn building groups through rainwater harvesting

Months	Ostrich House			Cattle Barns		
	Collected water (m ³)	Monthly Water Consumption (m ³)	Saving Rate (%)	Collected water (m ³)	Monthly Water Consumption (m ³)	Saving Rate (%)
January	17.18	4.86	100	148.74	135.24	100
February	14.57	4.86	100	126.15	135.24	93.2
March	13.58	4.86	100	117.62	135.24	86.9
April	11.94	4.86	100	103.40	135.24	76.4
May	9.76	4.86	100	84.49	135.24	62.4
June	6.86	4.86	100	59.39	135.24	43.9
July	4.31	4.86	88.6	37.31	135.24	27.5
August	3.48	4.86	71.5	30.12	135.24	22.2
September	8.33	4.86	100	72.11	135.24	53.3
October	12.62	4.86	100	109.25	135.24	80.7
November	15.13	4.86	100	131.00	135.24	96.8
December	19.07	4.86	100	165.13	135.24	100

Table 8. The rate of saving of the monthly water needs of sheep barn and hen house groups through rainwater harvesting

Months	Sheep Barns			Hen Houses		
	Collected water (m ³)	Monthly Water Consumption (m ³)	Saving Rate (%)	Collected water (m ³)	Monthly Water Consumption (m ³)	Saving Rate (%)
January	101.61	106.752	95.1	92.55	40.71	100
February	86.18	106.752	80.7	78.49	40.71	100
March	80.35	106.752	75.2	73.18	40.71	100
April	70.63	106.752	66.1	64.34	40.71	100
May	57.72	106.752	54	52.57	40.71	100
June	40.57	106.752	38	36.96	40.71	90.7
July	25.49	106.752	23.8	23.21	40.71	57
August	20.57	106.752	19.2	18.74	40.71	46
September	49.26	106.752	46.1	44.87	40.71	100
October	74.63	106.752	69.9	67.98	40.71	100
November	89.49	106.752	83.8	81.51	40.71	100
December	112.81	106.752	100	102.75	40.71	100

**Figure 9.** The annual water supply rates for all building groups

The main reasons for this situation are the lower roof areas and the amount of rainfall and the higher number of animals. When looking at the annual saving rate of the water needs of animal barns, the needs are fully met in the hen and ostrich house building groups. In the building groups of cattle and sheep barns, while the entire need cannot be saved, a large portion can be

saved. The annual water saving ratio for all building groups is provided in Figure 9.

The amount of water obtained through rainwater harvesting can be much more than needed to care for animals in the building groups during certain months so that it can be used for various purposes in barns. It is planned that the remaining surplus water will be used as an additional resource for cleaning the machines, vehicles, and workers used in the enterprises, as well as for irrigating the agricultural fields near the enterprises. In the groups of buildings for hens and ostriches, where the need for drinking and service water is lower, especially during the rainy winter, more water is obtained than needed. In this group of two building groups, an annual water harvest of 372.3 m³ is carried out for activities other than the animals' needs. Due to the high-water requirement for animal care, the remaining water available for other activities is 49.45 m³ in the cattle and sheep barn groups. After meeting the drinking and service water needs of the animals at the farm center, the amount of water collected through rainwater harvesting in all building groups is provided in Table 9 for use in other activities.

Table 9. Amount of water used in additional activities

Months	Ostrich House	Cattle Barns	Sheep Barns	Hen Houses
January	12.32	13.50	0	51.84
February	9.71	0	0	37.78
March	8.72	0	0	32.47
April	7.08	0	0	23.63
May	4.90	0	0	11.86
June	2.00	0	0	0
July	0	0	0	0
August	0	0	0	0
September	3.47	0	0	4.16
October	7.76	0	0	27.27
November	10.27	0	0	40.80
December	14.21	29.89	6.06	62.04

3.6. Economic analysis and payback period

When looking at the economic gain obtained by meeting the water needs of animals in all building groups through rainwater harvesting, the highest economic gain is 34219.5 TL annually, which is from the building groups where the most water is collected for cattle. The water required in the building group of ostriches is low, so the lowest economic gain of 1837.4 TL is achieved. Meeting the necessary animal needs of all building groups achieves an annual profit of 73607.36 TL. The monthly and annual economic benefits obtained from using rainwater harvesting methods in all groups are presented in Table 10.

After the amount of water collected through the rainwater harvesting method meets the water needs for the care of the animals, the remaining water is used in various activities in the barns, resulting in economic gains. In the hen house groups, the surplus water used in additional activities is at the highest level, with 291.85 m³, resulting in an annual economic gain of 8757.63 TL. In the sheep barn groups, the annual surplus water amount is at the level of 6.06 m³, and the lowest income from additional activities is obtained in this building group with an annual amount of 196.23 TL. The amount of water used annually in additional activities and the economic benefits obtained in all building groups are provided in Table 11.

The amount of water collected from the building groups is primarily used for the care needs of the animals. In contrast, the remaining portion is used for additional enterprise activities. By reusing the total amount of collected water, not only is a high level of water savings achieved, but an annual total profit of 86300.57 TL. Due to the high amount of precipitation in the winter months, the profit amount increases. In contrast, in the summer months, the decrease in precipitation is directly proportional to the decrease in the profit amount. The total economic gain obtained seasonally at the farm center is shown in Figure 10.

An initial investment cost is installing the rainwater harvesting system for all building groups. In the system, a modular galvanized steel water tank for collecting water, a rainwater filter to reuse rainwater, and a pump for sending the water back to the buildings after it has been stored have been added to the designs. When installing the system, the highest expenses are related to the water tank, while the lowest are related to the pumps. The total initial investment cost for the four

systems installed at the farm center was 974556 TL. The total list of materials and costs required for the installation of the four different systems is provided in Table 12.

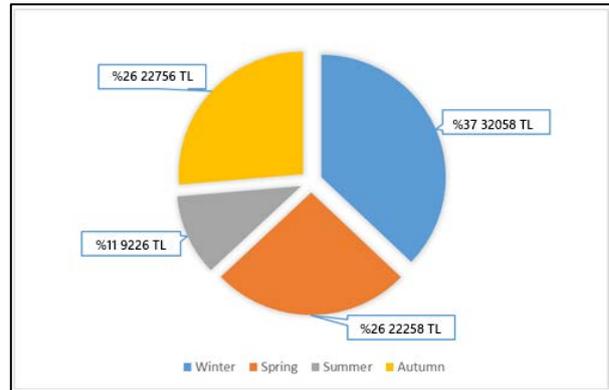


Figure 10. The amount of seasonal economic gain obtained from the farm center

The payback period has been determined by considering the systems to be installed at the farm center and the annual profit amount obtained due to the system's installation. The initial cost amount of the systems, the annual profit amounts, and the payback period are provided in Table 13.

In addition to the economic benefits gained from the use of rainwater harvesting methods, the primary benefit is the water savings achieved. There are many environmental benefits to water harvesting. It constitutes an important solution against the water and food crisis due to its ability to create an additional resource in irrigation and reduce the use of groundwater. Due to its ability to create additional resources for irrigation in agriculture and reduce the use of groundwater, it constitutes an important solution to the water and food crisis. Additionally, the system used helps prevent the uncontrolled flow of rainwater, thereby contributing to the reduction of floods and erosion (Fraiser, 1980; Helmreich and Horn, 2009; Boyacı and Atılğan, 2023).

Hacısalihoğlu (2022) conducted a study in the Karacabey district of Bursa province, determining the amount of water that can be obtained through rainwater harvesting from a residential building and a parking lot with a total roof area of 300 m² in the district, as well as the amount of water and economic savings that can be achieved from daily use in the residence and agricultural irrigation. While calculating the water consumption required for agricultural irrigation, he based the calculation on the water needs

of a 100 m² garden and the 40 planted trees in the area. As a result of the study, it was determined that with the rainwater harvesting method, an annual water harvest of 170.1 m³ would be achieved, and 86% of the annual water requirement of 197.1 m³ for daily use in household and agricultural irrigation purposes could

be met. It has been concluded that an annual economic gain of 940.65 TL was achieved after the system. Compared to our study, although the amount of harvested water is at a lower level, the need for water is also lower, resulting in a higher level of saving the demand.

Table 10. Monthly and annual economic gain amounts obtained from all building groups

Months	Ostrich Houses	Cattle Barns	Sheep Barns	Hen Houses
January	160.4	4066.1	3043.8	1234.3
February	160.4	3779.0	2581.6	1234.3
March	160.4	3523.4	2406.9	1234.3
April	160.4	3097.4	2115.9	1234.3
May	160.4	2531	1729.0	1234.3
June	160.4	1779.2	1215.5	1107.1
July	129.1	1117.7	763.5	695.4
August	104.2	902.2	616.3	561.3
September	160.4	2160.2	1475.7	1234.3
October	160.4	3272.8	2235.8	1234.3
November	160.4	3924.4	2680.9	1234.3
December	160.4	4066.1	3212.7	1234.3

Table 11. Annual water usage and economic gain from additional activities

Building Groups	Amount of Water	Profit Amount (TL)
Ostrich House	80.45	2424.70
Cattle Barns	43.39	1314.65
Sheep Barns	6.06	196.23
Hen Houses	291.85	8757.63
Total	421.74	12693.20

Table 12. List of materials and costs to be used in system installations

Material	Number	Unit Price	Total Price (TL)	References
100-ton galvanized modular water tank	3	180000	540000	
50-ton galvanized modular water tank	1	124000	124000	Anonymous (2025a)
22.5-ton galvanized modular water tank	3	58583	175750	
10-ton galvanized modular water tank	1	36000	36000	
Polyethylene (HDPE) Vortex Stormwater Filter (YFVR-3000)	1	39780	39780	
Vertical Drop Pipe Type Rainwater Filter (YFDI 0201)	2	13250	26500	Anonymous (2025b)
Polyethylene (HDPE) Vortex Rainwater Filter (YFVR-2000)	1	8400	8400	
Clean Water Submersible Pump	4	6032	24126	Anonymous (2025c)

Table 13. Initial cost amount and payback period of the systems

System Cost (TL)	Annual Income Amount (TL)	Payback Time (Year)
974556	86301	11.3

4. Conclusion

Today, the effects of global warming and population growth, along with the losses and pollution in water resources, have created a need to turn to alternative solutions. With the increasing popularity and use of rainwater harvesting methods, reusing rainwater provides an alternative to existing water sources. It measures against natural events such as floods and similar occurrences during heavy rainfall. This study

determined the potential for meeting the animal barns' water needs at the Agricultural Faculty Farm of Bursa Uludağ University through rainwater harvesting, and an economic analysis was conducted. Due to the large number of barns in the farm center and the distances between the buildings, they were divided into four groups: cattle and sheep barns and ostrich and hen house groups according to the animal species in the barns, and calculations were made.

As a result of using the rainwater harvesting method in all building groups at the farm center, a significant amount of water savings, totaling 2868 m³ annually, is achieved. When evaluating the building groups internally, the cattle barn groups achieve the highest

water harvesting with an annual volume of 1184.71 m³. In comparison, the ostrich house group achieves the lowest water harvesting with an annual volume of 136.83 m³. Although the amount of water collected from the ostrich house groups is low, the total need can be met in all four seasons due to the low water consumption. However, the total need can be met in all seasons except for the summer months. When more water than needed is harvested in the building groups, excess water is planned for various activities such as cleaning machines and vehicles or for human needs. By meeting the water needs for drinking and service for animals from all building groups, an annual economic gain of 73607 TL is achieved. Using the remaining water for additional activities results in an annual economic gain of 12693.20 TL. From the farm center, a total annual economic gain of 86301 TL from water fees is achieved through the rainwater harvesting method across all building groups. With the system's installation within four different building groups, a total initial investment cost of 974556 TL is incurred. With the economic gains obtained, this cost can be amortized over 11.6 years. As a result of the study, it has been determined that using the rainwater harvesting method in animal barns will lead to significant water and economic savings. The method of rainwater harvesting could be a good solution to the increasingly severe problem of water scarcity, especially with the increasing use of this method in buildings with large roof areas.

Conflict of interest

The authors declare no conflicts of interest.

Authorship contribution statement

U. K: Writing original draft, investigation, methodology, data collection, curation, conceptualization. İ. K: Writing, review & editing, methodology, project administration validation, supervision, conceptualization.

References

- Anonymous, (2025a). <https://voramekanik.com/galvaniz-moduler-su-deposu/>. [Access date: 21.03.2025].
- Anonymous, (2025b). <https://www.tankplast.com/yfvr-0200>. [Access date: 21.03.2025].
- Anonymous, (2025c). <https://www.genisreyon.com>. [Access date: 21.03.2025].
- Boyacı, S., & Atılgan, A. (2023, 17-18 Kasım). Büyükbaş Hayvancılık işletmelerinde yağmur suyu hasadı ve kullanım

- olanaklarının araştırılması. IV International Siirt Conference on Scientific Research, Siirt.
- Boyacı, S. (2023, 17-18 Kasım). Küçükbaş Hayvancılık işletmelerinde yağmur suyu hasadı ve kullanım olanaklarının araştırılması. IV International Siirt Conference on Scientific Research, Siirt.
- Chapagain, A. K., & Hoekstra, A. Y. (2003). Virtual water flows between nations in relation to trade in livestock and livestock products (Vol:13). Delft, The Netherlands: UNESCO-IHE.
- DIN (1989). Rainwater harvesting systems - Part I: planning, installation, operation and maintenance. German Institute for Standardisation (Deutsches Institut für Normung).
- Dünya Su Forumları (2009), 5. Dünya su forumu günlük raporu, No. 16 İİSD Yayınları, İstanbul.
- Eren B., Aygün A., Likos S & Damar A. İ., (2016). Yağmur suyu hasadı: Sakarya üniversitesi esentepe kampüsü örneği. International Symposium on Innovative Technologies in Engineering and Science (ISITES), Antalya, 3-5 November.
- Esen, F., & Özdemir, G. (2004). Devekuşu Yetiştiriciliğinde Bakım ve Besleme İlkeleri. *Fırat Üniversitesi Doğu Araştırmaları Dergisi*, 2(3), 79-85.
- Firidin, E. (2015). Su sorununun, su hakkı ve su etiği çerçevesinde değerlendirilmesi. *Aksaray Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 7(2), 43-55.
- Frasier, G. W. (1980). Harvesting water for agricultural, wildlife, and domestic uses. *Journal of Soil and Water Conservation*, 35: 125-128.
- Google (2025). Google Earth. Url: <https://www.google.com/earth/about/>.
- Hacısalıhoğlu, S. (2022). Su hasadı uygulamalarının kırsal alanların sürdürülebilirliğine katkısı: Bursa-Karacabey örneği. *Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 5(2), 767-782. <https://doi.org/10.47495/okufbed.1001531>.
- Helmreich, B., Horn, H. (2009). Opportunities in rainwater harvesting. *Desalination*, 248(1):118-124. <https://doi.org/10.1016/j.desal.2008.05.046>.
- IBM. (2019). SPSS 23 Statistics software, USA.
- MGM. (2025). Meteoroloji Genel Müdürlüğü, Resmi İstatistikler. <https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?m=BURSA> [Erişim Tarihi: 21.03.2025].
- TEMA. (2025). Geleceğin suyu. <https://silo.tips/download/geleceken-suyu-sutemaorgtr>. Erişim Tarihi: 21.03.2025.
- WWF-Türkiye (2011), Suyun akılcı kullanımına yönelik eğitim kitapçığı, İstanbul.
- Yalılı Kılıç, M., & Abuş, M. N. (2018). Bahçeli bir konut örneğinde yağmur suyu hasadı. *Uluslararası Tarım Ve Yaban Hayatı Bilimleri Dergisi*, 4(2), 209-215. <https://doi.org/10.24180/ijaws.426795>.
- Yeniçeri, M. (2018). Yağmur sularının hasadı ve aktif olarak tarımsal sulamada kullanılması. *Afet Ve Risk Dergisi*, 1(2), 126-136. <https://doi.org/10.35341/afet.447687>.