ISSN: 3067-2392
Research Article
Planetary Journal of Social Sciences & Humanities Research

Possibilities of Using Rainwater in Farm: Deguciai Example (Lithuania)

Gitana Vyciene[1*], and Vilda Grybauskiene[2]

[1]*Lecturer at Department of Hydrotechnical Engineering, Lithuania University of Applied Engineering Sciences, Lithuania*
[2]*associate professor at Department of Hydrotechnical Engineering, Lithuania University of Applied Engineering Sciences, Lithuania*

[*]Corresponding author: Gitana Vyciene, Lecturer at Department of Hydrotechnical Engineering, Lithuania University of Applied Engineering Sciences, Lithuania.

Submitted: 13 August 2024 **Accepted:** 19 August 2024 **Published:** 26 August 2024

https://doi.org/10.63620/MKPJSSHR.2024.1010

Citation: *Vyciene, G., & Grybauskiene, V. (2024). Possibilities of Using Rainwater in Farm: Deguciai Example (Lithuania). Planetary J Soc Sci & Hum Res 1(2), 01-05.*

Abstract
The rooftop rainwater harvesting means the collection of water from the rooftop of any structure. The tank is the most expensive and critical component of rainwater harvesting system.

The study was conducted at an individual farm in Deguciai village in Lithuania to find the optimum volume of the storage tank for harvested runoff from the rooftop of the farm building in years of different humidity. The precipitation data of Silutes region over 10 years was analyzed for the water harvesting potential. In the calculations, water demand for the vegetation period is taken into consideration according to the quantities specified by the farmer.

It is determined that rainwater harvesting potential during the vegetation period is 7.53 m3 in dry years, which can meet around 24 % of the farm water needs when the catchment area is 50 m2. Even in the wettest year, the farm's water demand could be satisfied only for two months. When the catchment area is 200 m2 over 7 months' period, it would be possible to accumulate 40.16 m3 of water and it would fully satisfy four months' water demand of the farm in dry years. In wet years, all accumulated water during the vegetation period can cover all of the farm's water demands. Optimal volume of the tank is 11 m3 for dry and average humidity years, and up to 14 m3 in wet years, respectively.

As it can be seen from the study, the volume of the tank mainly depends on the amount of precipitation, roof area and the farm's water demand.

Keywords: Rainwater Harvesting Systems, Water Use in Agriculture, The Volume of Water Storage Tank

Introduction

Water is vital in the agricultural sector. Farmers use water to grow crops, to process agricultural products as well as for other farm purposes. Agriculture is a major provider of food, but also one of the largest users of water resources [1,2]. Depending on the climate of the region and the level of economic development of the country, agriculture uses about 60-90% of available water resources.

For many decades in Lithuania, it was important to remove excess moisture from the soil, however, in the last decade with prolonged dry periods the increase in the number of days when high daily temperatures prevail, as well as with changes in the dynamics of precipitation, it has become more and more important to use all the precipitation water that infiltrates the soil and is collected through the rain systems as efficiently as possible. For a long time, economic entities have been able to use underground and surface water resources without limits. However, due to changes in the legal regulation of surface and underground water use starting in 2024, farmers are increasingly looking for alternative engineering solutions. Thus, collecting rainwater in tanks can be an excellent measure of an alternative water source on a small farm.

The growing number of published scientific articles in the world shows the relevance of installing rainwater harvesting systems. The number of published articles increased from two articles in 1999 up to 57 articles in 2018. It is noteworthy that almost 50 percent of these articles were published between 2014 and 2018 [3].

According to the author [4], rainwater harvesting is defined as the management and use of rainwater immediately for daily needs, or rainwater stored and used later. Rainwater harvesting encompasses all methods by which rainwater and runoff are effectively managed and used for various purposes. The practice of rainwater harvesting has been known since prehistoric times and is still part of many domestic and agricultural systems around the world, especially in arid and semi-arid regions.

The literature mentions three main methods for selecting the volume of the water storage tank [5]: a) using the falling daily precipitation and the amount of water demand, a water balance equation is created; b) assessing how many days the water from the tank will be used and what is the average water demand per day; c) using the annual amount of collected precipitation or water demand, the runoff coefficient and the catchment area are estimated.

The aim of the study is to determine the theoretical potential of rainwater collection from the roof of the farm building and selection of the optimal volume of the tank in years of different humidity.

Methods

The private farm chosen for research is located in Deguciai village, Silute region in Lithuania (Figure 1).

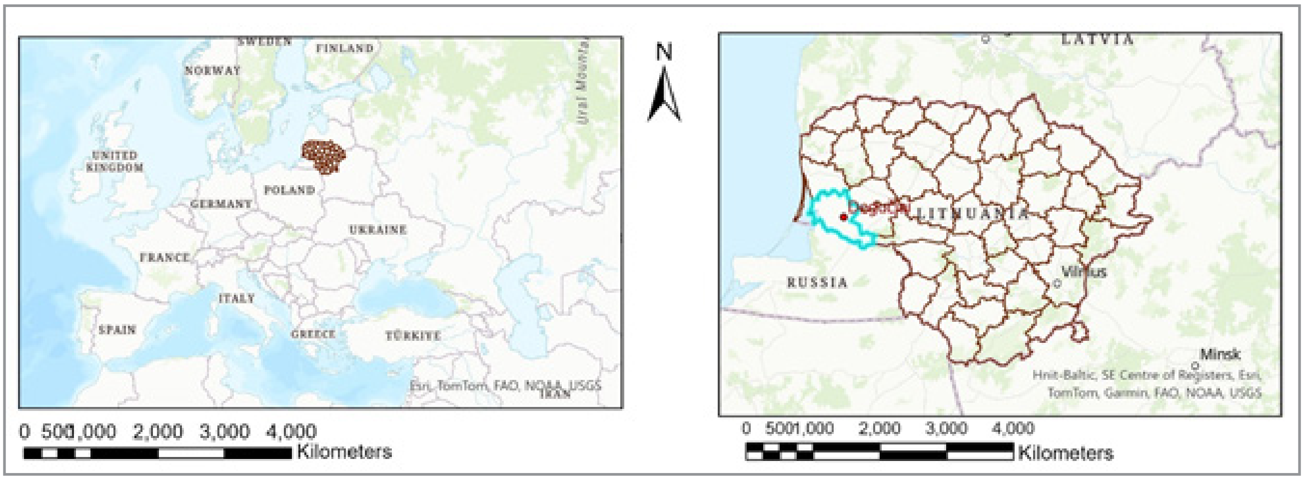

Figure 1.

The period of 2012 - 2022 was chosen for the precipitation analysis, the data was collected from the nearest Silute meteorological station. The distance from the farm to the weather station is about 20 km.

Precipitation in the farm is collected only from a part of the roof (roof area 50 m2, slope of the roof - 30°). The roof of the building is covered with corrugated sheets of fiber cement. Rain drainage system is installed lead the collected rainwater to an above-ground water collection tank with a volume of 3 m3 (Figure 2). In the system water-meters were installed in the inflow and outflow sections, and a water filter was installed in the inflow

Figure 2: Rainwater harvesting tank in the analyzed farm

The amount of precipitation (runoff) generated from the roof is calculated by an approved methodics [6]:

$$W_f=10\cdot H_f \cdot p_s \cdot A,\ m^3/\text{month} \quad (1)$$

where: Hf - amount of precipitation/month, mm; ps - runoff coefficient, in this case - 0.85 is chosen according to the roof covering [6]; A - area of the runoff basin, m2.

The area of the runoff basin is calculated according to the formula [7]:

$$A=As+1/2*(As*tan\alpha),\ m^2 \quad (2)$$

where: As - roof area, m2; α – roof slope.

Calculating the surface runoff from the roof, 10% was subtracted from the generated runoff to account for potential losses (overflow due to heavy rainfall and wind, evaporation from the roof covering). The study assumes that the rainwater tank is impervious to sunlight, so water loss due to evaporation from the tank was not assessed.

The possible rainfall accumulation and storage capacities are evaluated according to the assumptions used by scientists in the literature [2,8]: if the accumulated amount of precipitation was higher than the current volume of the tank, the excess water (overflow) was subtracted from the accumulated runoff; the water demand is subtracted from the accumulated/stored rainfall if there is sufficient water in the tank; in a situation where there is not enough water in the tank, it is assumed that the missing water demand is satisfied using another source of water supply.

Results

A 10-year rainfall analysis was performed to estimate the potential amount of water collected from the roof of a farm building. The average annual rainfall over the analyzed ten-year period was - 778.02 mm, this was by 2.74 percent less than the standard norm in Silute region - 800 mm (in 1991-2020). In 2022, the amount of precipitation comprised 572.2 mm. After analyzing the precipitation data, three relevant periods were selected: dry, averagely humid and wet years. The selected years and corresponding annual precipitation values are shown in Table 1.

Table 1: Characteristics of multi-year precipitation in the study area

Statistical characteristics			Rainfall (mm)	Year
Average (mm)	778.02	Dry year (10 perc.)	536.9	2014
Mediana (mm)	717.80	Averagely humid year (50 perc.)	703.9	2020
Standart devation (mm)	54.04	Wet year (90 perc.)	1115.6	2017

In the research period the farm had an above-ground tank installed in the rain collection system. The tank was emptied during the cold period and precipitation was not collected. Rainwater harvesting begins only when the prevailing average daily air temperature is positive. Based on the standard norm (1991-2020) for March the temperature is 0.9 °C and prevails until November (2.6 °C) (meteo.lt).

Since the farm uses stored water for greenhouse irrigation, it is accepted that the farm's water demand is 6-8 l/m2, i. e. avg. 6.1 m3/month. The demand was accepted according to the norms specified by the farmer. The remaining water in the tanks is used for other needs of the farm.

In dry years, in 7 months' period it was possible to accumulate 11.97 m^3 of rainwater, avg. 1.7 m^3/month, but in the vegetation period - only 7.53 m3 (Figure 3).

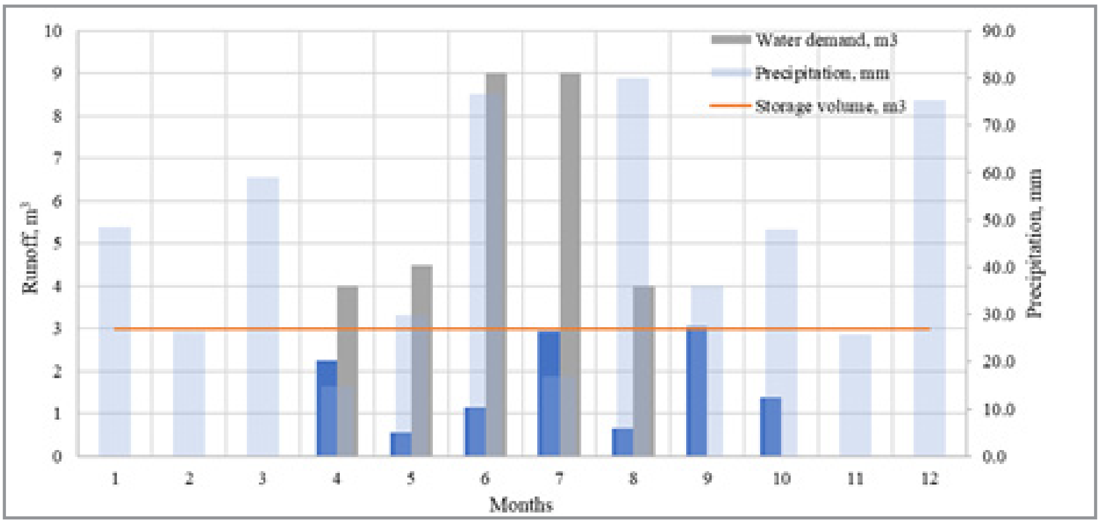

Figure 3: The amount of rainwater collected from the roof of the farm building and the demand in the farm in dry years

During the entire accumulation period the accumulated amount of precipitation does not exceed the volume of the available capacity without estimating the need for farm water use. In dry years the water needs of the farm will be satisfied by about 24% and the demand deficit will have to be covered with water from other sources. It is necessary to note that the limiting factor is the amount of precipitation and the area of the roof.

In the year of average humidity over seven months the amount of rainwater that could be accumulated would comprise 12.40 m3, around 1.77 m3 per month, while in wet years - 20.32 m3 (Figure 4).

As can be seen from the amount of collected precipitation, even in the wettest year, the farm's average water demand could be met for only two months and farm water demand remains by 39% higher than the amount of rainwater that can be stored.

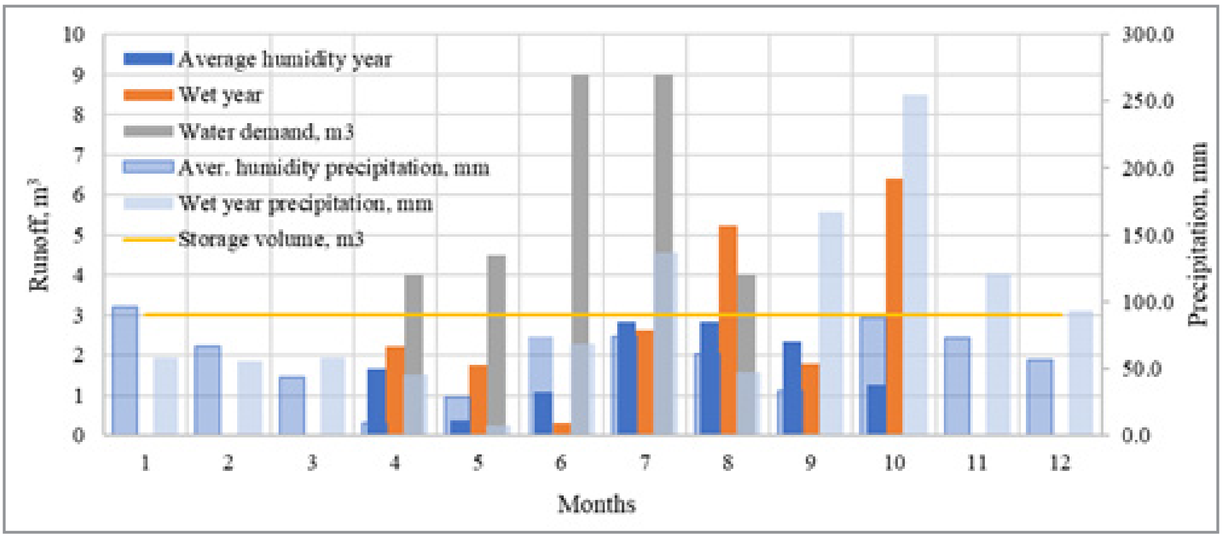

Figure 4: The amount of rainwater collected from the roof of the farm building and the demand on the farm in medium humid and wet years

In order to meet water demand of the farm, it would be necessary to start storing water several months earlier, but this is limited by the climatic conditions of Lithuania and the selected above-ground tank. To increase the volume of the tank is not useful, since the water demand of the farm exceeds the inflow into the tank, thus at the end of each month all the water from the tank would be used up, i.e. St < 0.

The scenario when water is collected in a tank from the whole roof of the farm building was analyzed as well (Table 2).

Table 2:s Recommended tank size according to the catchment area

	The amount of accumulated water in dry years, m3	The amount of accumulated water in averagely humid years, m3	The amount of accumulated water in wet years, m3
Runoff basin area, 200 m2	40.16	40.66	62.20
Tank volume, m3	11	11	14
Standart devation (mm)	54.04	Wet year (90 perc.)	1115.6

By increasing the roof area in dry years over 7 months‘ period it would be possible to accumulate 40.16 m3 of water and this would fully satisfy four months‘ water demand of the farm. A very similar situation was obtained in years of average humidity. During the entire vegetation period all accumulated water can cover all of the farm‘s water demand in wet years. After the analysis of different humidity years, optimal volume of the tanks is considered to be 11 m3 for dry and average humidity years, and up to 14 m3 in wet years.

As can be seen from the analysis, the runoff amount from a small roof area is small, and therefore the volume reliability of the tank is low. As the roof area increases, the amount of water entering the tank increases. As a result, the tank becomes more reliable in terms of volume.

The performed calculations show only the theoretical potential of rainwater collection in the farm. To obtain more accurate calculations, the rainwater drainage system should be assessed, i.e. downpipe diameters, filter capacity, as well as prevailing wind directions in the area should be considered. Selecting the optimal volume of the tank it is necessary to take into account the choices of tanks available in the market and the possibilities of the farm to install such tanks.

Conclusions

The tank is the most expensive and critical component of the rainwater harvesting system. The volume of the tank determines the reliability of the system operation and the satisfaction of the farm's water needs. Precipitation varies between years with different humidity levels, so it is difficult to determine the optimal volume of the tank and assess the reliability of system operation. As can be seen from the study, the volume of the tank mainly depends on the amount of precipitation, the area of the roof and the water demand of the farm.

In dry years, when water is collected from the surface basin area of 50 m2, the water needs of the farm will be satisfied only to a minor extent (24%), even in wet years. The amount of water stored will not be enough to meet the farm's needs and the demand deficit will have to be covered by water from other sources. Since the water needs of the farm exceed the inflow into the tank and at the end of each month all the water from the tank will be used up. The tank volume of 3 m3 is sufficient, because the inflow into the tank will not exceed its volume over a month.

By increasing the roof area (up to 200 m2) over 7 months‘ period it would be possible to accumulate 40.16 m3 of water and this would fully satisfy four months‘ water demand of the farm in dry years. In wet years during the vegetation period all accumulated water can cover all of the farm‘s water demands. The optimal volume of the tanks is 11 m3 for dry and average humidity years, and up to 14 m3 in wet years.

References

1. Fourozani, M., & Karami, E. (2011). Agricultural water poverty index and sustainability. Agronomy for Sustainable Development, 31, 415-432.
2. Lupia, F., Baiocchi, V., Lelo, K., & Pulighe, G. (2017). Exploring rooftop rainwater harvesting potential for food production in urban areas. Agriculture, 7(6), 46.
3. Muñoz, J. V., Aznar-Sánchez, J. A., de la Fuente, A. B., & Fidelibus, M. D. (2019). Rainwater Harvesting for Agricultural Irrigation: An Analysis of Global Research. Water, 11(7), 1320.
4. Qadir, M., Sharma, B. R., Bruggeman, A., Choukr-Allah, R., & Karajeh, F. (2007). Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries. Agricultural Water Management, 87(1-2), 2-22.
5. Monteiro Santos, C. M., & Taveira-Pinto, F. (2013). Analysis of different criteria to size rainwater storage tanks using detailed methods. Resources, Conservation and Recycling, 71, 1-6.
6. TECHNICAL REGULATION OF CONSTRUCTION STR. (2003). Water supply and sewage disposal. Building engineering systems. Field engineering networks (in Lithuanian). Vilnius. Retrieved from https://www.e-tar.lt/portal/lt/legalAct/TAR.EFD8078E42A8
7. TECHNICAL REGULATION OF CONSTRUCTION STR. (2018). BUILDINGS: WALLS, ROOFS, WINDOWS AND EXTERIOR ENTRANCE DOORS (in Lithuanian). Vilnius. Retrieved from https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/f58c3ad0544711e98bc2ba0c0453c004?jfwid=rivwzvpvg
8. Liaw, C.-H., & Tsai, Y.-L. (2004). Optimum storage volume of rooftop rain water harvesting systems for domestic use. JAWRA Journal of the American Water Resources Association, 40(4), 901-912.
9. Damkjaer, S., & Taylor, R. (2017). The measurement of water scarcity: Defining a meaningful indicator. Ambio, 46(4), 513-531.
10. Ghisi, E., Bressan, D. L., & Martini, M. (2007). Rainwater tank capacity and potential for potable water saving by using rainwater in the residential sector of south eastern Brazil. Building and Environment, 42(4), 1654-1666.
11. LITHUANIAN HYDROMETEOROLOGY SERVICE. (2023). http://www.meteo.lt/lt/oro-temperatura.
12. Singh, K. G., Sharda, R., & Singh, A. (2019). Harvesting rainwater from greenhouse rooftop for crop production. Agricultural Research Journal, 56(3), 493.