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# Evaluating the Ability of Rainwater Gathering to Meet Water Demand in the Debre Berhan University Community, Ethiopia

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## Abstract

Rainwater collection appears to be a viable technique to offer significant storage of water during rains in both rural and urban regions for agricultural, drinking, and industrial water demands. As a result, this study was carried out to estimate water collecting capability using rainfall as the only source of water supply. The potential and demand for rainwater on our campus were calculated using an empirical method. Interviews and direct measurements were used to collect primary data, while secondary data was gathered from a variety of sources. According to the research, the water harvesting potential on the study campus is 296269.7 m3. However, in order to satisfy the campus's needs, the water demand was calculated to be 644388.6 m3. On our campus, seasonal water consumption exceeded seasonal rainfall supplies. As a result, the yearly shortfall was calculated to be 348,118.9 m3 of water. Water harvesting structures are developed depending on the amount of water collected from building roofs and the ground surface. Using GPS readings, an appropriate site at a lower elevation was found for the predicted ground and surface water. Because of its low cost and ease of delivery, it is recommended that the predicted generated water of the roof catchment be stored in a high capacity (100 m3) constructed plastic water storage tanker. To cut expenses, the site was chosen close to the buildings, which are densely packed in one area, and close to the targeted area. Furthermore, a rooftop surface allows for more household storage of relatively clean water while also raising the ground water table in-situ. Rainwater harvesting from roof tops and surfaces is the only realistic way to develop water resources in metropolitan regions where a lot of dwelling clusters and commercial complexes are growing up in order to fulfill the local demands for water with self-sustainability.

## Article Info

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## Keywords

Demand, potential storage, rainwater gathering, supply, and water budgeting.

## Introduction

Water is a nature’s gift that is available through precipitation and as groundwater. The quantity and quality of water available for human use is linked to the ecosystem, sustainable management of natural resources and giving priority of water uses between different sectors. Factors like deforestation, disruption of hydrological cycle, surface runoff, over extraction of groundwater, pollution of water sources, silting of lakes and tanks, etc. contribute mainly to the scarcity of water. The demand for fresh water is constantly increasing every day with the rapid increase in population and the development of industry and agriculture in the country. Water resources are not evenly distributed in the country and it also varies from one season / year to another. Therefore, water has to be used and recycled most efficiently to produce an adequate quantity of food, fodder and fuel to meet the ever-increasing demand of the nation and to bring stability in agricultural production in a sustained manner. The concept of rainwater harvesting (RWH) has, therefore, come to collect, store, and convey rainwater on a watershed basis for more sustained agriculture production (Rana and Gupta, 2010).

The problem of water shortage in arid and semi-arid regions is due to low rainfall uneven distribution throughout the season, which makes rain-fed agriculture a risky enterprise. Even in high rainfall areas due to the miss management of rainwater there is a shortage of water for various uses. In chronic drought prone areas, the practice of water harvesting for drinking purposes from roof tops and hilly terrain was employed centuries. Rainwater harvesting is a simple and low cost water supply technique that involves the capturing and storing of rainwater from roof and ground catchments for domestic, agricultural, industrial and environmental purposes. When surface run-off is collected in reservoirs, it can be used for the management of floods and droughts. Surface runoff can also be used for recharging groundwater, which will positively impact on aquifers, springs and shallow wells. Rainwater harvesting yields numerous social and economic benefits, and contributes to poverty alleviation and sustainable development (Prinzand wolfer, 1999).

Water harvesting systems for runoff water collection and storage represent an attractive solution for resolving water scarcity in various parts of the world (Frot *et al.*, 2008). Rainwater harvesting (the accumulation and storage of rainwater) is already widely used throughout the world as a method of utilising rainwater for domestic and agricultural use. (Everson *et al.*, 2011). It can be sliced in to different techniques, such as rooftop water harvesting, runoff water harvesting (micro-catchment water harvesting systems and macro-catchment water harvesting system), and flood water harvesting. The principle of water harvesting is to conserve rainwater where it falls according to geographical conditions. In this process, the groundwater is recharged in the long run. In humid climate, runoff usually occurs when rain falls on a saturated soil surface. Conversely, the more arid the region, the more the soil is saturated by rainfall and the more frequent will be the chances of runoff from soil following rains that exceed certain intensity.

The central idea behind any water harvesting strategy is to store the excess water available during rainy season for use during post-rainy season. Rooftop and runoff rainwater harvesting is one of such techniques. Rooftop area and land surface catchment areas provide ample scope to harvest the rainwater in humid and sub-humid areas (Ray *et al.*, 2009). Every activity in Debre Berhan University campus is mainly dependent on groundwater source. As it is feared that over exploitation of groundwater is being done, the assessment of water harvesting potential study is necessary to know the present situation of the study area. Indiscriminate use of groundwater may lead to serious situations and may cause excessive drawdowns or mining of aquifers. There is an urgent need for harvesting every drop of rainwater, since this is the major source of replenishment of groundwater (Vashisht, 2008). Thus, this study was aimed to assess the rainwater harvesting potential at Debre Berhan University watershed.

## Statement of problem

It is very rare that people are aware with water conservation. Further understanding and knowledge gained from the experiences on water harvesting is also lack. The effort to collect water for completing the need and the use of water in efficient ways is becoming very urgent.

In the study area the annual rainfall is more than 874mm, and the campus needs much water for establishing different demonstration sites for students, such as nursery demonstration site and research site for Plant Science and horticulture department at college of Agriculture and natural resources science, even different researchers are put their proposals' on the shelve due to lack of water (vegetable product cover is null), for campus beautification (landscape) under this condition as you now our campus seems like degraded (bare land), especially from November to June, even within this year (2019/2020) almost more than 3000tree seedlings are died due to water scarcity, for laboratories, for cafeterias and lunchrooms, for toilets and for other purposes ;this ample amount should be supplemented from rainwater than tap water.

The campus has many buildings (14.2ha) and ground surfaces (87.8ha) which can be used as water harvesting catchment but not yet used and it has many areas that can be used for irrigated agricultural practices, furthermore, still no study was undertaken about the water harvesting potential of the campus. Water harvesting techniques (WHT) are promoted to be introduced to community for handling the water scarcity and disaster due to flood. Collected water from direct rainfall and runoff will be very valuable for covering the needs. Water harvesting may also increase recharge of the groundwater leading to increase groundwater storage. Due to this reason, there was needed to assess the rainwater harvesting potential at DBU campus.

## General objective

The main objective of the study is to estimating the potential of rain water harvesting at Debre Berhan University campus watershed.

Specific objectives of the study;

To quantify rooftop and runoff rainwater harvesting potential at DBU campus,

To assess Water budgeting by comparing yearly demand and supply of water in the campus watershed; and

To identify suitable site to store for the estimated rainwater.

## Materials and Methods

### Description of the study area

The study was conducted to know rainwater harvesting potential from different buildings and surface catchment in Debre Berhan University (DBU) campus, Debre Berhan, Ethiopia. DBU campus on which the research were carried out in Amhara national regional state, North Shewazone which far 130km from Addis Ababa, located in 939’23”N to 3931’18” E and at an altitude of 2780msl.The climate condition of the study site is mainly “Dega”, i.e. temperate type cool climate. The area demarcated under such region are characterized by three seasons and locally known as *Bega* (from October to January), *Belg* (from February to may), *Kermet* (from June to September). The maximum and minimum temperatures of the area are 20 and 3 degree centigrade respectively. At night frost occurs frequently from October to January.

The rain fall pattern in this region has two distinct peaks during a year. Short rain occurs from February to May and long rain from June to September The average annual rain fall is 874mm, 70% falling in long rain periods. The overall topography is almost plateau associated with undulation and valley bottoms and seasonal rivers. The soil type is dominated by *vertisol* having some organic matter.

### Data set and data collection

### Data set

For estimating the rainwater potential of Debre Brihan University campus watershed from roof and ground catchments, different data was collected. Meteorological data also were collected from Debre Berhan Agriculture Research Center meteorology including rainfall, reference evapotranspiration (ETo), Maximum and minimum temperature. From campus catchment ;soil type, slope, types of land cover and each area, number of building, roof plain areas, types of building, number of population, total area of the campus, type and number of trees, types of crops that grown in the campus, and number of cattle was collected from the campus. All buildings are counted and categorized depending on their roof size and their roof sizes were measured. Furthermore, the area covered by the roof of the buildings and also the areas other than roof catchment was measured. For identifying suitable water harvesting technologies relevant to Debre Brihan University campus condition, different water harvesting systems was reviewed and some of them were selected by giving justification. For designing rooftop water harvesting system for the estimated roof catchment water potential, the position of the water harvesting pond was determined after clustering the nearby buildings to one pond and the size is decided according to the potential of runoff was estimated and tape meter were used for distance measurement.

### Data Collection

The data collection was carried out with each representatives based on each data type that assigned by Debre Brihan University. For the study all the necessary data were collected from DBU office, from Debre Brihan Agricultural Research Center, field measurement and also during professional field visits periodically. Both primary and secondary data was collected. The data of water supply and demand was collected at the campus watershed.

### Primary data collection

Various types of primary data were collected through formal and informal survey approaches. Office representative interviews were practiced for gathering information and analysis. Additionally, GPS data was also recorded for the purpose to set different points at the correct position on the systematic layout of the study area. Frequent field observations has been made to observe and investigate suitable site for pond construction, land use land cover, type of trees, order of building, agricultural practice, and practices related landscape management techniques made by the assigned persons.

### Secondary data collection

Data from secondary sources kept by the responsible bodies or officials on the university, design document (building) for number, types and dimension of each building, number of population at university affairs were collected. For university the long time average climatic data of mean monthly minimum and maximum temperature, rainfall, and reference evapotranspiration data was collected from Debre Berhan Agriculture Research Center meteorological station.

Additional secondary data include command area for agriculture and types of land use land cover data area, total area of the campus, number and variety of trees, Crop coefficient, plant factor, crop type and irrigation application method were obtained from responsible bodies or officials.

### Data Analysis Techniques

The collected data were summarized, organized, analyzed and presented using tables and graphs.

### Estimation of rainwater harvesting potential (Availability)

To calculate the rainwater harvesting potential of the roof areas of buildings and ground surface in Debre Brihan University campus, the rainwater harvestable from building areas and ground surface was estimated. The capacity of rainwater harvesting systems was calculated from surplus water. Monthly rainfall data was obtained from Debre Berhan Agriculture Research Center meteorological station, and the average annual rainfall was worked from recent 20years (1999-2018) recorded monthly rainfall. At present for each office water is supplied by groundwater pumping. Rainwater harvesting potential study was carried out by considering rainfall is the only source of water supply and the catchment is rooftop and land surface.

The volume of rainwater that can be collected from the rooftops can be calculated by the following formula:

$$V=A*D*C/1000\ldots(1)$$

Where, V = Rainwater harvested from roof year-1 ($m^3$)

D = Annual average depth of rainfall received during the year (mm)

C = Runoff coefficient

A = Area of the roof surface (m2),

A= L*W, L=length (m) and D=width (m)

The runoff coefficient ranges from 0.7 to 0.9 for different roof surfaces. For example, it is 0.7 in concrete, 0.75 in tile, 0.8 in asbestos, and 0.9Galvanize Irion sheets. However, in this study, most of the roof surfaces are GI sheet. So the value 0.9 was taken for C (Michael, 1999).

And, the volume of rainwater that can be collected from the land surface (runoff) can be calculated by the following formula:Using empirical formula

$$Q=P*A*C/1000\ \ldots(2)$$

Where, Q=runoff (m3), A=catchment size (m2)

C=Runoff coefficient (weighted)

P = annual rainfall (mm)

Runoff coefficient from a given area can be estimated using the following methods.

$$C=\frac{[A_1C_1+A_2C_2+A_3C_3+\ldots+A_nC_n]}{A}$$

Where, A1, A2, A3, etc. = Areas in ha under various land uses and soil types

C1, C2, C3, etc. = Corresponding value of runoff coefficient for A1, A2, A3, etc..,

A= Total area of land use, (Gould, 1999)

## Water demand assessment

To obtain the Debre Brihan University's real water demand, it would be necessary to sum all of demand in our campus. The water demand for each department (laboratory) was assessed by assuming the appropriate quantity of water for laboratory needs in each department.

The estimation of the total water consumption in the campus was carried out according to the following formula or equation. So, water demand for irrigation, livestock, domestic use, landscape and tree water requirement will be estimate using the following formula or equation.

## Irrigation water demand

The demand for irrigation water depends on several factors, including the method of irrigation, the type of crops to be grown, soil condition and climate.

$$Ir(m3)=\frac{10*ETcrop(mm)*Ca(ha)}{Ef}\ldots(3)$$

Where, Ir = Irrigation water requirements in cubic meters for the whole period

ETcrop = Crop water requirement in mm during the dry period

Ca = Area irrigated

Ef = Overall water application efficiency(Allen *et al.*, 1998).

## Water demand for livestock

$$WL=\frac{NL*Ac*T}{1000}\ldots(4)$$

Where,WL = Water needed for livestock during the whole dry period in cubic meters

NL = Number of animals

Ac = Average rate of animal water consumption in liters per day per animal: 5 - 50 liter/animal/day

T = Duration of the period in days(12 month in our case)(Allen *et al.*, 1998).

## Water demand for domestic use

Domestic water demand includes the water required for drinking, cooking, bathing, sanitary purposewill be estimate using the following equation.

$$Wd=\frac{Po*Dc*T}{1000}\ldots(5)$$

Where,Wd = Domestic water supply during the dry period in **cubic meters**

Po =Number of population

Dc = Average rate of water consumption in liters per day per person: 40 liters / person / day

T = Duration of the period in days (12 month in our case)(Allen *et al.*, 1998).

## Tree water requirement

Tree water demand is met by water available in the soil that may be replaced by precipitation, irrigation, or a combination of the two depending on the local climate and season of the year. In the study area trees are planted in the form of isolated, not planting in the form of closely spaced trees. To estimate the water required by isolated trees, it is necessary to estimate the expanse of each tree's transpiring leaf area rather than the total landscape area since the entire area is not using water. The most actively transpiring leaves are the ones fully exposed to the sun, which are those on the surface of the canopy as the sun passes through the sky. So, the actively transpiring leaf area is roughly the area of the circle defined by each trees' canopy diameter projected over the soil. Thus, the equation to estimate the water requirements of isolated trees is (Pittenger*et al.*, 2012);

$$\text{Water demand } (m^3) = ETo \times PF \times (R \times R \times 3.14) \times NT \times 1.6387 \times 10^{-5} \ldots (6)$$

Where, ETo =is reference evapotranspiration

PF =is the plant factor for established landscape trees (0.5 for all trees).

R =is the radius of the tree canopy in m.

NT=number of tree

R × R × 3.14 = the area of the circle created by the tree's canopy projection over the soil.

## Landscape water requirement

In the landscape, water is transpired by grasses and evaporated from the soil. This process is defined as evapotranspiration or ET. The physiology and structure of a plant, its location in the landscape, and weather conditions are the primary factors affecting ET.

The primary climatic factors that affect ET are solar radiation, air temperature, relative humidity, and wind speed. Most landscape plants such askukuyugrass, groundcovers, and shrubs.

Simplified Landscape Irrigation Demand Estimation (Pittenger *et al.*, 2012) approach to estimating landscape water requirements is relatively simple, and scientifically based and defensible.

The SLIDE equation for estimating the water demand of an established landscape is:

$$\text{Water Demand } (m^3) = ETo \sum (PFcategory\ 1 \times LA1) + (PFcategory\ 2 \times LA2) + (PFcategory\ 3 \times LA3) \times 0.0037, \text{ etc} \ldots (7)$$

Where: ETo = reference evapotranspiration,

PF = plant factor for a given plant type category, and

LA = sq. m. landscape devoted to plants of a given plant category.

Pf of grass is 0.6 for good performance and 0.4 for minimum soil coverage of warm-season species, 0.8 for good performance and 0.6 for minimum soil coverage of cool-season species (Pittenger *et al.*, 2012).

## Suitable site identification

The best site for pond construction for runoff water were identifying based on filed observation by considering different factors, and for roof water the position of the water harvesting pond was determined after clustering the nearby buildings.

## Capacity of the Pond

Normally three types of ponds, viz. embankment type, excavated (dugout) and dugout-cum-embankment type are constructed for collection of excess runoff. Embankment type and dugout-cum-embankment types of ponds are feasible in hilly andundulating topography. Embankment type of pondsare created by constructing a small length of damacross a water course whereas dugout-cum-embankment type of pond can be created byexcavating a site surrounded by hillocks from two orthree sides and making the embankment fromexcavated soil on remaining sides. In flat areas thesetwo types of ponds are not feasible. In such areas,dugout ponds are constructed (Manoj *et al.*, 2008).

The capacity of the pond should be determined after estimation of irrigation water demand, water demand for domestic use, water demand for livestock, landscape water demand, laboratories water demand and tree water demand of the campus of catchment plus provision of evaporation and conveyance losses.

## Results and Discussion

Water balance is an integral part of water budgeting over a specified period of time, which may be over a week/month, season or a full year. Water demand and rainwater harvesting potential of building areas (supply) in Debre Brihan University campus was studied through water budgeting techniques by considering rainfall as the only source of supply of water. Yearly water supply ($m^3$) from roof area and ground surface was calculated and yearly water demand ($m^3$) for irrigation, domestic, laboratory, trees, landscape, and livestock was calculated.

## Estimation of rainwater harvesting potential (Availability)

To estimate the runoff water amount from the roofs, all buildings were counted and their roof areas were measured. The roof of all buildings is covered by galvanized iron sheet, the runoff coefficient is taken to be 0.9. Yearly rainwater supply ($m^3$) was calculated by multiplying the roof area with monthly rainfall and runoff coefficient (which is taken as 0.9). So the estimated values of runoff potential for each of buildings are given in Table 3.1.

The total amount of water that has harvested from each building was 117944.2 $m^3$/year.

**Table.1** Application efficiency with Irrigation methods

| Irrigation methods | Application efficiency |
|---|---|
| Surface irrigation | 60% |
| Sprinkler irrigation | 75% |
| Drip irrigation | 90% |

**Table.2** Recommended average daily water consumption of selected animals

| Animal | Consumption(l/d) |
|---|---|
| Camel | 50 |
| Cattle | 27 |
| Sheep | 5 |
| Goat | 5 |
| Donkey | 16 |

**Table.3** Rainwater harvesting potential from office/buildings in DebreBrihan University campus.

| S.N | Building type | No. of building | Sum of plain roof area, $m^2$ | Runoff ($m^3$/year) | Remark |
|---|---|---|---|---|---|
| **1** | Lounges for both staffs and students | 5 | 2436.4 | 2024.4 | Found dispersed |
| **2** | Work shop | 2 | 877.6 | 729.2 | Are relatively closer |
| **3** | Administration | 3 | 4821.4 | 4006.0 | Are relatively closer |
| **4** | College building | 4 | 4821.4 | 4006.0 | Found dispersed |
| **5** | Class room | 14 | 8188.6 | 6803.7 | Found dispersed |
| **6** | Lecture halls | 6 | 4390.8 | 3648.2 | Found dispersed |
| **7** | Library | 3 | 2108.9 | 1752.2 | Found dispersed |
| **8** | Students cafeteria | 2 | 2788.7 | 2317.1 | Found aligned |
| **9** | Laboratory | 9 | 4967.9 | 4127.7 | Found dispersed |
| **10** | Seminar building | 14 | 8846.7 | 7350.5 | Found successively in one row |
| **11** | Storage Rooms | 2 | 2584 | 2146.9 | Found dispersed |
| **12** | Dormitory | 41 | 17912.9 | 14883.5 | Almost found in one cluster |
| **13** | Others | 6 | 77205.6 | 64148.6 | Found dispersed |
| **Total** | | **111** | **141950.9** | **117944.2** | |

**Table.4** Land surfaces catchment and its characteristics

| Land use | Average slope (%) | Area(ha) | Soil type | Infiltration capacity | Runoff coefficient |
|---|---|---|---|---|---|
| Cultivated area | 3 | 4.75 | clay loam | poor | 0.3 |
| Rocky | 42 | 0.25 | gravel | high | 0.85 |
| Grass land | 4.13 | 81.39 | silt loam | medium | 0.2 |
| Coble stone paved road | 0.2 | 1.41 | - | high | 0.8 |
| Area covered by buildings | - | 14.2 | - | no | - |
| **Total** | | **102** | | | |

**Table.5** Estimated values of seasonal water demand in our campus

| Types of demand | Amount of water($m^3$/year) |
|---|---|
| **Irrigation water demand** | 75851.6 |
| **Livestock water demand** | 443.5 |
| **domestic use water demand** | 561939.4 |
| **Trees water demand** | 4838.8 |
| **landscape water demand** | 329.8 |
| **Laboratories water demand** | 985.5 |
| **Total** | 644388.6 |

**Table.6** Yearly water demand and rainwater harvesting potential in our campus

| Supply($m^3$) | Demand($m^3$) | Surplus | Deficit |
|---|---|---|---|
| **296269.7** | 644388.6 | 0 | 348118.9 |

**Fig.1** Map of the study area

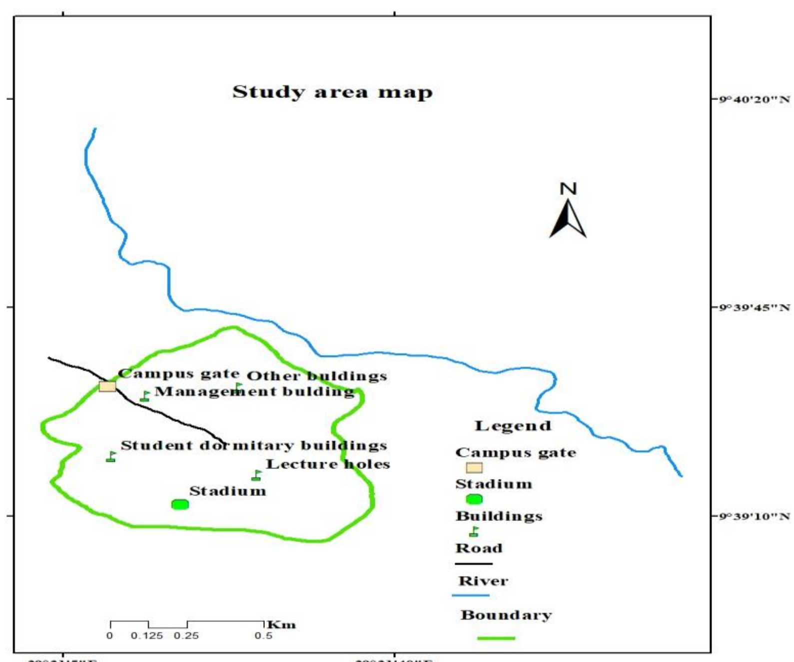

Table3.1 shows the runoff amounts of each building types. Form Table, it can be noted that the runoff amount showed that gradually increase towards the last building. Others (Post-graduation, Register, Graduation building, clinics, Soil lab, and Large administration), dormitory, seminar, as well as class rooms show the largest potential to collect rainfall. Lounges, workshop, storage rooms, library and students cafeteria buildings show the least option.

And the volume of rainwater that can be collected from the land surface (runoff) can be estimated using Equation 2 and the areas excluding the building areas (14.2ha) are summarized in the following Table 3.2.

Since the slope and soil type of our cultivated is 3 %(flat) and clay loam (having poor infiltration capacity) respectively, the runoff coefficient is 0.3; the grass land area is having 4.13% (average) slope and silt loam soil type, the runoff coefficient is 0.85; the rocky area having 42% slope and gravel soil type, the runoff coefficient is 0.2; and the coble stone paved road area having 0.2% slope and the runoff coefficient is 0.8,therefore the cumulative runoff coefficient is taken as:

$$C=\frac{C1A1+C2A2+C3A3+C4A4}{AT}$$

C=0.3*4.75 +0.85*0.25 +0.2*81.39 +0.8*1.41/87.8=**0.22**

So, runoff potential from land surface catchment was estimated using the formula=P.A.C/1000.Were, P= annual runoff, A=total roof plain area, and C=runoff coefficient.

The properly estimating the catchment yield from ground catchment is crucial to design of ponds. So the estimated amount of runoff is Q=923.2*878000*0.22/1000=178325.3 $m^3$/year.
Therefore, total amount water supply from our campus is the sum of building water harvesting and runoff from land surface is 296269.7 $m^3$/year.

## Water demand assessment

The demand of water in our campus such as irrigation water demand,water demand for livestock,water demand for domestic use,tree water demand, and landscape water demand can be estimated using Equation 3, 4, 5, 6, and 7, respectively.

The departmental areas have 9 laboratories for which water demand was calculated by multiplying the number of labs with the daily demand (300L/ day). Total population those lives in our campus are 38489 and we have 45 animals (16 Dairy farming and 29 for Cattle for fatting) those lives in our campus. For the last 20 (1999-2018) years ago according to meteorological data, we have 923.2 mm of annual average rainfall in our campus.

Total landscaped land (Soft land scape) is 81.39ha with the varieties (kukuyu grass) of good performances soil coverage of cool-season species and we have 8588 trees in our campus. Total agricultural area exist in our campus is 4.75 ha and more probability types of crop that grown in this area is onion, crop coefficient is 0.7 and also the value of reference evapotranspiration in our campus is 3.75mm/day.

The result of water demand for irrigation, livestock, domestic use, trees, landscape, and Laboratories in DBU campus is presented as follows, so the results are 75851.6, 443.5, 561939.4, 4838.8, 329.8, and 985.5$m^3$/year respectively. The total water demand was calculated by adding the water requirement for irrigation, livestock, domestic use, trees, landscape, and water requirement for laboratory is 644388.6$m^3$/year. The estimated values of seasonal water demand are given in Table 3.3. Form table, it can be noted that the water demand is very high at domestic use relative to others demands.

## Water budgeting

Water budgeting study was assessed by comparing the monthly demands and supplies of water for DBU campus. The period of surplus or deficit of water can be worked out by deducting the total water demands from the total water supply for any month. Surplus water, if any, can be effectively stored by rainwater harvesting structures and used during the period of deficit. The estimated values of rainwater harvesting potential (supply) and water demand) are given in Table 3.4.

From Table 3.4, the total annual water requirement was found to be 644388.6 $m^3$, while we can harvest 296269.7$m^3$ of rainwater. The annual water demand was more than the annual water supply. The annual deficit was estimated to be 348118.9 $m^3$ of water. Nearly 45.98% of the annual water demand can be met by annual supply by rain water by implementing rainwater harvesting structures. Remaining 54.02 % of annual water demand can be met by external ground water pumping and municipal water supply.

### Identify suitable site and design storage for the estimated rainwater

After we observe the direction of the surface flow of rainwater in the land and close to the targeted area the site was selected. Therefore, to harvest all the potential from roof catchment we need 1179 water storage tankers each have the capacity to store 100m$^3$ of water.

Nevertheless, for the water to be harvested from the ground catchment since the campus does not lie in a single watershed, it was difficult to locate a single place where the storage could be. Just by considering the main and the larger campus only an ideal site was selected at lower elevation by using GPS reading. After we have selected the appropriate site for harvested water from ground surface, we have going to design under cylindrical water tank with 8 m height and the radius of the tank is will be 84.3m.

### Recommendation

From our discussion points one can understand the campus has a great water potential from both ground surface as well as roof catchments. But all this resource is not yet utilized. From the assessment of the potential, there is a possibility to harvest 117944.2 m$^3$ of water from roof catchment, only, and 178325.3 m$^3$ of water from ground surface catchment.

Currently, the total demand in the campus is more than 644388.6 m$^3$/year of water for different activities. So, from the study, the water harvesting potential in our campus was estimated to be 296269.5m$^3$. However, the water demand was found to be 644388.6 m$^3$ in order to meet the demands in our campus. Seasonal water demand was more than seasonal rainwater supply in our campus. Hence the annual deficit was estimated to be 348118.9 m$^3$ of water. Nearly 45.98% of the annual water demand can be met by annual supply by rain water by implementing rainwater harvesting structures. Remaining 54.02 % of annual water demand can be met by external ground water pumping and municipal water supply.

Water harvesting structures are designed based on the quantity of water collected from the roof areas of buildings and ground surface. For the estimated water from ground surface an ideal site was selected at lower elevation by using GPS reading.

For the estimated roof catchment produced water it is advised to use a high capacity (100 m$^3$) fabricated plastic water storage tanker because of its most economical and easily supplying nature. The site was selected near to the buildings which are crowded in one place and near to the targeted area in order to reduce costs. The harvested water could be taken to different purpose through the use of different pipes and canals through gravity push.

Supply-demand gap during non-rainy season can be brought down by supplemental usage of harvested water. The rooftop and runoff water harvesting techniques helps to meet the local needs of community. A rooftop surface offer greater scope for domestic storage of relatively pure water and in addition, rises of ground water table in-situ. Urban areas where a lot of housing clusters and commercial complexes are coming up, rainwater harvesting from roof top and surface is the only feasible solution to develop water resources in order to meet the local needs of water with self-sustainability.

All the surfaces areas in entire Debre Brihan University campus can profitably be used to harvest rainwater. Based on the results of this study the following recommendations are given so as to enhance the benefit of the campus from those assessed potentials.

To use this ample amount of water with the best options awareness creation to the campus community is critically important;

The proper location of rainwater harvesting structure, basic design of a suitable rooftop rainwater structure, and its impact on ground water recharge should be studied for the entire campus.

More detail and highly supported, by budget and professions, study need to be facilitated by the College of Agriculture and Natural Resource Sciences;
The higher officials of the campus need to support this project by thinking of:-

Reducing the cost of tap water;

Increasing the income of the campus;

Saving money that could have been paid for field trips to see animal production and irrigation farms.

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## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

## References

Allen R., L. Pereira, D. Raes, and M. Smith (1998).Crop Evapotranspiration – Guidleines for computing crop water requirements. Irrigation and Drainage Paper Nr. 56, FAO, Rome, Italy.300 pages.

Everson. C., T M. Everson, A T. Modi, D. Csiwila, M. Fanadzo, V. Naiken, R M B. Auerbach, M. Moodley, S M. Mtshali and R. Dladla (2011). Sustainable Techniques and Practices for Water Harvesting and Conservation and Their Effective Application in Resource poor Agricultural Production through Participatory Adaptive Research.

Frot, E., van Wesemael, B., Benet, A. S., House, M. A., 2008. Water harvesting potential as a function of hillslope characteristics: a case study from the Sierra de Gator (Almenria Province, south-east Spain). Journal of Arid Environment 72, 1213-1231.

Gould, P., 1999. Water quantity consideration with environmental and ecological impacts on the rain water harvesting.

Manoj P. Samuel, A. C Mathew (2008). Rejuvenation of Water Bodies by Adopting Rainwater Harvesting and Groundwater Recharging Practices in Catchment Area- A Case Study, Proceedings of Taal2007: The 12th World Lake Conference: 766-776

Rana, R. S., and Gupta, M., 2010. Impact assessment of rainwater harvesting tanks in hilly areas: a case study of NWDPRA micro watershed in Himachal Pradesh. Indian Journal of Soil Conservation 38(2), 137-141.

Ray, L. I. P., Moulick, S., Mal, B. C., Senthilvel, S., Natarajan, P., 2009. Economics of a roof top rainwater harvesting structure-a case study. Journal of Indian Water Resources Society 29(2), 47-50.

Pittenger, D., R. Kjelgren, and D. Shaw, 2012. Simplified landscape irrigation demand estimation – a new paradigm. Proc. Water Smart Innovations Conf., Las Vegas, NV, October 4, 2012.

Prinz, D., and S. Wolfer. 1999. Traditional techniques of water management to cover future irrigation water demand. Z. f. Bewässerungswirtschaft, 34 (1), 41-60. ISSN0049-8602

Vashisht, A. K., 2008. Status of water resources in Punjab and its management strategies. Journal of Indian Water Resources Society 28(3), 1-8.

Michael, A. M., 1999. Irrigation Theory and Practice. Vikas Publishing House Pvt. Ltd., New Delhi, 516.

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