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# Incorporating Rain Water Harvesting into the Green house Farming

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**Abstract**

A greenhouse is a structure where crops could be grown under controlled conditions. A greenhouse is needed in experimental determination of optimum conditions under which a crop(s) will perform the best. Rainwater may be used to water the crops inside a greenhouse.

A 9m x 6m green house of roof slope 20 degree was constructed according to standard recommended by FAO/SIDA. The roof plan area was determined and quantity of harvestable water was calculated using standard formula. Gutter brackets were fabricated in the Department of Agricultural Engineering, LAUECH. Roof gutter size was determined using standard equation. The roof gutter was attached to the fascia board of the roof, using the gutter bracket at a slope of 1.5% and projection of 0.12m Water from the storage tank was diverted to inside the green house with the aid of pipe network and a tap.

The results of rainfall analysis indicated that Ogbomoso has a mean annual rainfall of about 1.2m with a standard deviation of 0.27m and a coefficient of variation of 0.002m, which indicated that the rainfall is fairly well distributed. The rainfall pattern was found to be bimodal in nature, peaking in the month of June and October. The roof plan area was found to be 40m square. The theoretical harvestable water was found 36m square per annum. The required gutter diameter was determined to be 0.086m but a commercially available gutter diameter 0.1m was used.

Rainwater from greenhouse roof, if well harvested and stored, may be used to water the plants inside the greenhouse. Adequate storage facility needs to be provided for harvested rainwater. Experimental crops of known crop water requirement should be grown in greenhouse with the harvested rainwater.

## INTRODUCTION

Plants always respond to their environment and this often affects their production in terms of yield. For each crop, there is an optimum condition under which the production would be maximum. This optimum condition is not easily determined, thus there is the need to perform experiment on each crop aimed at obtaining information such as water requirement of the crop, temperature range for maximum production etc. this kind of experiment is better done in a greenhouse.

A greenhouse is a building where plants are grown for different purposes under controlled condition. Such environmental conditions may include temperature, relative humidity, and soil moisture etc. water for use in the greenhouse may be sourced for through many means. However the available source may be demanding in terms of cost and energy input.

## OBJECTIVES

The objectives of this research were

To select an appropriate type of greenhouse suitable for the environment.

To design and construct the selected greenhouse type.

## JUSTIFICATION

Responses of different types of crops to different treatments, including soil types, fertilizer application, moisture availability, temperature, etc. are very important in determining the optimum conditions for production. These treatments cannot be carried out on ordinary field as the result would be affected by the environmental factors. A controlled growing environment is therefore needed and hence, the need for this work.

## SCOPE

This work is limited to the design and construction of an appropriate greenhouse of size 9m by 6m in the Department of Agricultural Engineering, LAUTECH, Ogbomosho.

## MATERIALS AND METHODS

### Materials for the Greenhouse Construction

The following are the materials used considering the cost, easy installation, aesthetics value.

►Wooden frames were used to offer support to the greenhouse.
►Bricks or concrete blocks were used as wall material.
►Mosquito net and wire gauze were used as wall material.
►Transparent roofing sheets used as roofing materials.

### Site Selection and Land Preparation

A 9m by 6m area of land was marked out at the back of Agricultural Engineering Workshop in south east direction. This location was chosen in order to receive morning sunlight which is sufficient for plant use. Thereafter, the land area was cleared and leveled to have a uniform slope or flat surface. This was achieved by removing soil clods and tree stumps to fill the unleveled area with sand.

### Method of Construction

The methods adopted in the construction of the greenhouse are detailed below

**Sidewall**: A double layer of covering material was used. Mosquito net of 0.00005m hole, 6m long and 2m wide was used as the inner wall while the outer layer was made of wire gauze of 10m long, 5m wide and 0.002m hole. These materials were chosen in order to ease the movement of air in and out of the greenhouse and to control infestation from pest and insect.

**Frame:** the frame of the structure was made of wooden planks on the side wall and at each corner of the structure to carry the load of the building and to provide easy covering of the whole structure.

**Trusses:** The trusses were made of wooden planks that bear the load of the roof. Gable type structure which will allow free flow of water under gravity was considered for this work.

**Roof:** The roof was made of transparent plastic roofing sheet. This allows the entrance of solar radiation coming from the sun into the greenhouse and also to prevent the impurities or dirty substances from dropping inside during whirlwind, also to prevent water to enter the building during rainfall. These were fastening into the trusses with the aid of nails for firmness.

**Entrance:** The door of the entrance was made of wood covered with mosquito net for moving into and out of the structure.

**Guttering system**: This is a channel that was used on the edge of the roof to collect rain water and direct it into the storage tank.

**Storage tank**: The storage tank was installed to collect all water that is coming from gutter to prevent wastage and use of the rainwater collected to wet the crops or plants inside the greenhouse. This was achieved by creating a tap at the lower end of the storage tank and a pipe hose was connected to the tap laid to allow water to flow under gravity into the structure.

### Rain water collection

Rainwater for irrigating the crop inside the greenhouse was collected from one side of the roof. The roof was constructed with a slope of $20^0$. The roof area was calculated

$A_p$= length x breadth
= 4m x 10m
= $40m^2$

Also, the gutter was installed at a slope of 1.5% with a projection of 1.2m according to Abegunrin (2012).

### Analysis of Ogbomosho Rainfall Data

The rainfall data of Ogbomosho, obtained from Ogun-Osun River Basin Development Authority (Faluyo, 2008) was analyzed for pattern (amount and distribution).

### Determination of the Storage Size

The storage size for rainfall was determined according to the basic rainwater harvesting equation. The equation according to Abegunrin (2004) state that

$$Q_{th} = C_r \, x \, A_p \, x \, R^a$$

Where

*Qth = theoretical harvestable water ($m^3$)*
*$C_r$ = runof f coefficient; a property of roof material*
*$R_a$ = average rainfall amount (m)*
*$A_p$ = roof plan area ($m_2$)*
*$Q_{th}$ = 0.75 x 1.2 x 40*

$= 36m^3$

According to DTU (2003), the runoff coefficient of plastic roofs ranges from 0.6-0.9. In this work, a value of 0.75 was used. The actual quantity of water to be diverted to the storage is a function of the guttering efficiency. Thus the actual storage capacity is given as, according to Abegunrin (2011).

$$Q_a = E_g.Q_{th}$$
$$= E_g.C_r.R_a.A_p$$

According to Abegunrin and Sangodoyin (2012), the optimal guttering efficiency at a slope of $20^0$, gutter of 1.5% and gutter projecting of 0.12m is 0.96, thus, the actual storage capacity is given as:

$$Q_a = 0.96 \times 0.75 \times 1.2 \times 40$$
$$= 34.56\ m^3$$
$$= 34560l$$

Thus, a tank of 34560 litres would be adequate for the site. However, abstraction would be made from the tank, possibly before the next rainfall event. This indicated that the tank size may not be up to 34560*l*. According to Abegunrin (2011), the critical period in sizing rainwater tank is the period of dry season – about 150 days. This may also influence the sizing of the tank. The tank required, $Q_r$ is therefore calculated as

$$Q_r = \left(\frac{150}{365}\right) \times 34560l = 1.4203\ liter$$

However, due to financial and time constraint, a tank of 1000*l* was installed. In the good raining years, the tank will come to full earlier than expected thus an overflow device is installed at the top of the tank.

**Determination of Gutter Size**

One of the major problems of rainwater harvesting is the gutter size. An oversized gutter will incur additional expenses while an under sized gutter will capture a little of the available water from the roof. Lucas *et al* (2005) give the gutter size for rainwater harvesting in Ibadan as

$$d_g = 2.445 \times 10^{-2}(A_p.\ C_r.\ \cos\Theta)^{3/8}$$

Where

$d_g$ = diameter of the gutter (m)
$A_p$ = root plan area ($m^2$)
$C_r$ = runoff coefficient
$\Theta$ = roof slope (degree)

Thus the gutter diameter required is

$$d_g = 2.445 \times 10^{-2} (40 \times 0.75\cos 20)^{3/8}$$
$$= 0.086m$$
$$= 8.6cm$$

This dimension of PVC pipe is not commercially available, thus a 0.1m (4'') PVC pipe (halved) is used.

**Results and Discussion**

**Rainfall Analysis**

The result of rainfall analysis is presented in Figure 1. The results indicated that Ogbomosho has a bimodal rainfall pattern, peaking in the months of June and October. The place experiences the phenomenal 'August break'. It was also revealed that Ogbomosho, like many places in South-Western Nigeria, has distinct rainy and dry seasons. The dry season is from the month of November through March, while the raining season is from the month of April through October. Figure 1 revealed that the annual average rainfall in Ogbomosho is about 1.20m, which is good for rainwater harvesting system.

 

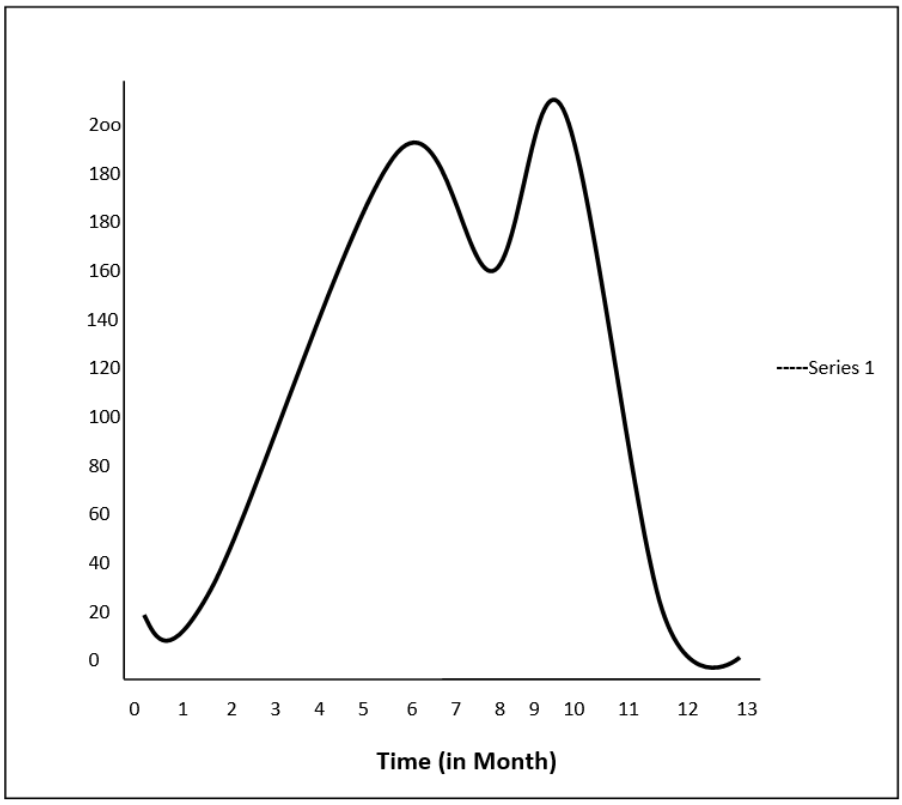


Fig 1: Rainfall Pattern of Ogbomosho

**THE GREENHOUSE**

The greenhouse constructed in this study is shown in Fig. 2. The outside dimension was 9m x 6m. The outside of the greenhouse was covered with nylon netting and metallic chicken mesh. This will ensure adequate natural ventilation inside the greenhouse. The transparent plastic roofing will ensure exchange of solar radiation between the inside of the greenhouse and the surroundings. Although the greenhouse is, as a result of financial constrain, deficient in some facilities such as air conditional and humidifier, it could serve as a model for experiments under fairly controlled environment.

 

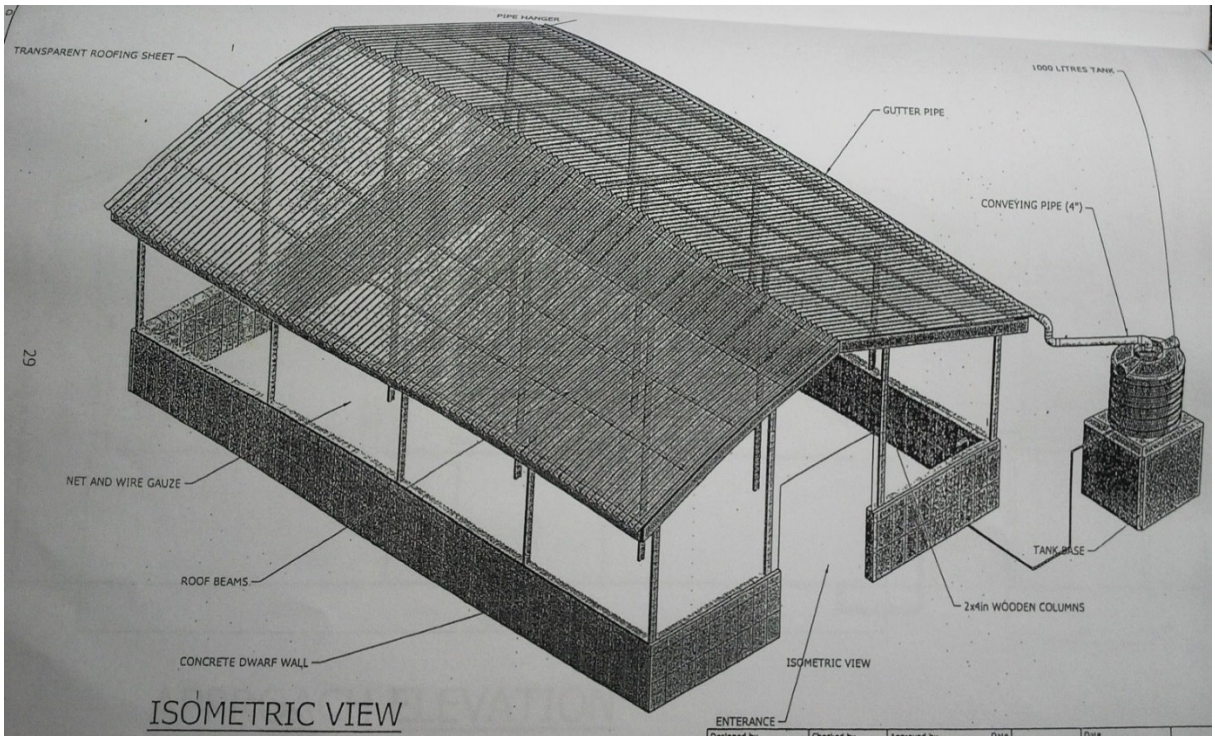

Fig. 2. The Isometric view of the green house constructed

**Rainwater Harvesting**

Rainwater from half of the roof area was collected and diverted to inside the greenhouse through a network of pipe system. Water from the roof was found to be flowing adequately into the greenhouse. Due to time limit, no crops were planted in the greenhouse. However, it was observed that with the facilities on ground, experiments could be conducted inside the greenhouse without shortage of water.

**Conclusion and Recommendation**

**Conclusion**

A greenhouse was constructed and water harvesting facilities put in place. It could be concluded that reasonable agricultural experiments could be conducted in the greenhouse without much fear of water shortage.

**Recommendation**

Based on findings of the work, the following recommendations are made

►The system should be put to use to determine how effective it could be

►An ideal greenhouse should be constructed and the results obtained in the two be compared. This will give adequate information on the usefulness or otherwise of the greenhouse.

►Necessary maintenance steps should be put in place to ensure the durability of the greenhouse.

**REFERENCES**

[1]. Abegunrin, T.P. (2004). The Design and Evaluation of an Appropriate Rainwater Harvesting Technology for Households in Ibadan. An Unpublished M.Sc. project Report. Department of Agricultural and Enviromental Engineering, Univeristy of Ibadan, Ibadan Nigeria.

[2]. Abegunrin, T.P. and Sangodoyin, A.Y. (2012). Gutter Projection, Roof and Gutter Slopes Effects on Rainwater Harvesting. International Journal of Engineering and Technology.

[3]. Abegunrin, T.P. (2012). Lecture Notes on Rural Water Supply and Sanitation, Agricultural Engineering Department, LAUTECH, Ogbomosho, Nigeria.

[4]. DTU (2003). ‘’Domestic Roof Water Harvesting Technology: A Publication of Development Technology Unit, School of Engineering, University of Warwick, UK’’

[5]. Faluyo, T. (2008). The Design of a Fibrocement Tank for Domestic Rainwater Storage in Ogbomosho, Oyo State. An Unpublished B.Tech. Project Report. Agricultural Engineering Department, Ladoke Akintola of Technology, Ogbomosho, Nigeria.

[6]. Lucas, E.B., Ogedengbe, K. and Abegunrin, T.P. (2005). Guttering system Design for Rainwater Harvesting Applicable for Ibadan Metropolies, Nigeria. LAUTECH. Journal of Engineering and Technology 3(2): 93-98.

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