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The Investigation of Rain Water Harvesting Technique and Use of Solar Power Pump

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Abstract:- Water is the most valuable resource which is available on the earth's surface, covering 2/3rd part of the total earth's surface. Human requires water for a variety of tasks in our daily lives, so life would not exist without it. As the world population is increasing day by day, the demand increases for quality drinking water. In a growing country like India, Nepal having scarcity of water sources, became a major problem due to the increase in the consumption of water. Besides this many coastal parts of Nepal and India are challenged by floods due to heavy rainfall during the monsoon season. Due to the increasing population, weather change, variation of rainfall within the country, and sudden disparity of metrological parameters like humidity, the surface, and sub-surface resources are constantly depleting in many countries. Hence its proper management could reduce problems due to shortage of water and food crises. So rainwater harvesting has proven to be one of the most cost-effective and environmentally friendly methods to overcome this problem, conserve the water for future use, and recharge groundwater. The RWH technique is used to resolve the problem of water scarcity problems during the non-monsoon season by storing 129.5m^3 in a year on the rooftop of the house. This initiative helps to utilize the water supply for household purposes, and agriculture and also will help in the recharge of the groundwater. There is greater chance that the rainwater might be contaminated by dust, floating substance, bacteria, and hazardous Chemicals that require treatment before usage. We have used slow sand filtration and solar technology methods to reduce pollution. This study aimed at designing a rooftop rainwater harvesting structure for a rural house in Dhangadhi Nepal. The roof of the house was chosen as the required catchment area for rainwater harvesting taking into the consideration of the water demand for household purposes. The necessary data such as catchment regions and average precipitation are gathered. In this paper selection of good rooftop materials, basic rooftop designing for rainwater harvesting, basic cost analysis, and solar power pump for lifting the water for future use have been done.

Keywords:- *Rooftop Rainwater Harvesting, Water Scarcity, Dhangadhi Nepal, Catchment, Cost Analysis, Solar Power Pump*

I. INTRODUCTION

➢ *Overview*

The phrase "rainwater harvesting" is frequently used to refer to all methods that utilize rainwater "close" to where it initially enters the land. The phrase has been used to describe methods of preventing floods, flood control measures, the creation of tiny reservoirs to collect run-off water for use in micro-irrigation or the care of livestock, as well as the collecting of run-off from roofs and other impermeable surfaces. Consequently, a subset of rainwater collecting is roof water harvesting. The primary components of RWH are the collection of water, stored in a tank, and following the use of harvested rainfall as a primary or secondary source of water.

Rooftop rainwater collection is a frequently utilized concept and technique. Concepts of aqua voltaic and agriculture have recently received a lot of attention. There are a lot of PV power plants around the globe, but as far as we are aware, no research has been done on how they gather rainwater. Although there are some agri-voltaic applications, the capacity of PV power plants is fast-rising worldwide. However, as far as we are aware, there has been no power plant-based research on rainwater collecting in these power plants. This research intends to provide the most practical and efficient production techniques for all PV power plants. Rainwater collecting 'may be a broadly utilized term covering all those strategies whereby rain is captured and utilized 'close' to where it begins to come to the soil. The term has been connected to courses of action to cause precipitation to permeate the ground instead of run off its surface, to shapes of surge control, to the development of little supplies to capture run-off water so that it can be utilized for cattle or micro-irrigation and to the collection of run-off from roofs and other impermeable surfaces. In this way, roof water gathering could be a subset of water harvesting.

Water gathering (RWH) fundamentally comprises of the collection, capacity and consequent utilize of captured water as either the vital or as a supplementary source of water.

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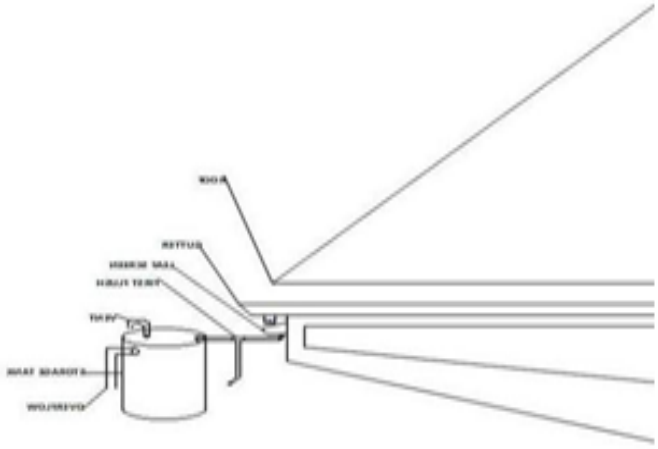

Fig 1 Rain Water Harvesting Setup

➢ *Justification*

Methods of Rain water Harvestings:

- Surface Runoff Harvesting: In order to collect rainwater for irrigation and other uses, surface runoff rainwater harvesting involves collecting rainwater that runs off the ground when it rains into a tank below the surface of the earth. Incorporating efficient and effective water conservation techniques, such as lowering evaporation, is crucial for storing rainwater. If utilized properly, this technology is incredibly simple to use and quite profitable. The major goals of surface runoff rainwater collecting are to fulfil the water demand that is always growing, to lessen water pollution, land erosion, and road floods.

- Roof top Harvestings: For the collection of water the main things is used is the roof of the house. With the different climatic conditions the structure of the roofs are different and the setup of the harvesting might be different. Rooftop Rain Water Harvesting is the technique through which rain water is captured from the roof catchments and stored in reservoirs. Harvested rain water can be stored in sub-surface ground water reservoir by adopting artificial recharge techniques to meet the household needs through storage in tanks.

➢ *Components of Rainwater Harvesting System*

- *Catchment*

The area under consideration for the take a look at have a massive roof area and large site area and consequently can harvest massive portions of rainwater. The rooftop regions of all homes, paved regions, and unpaved regions are measured. This dimension turned into finished manually with the assistance of 'reinforced fiber tape' that's the most effective approach recognized as 'tape survey'. Before the use of the tape, the tape was checked for any 0 mistakes additionally for accuracy the length of the tape should be carefully checked.

- *Roof and Tanks*

Ferro-cement jar or tanks starting from 2,000 to 20,000 litre potential are built at family stage and in faculties relying at the requirement. There are numerous varieties of tanks which includes Ferro-cement tank, stone masonry tank, brick masonry tank, RCC tank and GI sheets tank also are utilized in exercise for RWH in Nepal in each rural and concrete settings, however Ferro-cement jarsare inexpensive than different tank alternatives withinside the rural regions.

Fig 2 Catchment in Roof and Tank

- Gutters and Inlet Pipes

Bamboo or wooden or HDPE (high-density polyethylene) pipe for gutter, first flush and delivery pipe from roof to tank withinside the rural regions. In city regions use PVC and GI sheets for gutters, and PVC pipes and fittings for first flush and shipping pipes.

- *First-Flushing*

A first flush tool is a plug that guarantees that runoff from the primary spell of rain is flushed out and does not input the system. This needs to be finished because the first spell of rain includes an exceedingly large quantity of pollution from the air and catchment floor.

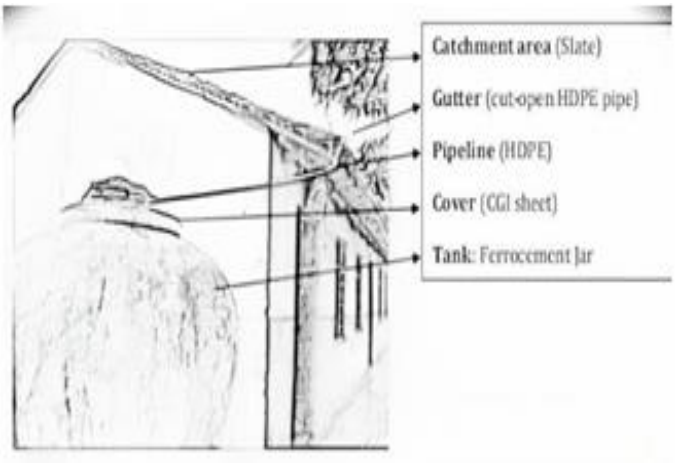

Fig 3 Gutter, Pipeline, and Tank

- *Washout and Overflow*

Washout system flushes sediments and different remnants from the bottom of the tank. An overflow pipe is also had to manage the water stage and take away the extra water.

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- *Water Delivery Tap*

For the family use, a faucet is at once linked to the tank and for faculty use a separate faucet stand is built in an to be had area connecting it to the rain water series jar.

- *Solar PV Setup*

The arrangements of solar PV setup is installed in the roof of the house where the energy in the form of radiation is collected in the PV cells further helps to charge the battery which going to be help for pumping of water from bottom reservoir to top reservoir. The overall energy stored firstly used to store it in battery then the remaining energy after completion charging goes to operate the pump.

II. LITERATURE REVIEW

- Seyfi şevik, (2021): The author explain and study about the rain water harvesting technique and done a project on solar power plants with in the large area. The project basically helps for the irrigation and the drinking water problems for the place. They use the rain water which are falling in the panels by giving suitable path for storing in the tanks and excessive in the ground discharge.
- J.R.Julius, (2013): Most Quick and efficient managing of water resources and concept of using of water resources recharging the ground water and utilization of harvested water. Recharged to ground through recharge pits, dug wells, bore wells, soak pits, recharge trenches, etc.
- Mohammad Abdullah Al Mamun, (2020): Water purification done with the laboratories where the testing of water is done on the purification, filtration, etc. The Lab testing is basically done on chemical, minerals and microbiology.
- Abhijeet Keskar, (2016): Groundwater table recharge is a slow process; we cannot quickly raise the groundwater level after building recharge structures. However, we may contribute to aquifer recharge by building any sort of recharge structure. As a result, the declining ground water supplies will be revitalized. Additionally, contribute to saving the meagre amount of rainwater that for a long time was lost to drainage. The deployment of the RWH system at the Government College of Engineering Aurangabad (GECA) campus is thus considered to be the optimum strategy for addressing the current water scarcity situation and for storing a sizable volume of 53,96,816 litres annually on the college campus.
- Adil Ahmad Khan, (2016): The necessity for and solution for rainwater harvesting in the Indira puram neighborhood of Ghaziabad are described in area in this study. In addition to helping with flood management, rainwater collection also helps with pollution control and continuous water supply.
- Dr. Sanjiv Bickram Rana, Executive Director, and Kathmandu Valley Water Supply Management Board, (2016): The statistics produced by Kathmandu Upatyaka Khanepani Limited (KUKL), which depicts a vast difference in water demand and supply and has led to a higher reliance on groundwater, were the main topic of Dr. Rana's presentation. They highlight the sad reality of water shortage. Rapid economic growth and a significant influx of city people make this worse. Rainwater harvesting (RWH), the investigation and confirmation of data for the shallow and deep aquifers separately, and the establishment of essential rules are all likely answers for sustainable groundwater management.
- Mr. Andy Prakash Bhatta, President, and Nepal Hydrogeological Association, (2014): Mr. Bhatta berated the government's approach to formulating policies. The creation of project-specific policies makes it difficult to execute groundwater policy. He requested swift action by the Department of Irrigation (DoI) and the Department of Water Supply, the two key government agencies involved in groundwater management, in order to manage and utilise groundwater resources sustainably. He continued by saying that the media is essential for spreading information. He argued that groundwater extraction should be given priority by the organization in charge of gathering data on the existing wells, bore holes, and deep delving.
- Dr. Dhiraj Pradhananga, SEN and C4H-Usask, (2016): Dr. Dhiraj Pradhananga highlighted the results of his study on the Canadian Rockies' Cold Region Hydrology, demonstrating how the Cold Region Hydrological Modelling (CHRM) Platform may be used in the Nepal Himalayas. Dr. Pradhananga gave a quick overview of the research and communication tools available. And shared the SEN's operational mode.
- Gurung and Sharma (2019): In this study, rainwater collection is offered as a feasible substitute for meeting a transportation logistics company's entire (100%) water need. Implementing the rainwater harvesting system will not only help reduce the amount of water used from the public network but will also result in significant financial savings for the business and the operator of the public water system, demonstrating that rainwater harvesting is a viable and dependable strategy for uses other than the typical urban and commercial ones. Such a plan becomes financially feasible, and the investment can be repaid in just 5 years**.**
- Harshwardhan Sharma (2021): Groundwater table recharge is a gradual process; we cannot instantly raise the groundwater level by building any form of recharge structure. We are able to contribute to the aquifer recharge structure. As a result, the declining ground water resources will be revitalised. It contribute to saving the meagre amount of rainwater that for a long time was lost to drainage. The adoption of the RWH system at JIET JODHPUR campus is therefore considered to be the optimum strategy for addressing the current water scarcity situation and for storing a sizable volume of 4,97,654.4 litres annually on college.
- Anzecc & Armcanz (2020): A purpose-built sophisticated water balance model based on a variable time-step, a conservative spill-supply sequence, and application of established methods for evaluating the environmental benefits of WSUD installations were used to simulate a hypothetical assessment of various configurations of dual-duty RWTs. The model's parameters were taken from typical home settings seen throughout Australia, and simulated outcomes were

confirmed by independent research. By acquiring measurements of pluviographs and daily maximum temperatures that reflect climatic conditions in all capital cities, the climatic variation in Australia was taken into account. The findings suggest that RWTs have the ability to dramatically boost environmental benefits by restoring natural urban stream hydrology without materially impacting supplemental city water supply.

- Jyotiba B.Gurav and D.G. Regulwal, (2013): Groundwater table recharge is a gradual process; we cannot quickly raise the groundwater level after building recharge structures. However, we can contribute to aquifer recharge by building any sort of recharge structure. As a result, the declining ground water resources will be revitalised. Additionally, contribute to saving the meagre amount of rainwater that for a long time was lost to drainage. The implementation of the RWH system at the Government College of Engineering Aurangabad (GECA) campus is therefore considered to be the optimum strategy for addressing the current water scarcity situation and for storing a sizable volume of 53,96,816 litres annually on the college campus.
- Abdulla FA, Al-Shareef AW, (2009): Construction of rainwater collecting tanks must follow the specifications of the SamSam rainwater harvesting model (tables 1 and 2). In order to lower population density and boost rainwater collection for less consumption, new developments must increase the minimum sizes of plots.

- *Study Area*

Dhangadhi is located in the district of Kailali in Sudurpaschim state in Nepal. It is densely populated due to being a Sub-Metropolitan City. It is the first Sub-Metropolitan City in the district of Kailali. During the months of monsoon from June to September, the condition of the weather in Nepal is generally humid and wet. The rainfall is heavy during this season in this area. The weather is enjoyable & comfortable in October & November month.

Taranagar is the place where lots of greenery is available and heavy rainfall seems there. Mainly the study of the rainfall and harvesting technique is done in the monsoon weather. The area contains the trees, two wells, and one rivulet. The technique that we are purposing is helped by Sub-Metropolitan city and data collection helped by Weather Forecasting Dhangadhi.

Fig 4 Taranagar, Kailali Dhangadhi
(Source: www.googlemap.com)

III. OBJECTIVES AND METHODOLOGY

➢ *Objectives*

- To estimate the water quantity to be harvested.
- To design the setup of the water harvesting unit.
- To identify economical items for constructing the reservoir and solar power for pumping.

➢ *Methodology*

The Rain Water Harvesting technique have mainly Five parts i.e. Catchment area, Roof and tanks, Reservoir, Solar PV panels, Pumps and Taps Distribution. Firstly the rain fall acts on the catchment area with a certain force. The falling water have tilted on the inclined way for going under the gutters. Gutters have the property to catch the water falling from the Catchment Area. The water flowing in the gutters joined with the inlet pipes which allow the falling water to collect on the Tanks which is made up of Ferro cement lies in the grounds. The Tanks allows the water to collect on it and become to filtration process where filtration made up of stone, pebbles and sand is present.

The solar PV panels is situated in the height to capture the solar radiation from the sun for producing the electricity. The produced electricity helps to charge the Heavy battery which allows the pumping the water from filtrated water tank to the top situated tanks. After completion of charging the battery they gained solar power directly helps to pump the water.

In the calculation part of the projects firstly the area of the roof is calculated and allows to know the Discharge of water. The discharge allows to find the diameter of pipe according to the requirement in the project. After collecting the water the total usable water is calculated for Drinking, Washing, Bathing and Irrigation.

The estimation of money is done according to the requirement in the pipe quality, reservoir quality and the filtration quality.

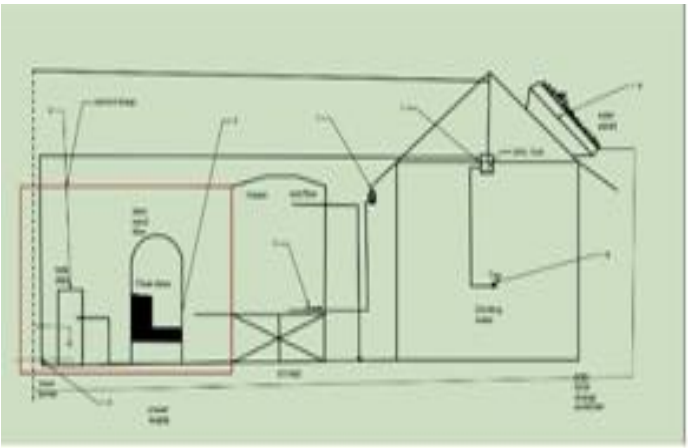

Fig 5 Rainwater Harvesting System with Solar Power

The overall Methodology having the flowchart which shows the stepwise doing of projects. The following are the steps for the Rooftop Rainwater Harvesting Technique:

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Fig 6 Methodology of the Rainwater Harvesting

- *Determination of the Catchment Area*

The house that we are doing the experiment is inclined type where the area differs on it compare to the flat roofs. The area is calculated by taking the length and breadth in which estimation is done for the proper rainfall.

- *Estimating the average rainfall*

With the help of weather forecast and Environmental Protection Office we can find the average rainfall in the particular areas. The average rainfall also calculated by the experimental way by taking the reservoir and the Collecting area.

- *Calculation of Discharge*

The rain is falling on the roof which allows to water to fall on the gutter which is attached in the edge of the roofs, For the amount of water falling in the area allows to find the discharge of water from gutter to inlet pipes. Discharge makes us to know the amount of water falling and calculating the volume needed for the reservoir.

- *Estimating reservoir required*

The water discharge is the main factors effects on the estimation of reservoir requirement. The average rain fall and heavy rainfall both should get into mind for the reservoir. Firstly according to the maximum discharge in the June/July months the reservoir get designed.

- *Using Solar Power for Pumping*

The PV apparatus is kept on the roof of the house which allows the body to collect radiation from sun further produce the electricity. The produced electricity get charge the battery and battery is used for the pumping the water from ground reservoir to top reservoir. After completion of charging the battery the remaining energy is directly connected to the pumps in the day time. The battery using in the project is enough for the pumping and Solar Panel is also a heavy in Nature.

- *Calculating the overall use of water in family*

After finishing the pumping the water get collected in roof situated tanks which allows for the filtration of water for using in the drinking, washing, etc. How much amount of water is usable for each members use for drinking, bathing, washing etc. For getting the estimation of that requirement is matched or not is calculated. If the requirement is fulfilled the water harvesting is more than the.

- *Cost Estimating and the Result Analysis*

The price of the gutter, inlet pipe, cement for making Reservoir and the filtration is done in the section of cost estimating. For the result prospective the cheapest estimating, material procurement should cheap, Zero labour charge and using of Ferro cement play the main role on the method of completion of project.

IV. CALCULATIONS

➢ *Determination of Capacity of Rainwater Harvesting*

In order to calculate the potential of rainwater harvesting we have to determine the rooftop area of the relative structure (rural house). And then surface runoff has been calculated based on the rooftop area.

The equation used is given below. The potential of rainwater harvesting has been calculate by multiplying the average annual rainfall of that place, the area of the roof top & runoff coefficient whose value is given in the code book.

- The capacity of RWH in each structure= R*A*C
- Where,
- A= rooftop area in square meter
- R= annual average rainfall of the given place
- C= runoff coefficient (whose value ranges between 0.8-0.95) from 15797:2008
- Water demand, D= N*Q*D
- Where,
- N= occupants number
- Q= daily water demand of per person in m/day; &
- D= days
- Losses of water due to evaporation is negligible.
- According to is 1172 the average per capita demand for one person is 135 lpd. The break-up is as follows:
- Water required for Bathing: 55 lt (liters)

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- Water required for flushing the toilet: 30 lt
- Water required for clothes washing purpose: 20 lt
- Water required for cleaning the interior area of house: 10 lt
- Water required for utensils washing: 10 lt
- Water required for cooking foods: 5 lt
- Water required for drinking purpose: 5 lt

➢ *For the Rural House:*

- C= 0.9
- R= 177.77mm/d
- A= 70 square meter
- Capacity of RWH for the rural house = A*R*C
- (70×177.77× 0.9)/1000
- 11.2 m^3/d
- =11200 liter/d

➢ *The Demand of Water in the House for Different Purposes*

For the six people, the total amount of water required for a different purpose is calculated below

- *Water Required for Drinking*

✓ Drinking water for one person= 5 l/p/d
✓ So, Drinking water for 6 persons = 5×6 =30 litter per day

- *Water Required for Cooking the Foods Item*

✓ Cooking purpose for one person= 5 l/p/d
✓ Cooking purpose for 6 persons = 5×6 = 30 litter per day

- *Water Required for Clothes Washing*

✓ Washing Clothes purpose for one person= 20 l/p/d
✓ Washing Clothes purpose for 6 persons = 20×6 =120 litter per day

- *Water Required for Bathing Including the Ablution*

✓ Bathing purpose for one person= 55 l/p/d
✓ Bathing purpose for 6 persons = 55×6 = 320 litter per day

- *Water Required for Utensils Washing*

✓ Washing Utensils purpose for one person= 10 l/p/d
✓ Washing Utensils purpose for 6 persons = 10×6= 60 litter per day

- *Water Required for Cleaning House*

✓ Cleaning House purpose = 10 l/p/d

- *Water Required for Flushing The Toilet*

✓ Toilet Flushing purpose for one person= 30 l/p/d
✓ Toilet Flushing purpose for 6 persons =30×6=180 litter per day

- **Total Water demand** =750 liter/d
- **Potential of Rooftop Rainwater Harvesting System =** 11200 liter/day
- **Percentage of water that fulfilled the demand** = (750/11200)*100 =6.69%
- *Determination of Discharge Value*

In order to calculate the required diameter of the gutter to carry the rainwater the calculation of discharge is required, so firstly, we have calculated the discharge Q by using the formula given below:-

✓ Q = C*I*A

✓ Where Q= Amount of water discharge from the area of the rooftop due to rainfall in (m3 /s)

✓ C= Runoff coefficient whose value is taken as 0.9 from the code book

✓ In this case the term I= Rainfall intensity in term of mm/hr i.e.28mm/hr.

✓ A= Catchment area, meter square

✓ Q= (0.9*28*70)/ (1000*60)

✓ =0.029 m^3/min

✓ =29 liter/min

➢ *According to the IS Code 15797:2008*

From table 1 water availability for sloping roof

Table 1 Rainfall Water Availability in Sloping Roof

Rainfall(mm)	Water availability
100	6.7
200	13.3
177.77	x

- *From Interpolation*

✓ (200-100)/ (13.3-6.7) = (177.77-100)/(x-

✓ 6.7)
✓ X=11.83m^3/month

✓ =142 m^3/year

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➢ *Table 2 for the Diameter of the Gutter (D) and Width (W) of G.I.Sheet*

Table 2 Determination of Diameter and width

Rainfall(mm/hr)	Water
	availability
25	58(D)
	111(W)
30	62(D)
	117(W)
28	X
	y

- (30-25)/ (62-58) = (28-25)/(x-58)
- X=60.4mm
- (30-25)/ (117-111) = (28-25)/(x-111)
- Y=114.6mm

V. RESULTS

The technique of rainwater harvesting is implemented in the area of Taranagar, dhangadhi, Nepal. We have taken a traditional house with having slope roof and an area of about 70m^2. The potential of rooftop rainwater harvesting has been calculated further goes for the total water demand in the family having 6 members. The total water demand for a family per day is 750 liters and the harvested water is calculated as 11200 liters per day. so about 7% of the water has been utilized and the remaining is used for irrigation purposes and is stored in an overhead tank with the help of a solar pumping system if needed the water can be stored near the well and later it can be utilized for household purposes.

VI. CONCLUSION

We are looking at options that are cost-effective, dependable, and sustainable in order to optimize the use of water. Harvesting rainwater appeared to be a possible supply source. The long-term solutions to the issue of water scarcity are provided through rainwater harvesting. Rainwater harvesting is a distinctive method since it offers advantages in terms of both cost and water supply.

This study was aimed at designing a rooftop rainwater harvesting structure for rural house located in village of dhangadhi. This will help in fulfilling daily water demand of the house in addition to this supply to the agricultural land and artificial recharge of groundwater in this area. In addition to this, the different parts which is required for managing the rainwater in the RWH system were designed on the basis of guidelines given in the code book and other standard guidelines. From the analysis and calculation, it was observed that the application of a rainwater harvesting system can resolve the problems like water scarcity during the non-monsoon season by storing water in a huge quantity of about 1200 liters of water daily. This inventiveness can rise the water supply for gardening, and watering agricultural land and also will help in the recharge of groundwater thus increasing both the surface and the groundwater resources.

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