.

RAINWATER HARVESTING AND ITS EFFECTIVE USE WITH MODEL DESIGN

By:

PA 53597 Capt M. Haris Sharif

PA 53573 Capt M. Osama Zahid

PA 53010 Capt Faizan Khan

PA 53492 Capt Talal Anwar Rind

PA 53107 Capt Hamza Hussain Wyne

PA 53179 Capt M. Umer Farooq

Project advisor

Lecturer Muhammad Ukasha

Military College Of Engineering Risalpur

National University Of Science And Technology

Islamabad Pakistan


بسم الله الرحمن الرحيم

This is to certify that

thesis entitled

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Has been accepted towards the partial fulfillment of the requirements for

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Lec Muhammad Ukasha

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Dedication

To our esteemed parents and beloved teachers.

“We can never forget when we took our first step into this world and you not only hold our hands with extreme compassion and affection but also give us the right direction to achieve success.”

Acknowledgements

We humbled our heads in front of Allah Almighty, the most Gracious and Merciful for completing this research. He blessed us with such blessings, which makes words unable to deliver justice and sometimes makes us beyond our reach. He ignored our sins and shortcomings, led us on the road of knowledge and wisdom, and explored our unfamiliar horizons and boundaries.

We are very grateful to our parents for their countless prayers and endless support. They have been and will always be our strength and the source of our continuous motivation and encouragement.

We are convinced that just mentioning Lecturer Muhammad Ukasha of our Advisor cannot express our gratitude for his guidance and support. His easy-going and interesting attitude makes our work much easier, and the constant demand for quality work makes us harder than ever.

We also thank Assistant Dr. Arshad for his guidance and supervision in the early stages of the project to push the project to its current state.

Abstract

Water is life and is necessary for all life forms on earth. The world population is increasing rapidly. On the contrary, basic facilities are not suitable for the large population of the world. 1.5 billion people in the world lack facilities for clean water. Pakistan is one of the countries where the water crisis is imminent. In order to provide water in places where it is difficult to provide rivers or groundwater, there is a simple and comprehensive solution, namely rainwater harvesting (RWH). RWH can be used for many reasons, from drinking to domestic use, irrigation purposes, livestock and groundwater supplementation. The goal of our project is to develop a comprehensive plan for RWH that ordinary citizens can easily follow and will help meet their needs and can be used for income-generating activities.

CONTENTS

INTRODUCTION

Water is a precondition for human existence and sustainability of planet, availability of which plays a crucial role for the climate, food security and daily household needs . All civilizations have flourished on the basis of adequate water supply, and this stands true even today. The arrangement of drinking water with a working sterilization system is the most important necessity for a sound life. In metropolitan regions, the populace is expanding, and the availability of sufficient water supply accomplishment of daily needs is possibly the most challenging difficulty confronted by policymakers. To meet the most suitable option with regards to the supportable administration of unadulterated water, there are two arrangements: utilize a brought together strategy to discover elective or extra water assets; or utilize a restricted measure of water in the most appropriate manner. Among the different advances for expanding water assets, the assortment and use of water might be a decentralized technique that can stay away from a few natural issues normally brought about by regular enormous scope projects that utilization concentrated strategies.

In different parts of the world, water supplies and such constructions have taken different shapes in different eras. Rainwater is collected because it flows from roofs, grounds, sidewalks, yards or specially prepared structural areas. About 4000 years ago, rainwater was first used for domestic purposes in developed areas. Roman plans to use rainwater to supply drinking water. In the hills near the metropolis of the Republic of India, the first Buddhist monastery's cell has a series of intricate drainage ditches and cisterns that cut into the rocks to produce water for domestic use throughout the year.

Rainwater harvesting means capturing rainwater falling everywhere or capturing runoff in farms, villages or cities, and taking measures to store the water and keep it clean.

In 1950, Geddes started modern water withdrawal analysis in Australia. As cited by Myers (1975), Geddes gave the first definition of water harvesting: "Rainwater is collected and stored by runoff or small streams for irrigation use"

In other words, this is a strategy for collecting and storing runoff from many sources and fulfilling various functions. The strategy adopted depends heavily on local conditions and includes a variety of practices such as cultivating terraced beds, planting trees in small catchments, excavating underground runoff, and storing runoff behind dams.

Particularly in rustic regions in Europe and Asia, water collecting is generally utilized for water supply. In any case, any place funneled water supply is given, the significance of water as a water source has decreased.

Water is the lone homegrown water utilized on some tropical islands. In parched and semi-dry regions, where individuals live essentially in dispersed or unsettled settlements, water collecting might be a fundamental methods for giving water to family works. This is generally particularly obvious when groundwater assets are hard to acquire or costly to create. In some agricultural nations, water is utilized to enhance channeled water supply frameworks.

All these methods have the following common features:

- They are used in arid and semi-arid areas with intermittent runoff characteristics. Surface runoff occurs as a separate event, and groundwater may flow for part of the year and stop flowing throughout the drought. Due to changes in flow, water storage is an indispensable part of water collection.
- In terms of area, warehousing and investment, they are smaller companies (Myers 1964). This may be the logical result of two different characteristics of intermittent flow and natural water.

Rainwater harvesting is outlined as a technology used to induce, collect, store and protect agricultural surface runoff in arid and semi-arid region

1.1 World Statistics

Since 1950, the world's population has doubled, and by 2001 it exceeded 5.25 billion. The recent population projections of the United Nations indicate that with a moderate fertility rate, by 2050, the value of the world's population may be about 8.9 billion.

Alongside these segment changes, the populace has gone through significant changes since people are as yet relocating from rustic to metropolitan regions looking for work. The numeration of individuals living in metropolitan regions has bounced from 750 million of year 1950 to about 2.93 billion in 2001. As of now, consistently through the movement from country to metropolitan, the regular development among urban communities and the progress from provincial to metropolitan. By 2025, the absolute metropolitan populace is relied upon to surpass 5 billion, and 90% of this expansion is required to happen in non-industrial nations. 60% of the worldwide populace lives in Asia. The yearly development pace of Asian urban communities is 2.7%, which is 27% higher than the world normal. By 2010, Asia's populace living in metropolitan regions is relied upon to reach 43.0%, representing 50.8% of the worldwide metropolitan populace. It is assessed that by 2020, the number of inhabitants in Asian urban communities will twofold. By 2025, the majority of the populace in this space may live in urban areas (*UNDP* **|** *United Nations Development Program*, 2021).

1.2 Water Crisis around the Globe

Rapid growth, coupled with industrialization and unfamiliarity with water-saving lifestyles, has led to water problems worldwide. In 2000, about 1.1 billion people (about one-fifth) of the world had no safe drinking water. 65% of the population in Asia does not have safe water, and 28% of the population in Africa does not have safe water. All through the 1990s, there have been some turns of events: around 438 million individuals in non-industrial nations approach safe water, yet because of the quick increment, the quantity of metropolitan inhabitants without admittance to safe water has expanded by almost 62 million. Declining groundwater levels are normal and cause major issues, every one of which prompts water deficiencies and salt considerations in waterfront regions. Severe metal pollution in rivers, lakes and reservoirs is a major problem worldwide. The global supply of fresh water cannot be doubled. Like food security, water security is becoming a serious national and regional priority in several regions of this planet.

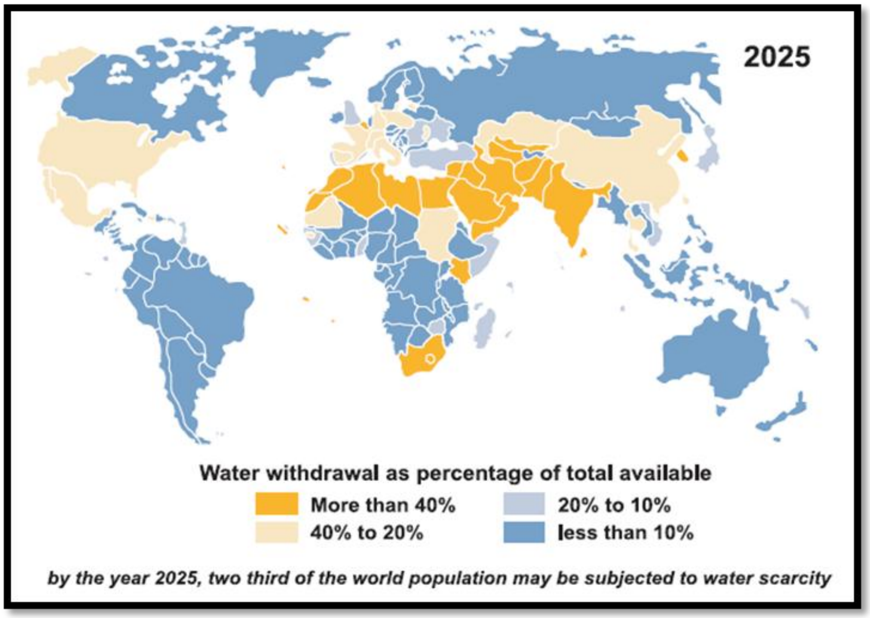

Fig 1.1 Water Withdrawal As Per Total Percentage

the Islamic Republic of Pakistan, the greater part of Karachi's (12 million) inhabitants live in katchi abadis, which gives water to half of the local area. In Faisalabad, Pakistan, around 66% of the city's 2 million occupants live in most underserved regions. The greater percentage of individuals lack sterilized and fresh drinking water. In Kolkata, India, most of the individuals living in ghettos or shanty towns draw water from the stands. The excess ghetto populace can't utilize city offices and need to build up their own plans for instance, depending close by siphons/siphoning water from tube wells. In Bangalore, Republic of India, a town with around 6 million occupants, it is assessed that the greater part of them depend on open wellsprings. Almost 33% of the populace can't utilize a piece of the faucet water or no faucet water by any means. It is assessed that in Dhaka, Bangladesh, there were 2.5 million individuals in the "ghetto" region in 2002, the vast majority of whom had genuine deficiencies of water and sterilization offices. A huge number of kids kick the bucket of water-borne sicknesses and water contamination in Dhaka consistently. Just in Kampala (Uganda), occupants of prosperous and center pay regions in the focal and local locations can keep up non-public connections with the Public Water and Wastewater Treatment Company. The greater part of the populace in the capital of (Kenya) relies upon standpipe providers for water. In the capital (Peru), there are very nearly 2,000,000 occupants with no offices, and the nature of faucet water for thirty minutes (1996) is dicey. The water deficiency in Tegucigalpa (Honduras) is especially genuine on the grounds that there isn't even sufficient water to supply clients who as of now have a civil water supply framework. Moreover, as indicated by the 2001 statistics, the number of inhabitants in India was 10702 million. Over 60% of families in the Republic of India use groundwater, for example, hand siphons, tube wells and water wells to meet their drinking needs. In metropolitan regions, 68.7% of families use water, and 29% of families straightforwardly utilize these groundwater assets. The inescapable utilization of well water has prompted the consumption of underground water assets in most parts of the world.

1.3 Water Preservation Techniques

If we take the following practices in our lives, we can alleviate the water shortage problem

Some techniques that can be very useful are

- Water reuse
- Irrigation
- Behavior
- Rainwater harvesting

1.3.1 Water Reuse and Recycling

Recycled water reuse is the utilization of wastewater or recycled water from one application (like metropolitan wastewater treatment) for another application, (for example, scene water). The reused water should be utilized for gainful purposes and consent to material guidelines. Some possible applications for wastewater or recycled water reuse incorporate other modern uses, scene water system, farming water system, stylish utilizations (like wellsprings), and fire security. The elements that ought to be considered in the mechanical water reuse plan generally rely upon the kind of industry.

1.3.2 Irrigation

Water-saving practices can be separated into three classes: field rehearses, the board methodologies and framework alterations. Field practice alludes to strategies that keep water in the field, appropriate water all the more viably in the field, or empower the maintenance of soil dampness. Instances of these practices incorporate burrowing very thick soil, trenches to forestall spillover, and evening out the ground to circulate water all the more uniformly. Generally, the expense of on location practice isn't high.

The executive’s procedures incorporate observing the state of soil and water and gathering data about water use and effectiveness. This data helps settle on choices about booking applications or improving water system framework proficiency. These techniques incorporate estimating precipitation, deciding soil dampness, checking siphon productivity, and booking water system.

Framework adjustment requires changing the current water system framework or supplanting the current framework with another water system framework. Since framework alterations require the acquisition of gear, they are normally more costly than field practices and the board systems. Common framework alterations incorporate adding downpipes to the focal turn framework, retrofitting wells with more modest siphons, introducing flood water system or building water recuperation frameworks.

1.3.3 Behavioral Practices

Social propensities include changing water utilization propensities to utilize water all the more productively, accordingly lessening the complete water utilization of the family. These practices require changes in conduct without adjusting existing pipes or installations in the house. The conduct propensities for private water clients can be applied to the kitchen, restroom, pantry and outside.

For instance, in a kitchen, just pursuing the dishwasher is loaded up with water can save 10 to 20 gallons of water each day. In the event that you wash the dishes by hand, you can save water by filling the sink or dishes with water as opposed to running water ceaselessly. A customary fixture that is opened permits around 5 gallons of water to move through at regular intervals.

By turning off the faucet when brushing or shaving, you can save water in the bathroom. You can save water by taking a short shower instead of a long shower or bathtub and turning off the water during soaping. As mentioned earlier, the water saving effect can be further improved by installing a low-flow shower head. The toilet should only be used to take away sanitary garbage.

Families with toxic weld in their lines should flush the initial not many gallons of water and gather this water for other non-consumable employments *(Zagelow & Publishing, 2014*).

1.3.4 Rainwater harvesting

Rainwater harvesting can be very effective in controlling the reduction in water volume because it contains few impurities and can be effectively used for many purposes (from irrigation to drinking).

1.4 Functions of rainwater harvesting

Rain harvesting has many functions:

• Supply water for individuals and livestock

•Provide water for cash crops

• Increase groundwater recharge

•Reduce rainwater discharge, urban flooding and overload of sewage treatment plants

• Reduce the ingress of seawater in coastal areas.

In countries where the intensity of rain is so strong that it rains heavily, rainwater collection may be the supply of domestic water. It needs adequate facilities to intercept, collect and store water. Food security is additionally a significant issue in nations where populace pressure is expanding and food creation is declining. In addition to other things, the justification the decrease in rural creation is helpless administration of soil richness. Sped up misfortune will prompt soil misfortune and decreased soil dampness maintenance. There is a pressing need to forestall the slow corruption of soil through more and better water gathering frameworks. In the event that water overflow is controlled and kept in the catchment framework, it tends to be utilized to improve water and food security.

The principle reason for gathering water is to drop water here as precipitation simultaneously to shield the land from disintegration. Through countless specialized and vegetative measures, water might be postponed headed to the standard of normal sorrows and diverted to supply a progression of land and water catchment structures at different levels, and supplement the groundwater table. Thusly, it has exceptional mindfulness (environmental, money related and political importance) in advancing local area and family based water gathering frameworks

Where there is no surface water, or where the groundwater is deep or inaccessible due to hard ground conditions, or where salt, acid, or other unpleasant or unsuitable places for drinking, you should seek another supply. Rain will provide much of the cleanest natural water anywhere. The latest technology for drinking is related to the extraction of surface water and groundwater. However, these sources account for less than one-fortieth of the total precipitation. Therefore, it is obvious that once rainwater falls, the scope of rainwater collection expands before huge losses due to evaporation and transpiration, and before being polluted by natural means or artificial activities.

1.5 Benefits of rainwater harvesting

Rainwater harvesting can solve the problem of water shortage for a long time. In areas with abundant rainwater, insufficient well water supply, or insufficient or insufficient surface water resources, rainwater harvesting provides an ideal solution. In rocky regions, people, vegetation and creatures may utilize water. The water gathering framework is especially valuable in distant and tough territory in light of its capacity to work freely. The entire strategy is harmless to the ecosystem. Water benefits the local area from various perspectives. Water assortment can monetarily gather and store water, making water simple to get and supplanting low quality water. Catchment assists with taking out changes in water accessibility by classifying water and putting away it all the more rapidly in repositories or sandy stream beds. In this interaction, water assortment can guarantee continuous and solid admittance to water.

Catchment gives an elective inventory of great (water is the most financially savvy crude water) occasionally or consistently. This might be identified with regions where groundwater or surface water is tainted with hurtful synthetic substances or undesirable microorganisms or pesticides, as well as is additionally significant in regions with pungent surface water. The water assortment framework can be either close to home or local area/utility activity and the executives.

Compared with alternative technologies that increase water resources, rainwater collected in multiple ways has less negative impact on the environment. The nature of rainwater is sometimes better than that of contaminated well water. Rainwater is relatively clean, and the quality of several functions that have been treated with little or no treatment is usually acceptable. Rainwater harvesting technology has a wide range of uses and can meet almost all needs. Construction, operation and maintenance are not labor-intensive. The prediction of global warming may severely affect the water demand of several cities. At the same time, the evaporation of the reservoir has increased, and the flow of water in some areas has decreased, which may reduce the local water supply *(Zagelow & Publishing, 2014)*.

The job of water collecting framework as beneficial water, reinforcement water or crisis water framework may turn out to be more important, particularly thinking about the changing environment and the regular danger of dry spell and flooding in specific regions. This might be especially the situation in regions where there is expanding tension on existing water assets.

In urban areas, the scarcity of water and increasing demand are a major drawback. The formation of the bottom can be expanded by using many existing structures such as roofs, parking spaces, playgrounds, parks, ponds, floodplains, etc. Rainfall is used to reduce rainfall; as the water level rises by one meter, the electricity used to transport the bottom water is saved, thereby saving 0.40 kW-hr of electricity. After that, it can even reduce rainwater discharge load and flooding on city streets.

With the development of future cities, such problems may become more and more common. Air pollution is still a serious limiting factor because it pollutes rainwater and building surfaces at the same time bringing about water that isn't reasonable for savoring various urban communities all throughout the planet. By the by, water will in any case be utilized for non-consumable water purposes, for example, restroom washing, clothing and farming.

In addition, the use of more rainwater in urban areas in the future may greatly enhance the function of the hall to completely clean the urban atmosphere.

To put it bluntly, rainwater harvesting can be used to:

- Improve groundwater quality
- To rise water level among wells
- Mitigating the consequences of drought and gaining drought resistance
- Reduce erosion because it reduces surface runoff
- Reduce rainwater discharge and blockage of road flooding
- Save energy to transport groundwater.

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1.6 The Growing world Interest in rainwater harvesting

In the first half of this century, with the recent development of "conventional" facility systems, some traditional water sources are no longer favored. This is the case with rainwater harvesting technology, which was later considered to be a last resort, and rainwater extraction is considered appropriate to ensure that it is uneconomical to use meshed water supply in extreme conditions such as coral islands or remote farms.

However, the situation has changed since the 1980s. With the support and support of enlightened governments and donor agencies, many grassroots initiatives have promoted and implemented rainwater harvesting techniques. This is partly a response to the growing technical utility of using roof structure systems in the south, because roof materials in cities are similar to those in rural areas and are impermeable. The paradigm shift in the world’s attitude towards the environment and the increasing recognition that water use must become more sustainable have also inspired its development.

In 1979, UNEP charged a progression of local contextual analyses on rustic water and water gathering. These incorporate works from China, India, Mexico, the US, Africa, Australia and the Pacific. This is the first occasion when that a worldwide synopsis of this innovation experience has been distributed in a distribution. Soon thereafter, Pacey and Cullis (1986) offered another and even more important overview. At the same time, UNICEF, many bilateral donor agencies and many non-governmental organizations are promoting the employment of unit roof structure storage tanks in geographic areas and are committed to developing a variety of low-cost models in the Republic of Kenya. This work was done directly by the community team, which led to the rapid adoption of rooftop storage tanks in rural communities.

1.7 From where we can Harvest Rainwater

Rainwater can be collected from the subsequent surfaces:

Rooftops

If there are already buildings with impervious roofs, drainage areas can be effectively provided for free, and replenishment can be provided at the time of consumption.

Areas that are Paved or Unpaved

Streets and walkways and other open regions might be utilized adequately to gather water. The benefit of utilizing the ground as an assortment surface is that water can be gathered from a bigger space. This is generally profitable in low precipitation regions.

Water bodies

Water bodies like lakes, tanks and lakes have tremendous potential for putting away water. The gathered water can be utilized not exclusively to satisfy the water need of the city, yet additionally to be utilized around there. It likewise recharges groundwater springs.

COLLECTION OF RAINWATER AND FILTRATION

2.1 Collection

Collection of Rainwater can be undertaken by following ways:

- Roof tops catchments
- Land surface catchments
- Rock catchments

2.1.1 Roof catchments

The rooftop is the most well-known catchment surface. Numerous different surfaces can be utilized. Sensible unadulterated water can be gathered from house rooftops made of clay tiles, record, (ridged) electrifies iron, aluminum or asbestos concrete sheets. Most covered rooftops are not reasonable for use, since natural materials can expand the shading and sloppy water of the water. Notwithstanding, covered rooftops made of certain palm leaves can frame a decent catchment region. At the point when water is extremely destructive, use asbestos concrete board in the rooftop catchment region with extraordinary consideration. Asbestos strands may filter from the roofing material, bringing about a generally high centralization of asbestos in the gathered water. In any case, there is no proof that asbestos filaments in drinking water can unfavorably influence wellbeing. Then again, breathing high centralizations of asbestos strands noticeable all around may cause cellular breakdown in the lungs. Accordingly, the creation of asbestos items is prohibited, and the evacuation of old asbestos concrete sheets requires unique consideration. Plastic material is efficient, however generally not solid. The recently evolved roofing materials are pitch felt and sisal supported paper. Applying paint to the rooftop for waterproofing may make the gathered water smell or shading and ought to be kept away from.

The drainage pipe that drains the water to the storage tank should be made to ensure that the collected first runoff can be wasted (first dirty washout), thereby preventing the accumulation of bird droppings, leaves, branches and other plant matter, such as: and dust And debris into the storage tank. Sometimes a collection box with a mesh filter (sometimes with additional filter media) is used to prevent the entry of potential contaminants. Alternatively, a sewage tank can be installed between the sewer pipe and the water storage tank, and the sewage tank can be drained separately. . The rooftop spillover is corresponding to the precipitation and the arranged space of the rooftop. For each 1 mm of precipitation, one square meter of rooftop region will create one liter of water, subsequently lessening dissipation, spillage misfortunes and wind sway. The size of drains and downpipes should be such that they can withstand the peak runoff. In the tropics, this may happen during short-duration high-intensity storms *(Eng & Eng, 2018)*.

2.1.2 Land surface

The ground catchment area is used to collect rainwater runoff. A piece of it will be lost by wetting the ground, put away in a downturn or vanished by dissipation. Laying clay tiles, cement, black-top or plastic sheeting can frame a smooth and impenetrable surface on the ground, which can significantly lessen such misfortunes. In some cases it is adequate to minimal the surfaces as it were. The measure of water that can be gathered in a surface bowl relies upon whether the bowl is level or inclining, and furthermore on the water snugness of the top layer.

By preparing the ground, you can ensure that the water flows to the collection and storage points fast enough to reduce evaporation and permeation losses. For a flat catchment area, the rainfall that can be harvested is about 10%, and for a sloping strip catchment covered with impermeable materials, the harvestable rainfall is about 90%.

2.1.3 Rock catchment

Some places, such as bare mountain tops and rocky outcrops or lowlands suitable for forming ground catchment areas, are called rock catchment areas. Depressions and ravines are good places to form reservoirs. The spillover water captured by the stones streams along the blueprint of the incline through the stone box and hindrances to the repository, where the water is put away for use. The area of the dam and the lower part of the repository ought to be liberated from rock breaks or breaks that may make water stream away from the site. Water may move from the supply to the downstream local area by gravity. The sort, size and state of storage spaces rely upon site attributes and water interest.

2.2 Filtration

The cleaner the water entering the storage tank, the smaller the need for draining and cleaning the tank. The rainwater flowing from the roof inevitably contains dust, leaves, branches and other debris. The sieve can remove a lot of large debris. The water from the gutter and downpipe collection funnel should be screened and filtered before entering the storage tank. After each rain, the first gallon per 100 feet of roof area should be discarded to ensure that only the cleanest water is collected.

The filtering method depends on the purpose of using rainwater. We will discuss the three uses of rainwater. In addition to irrigation, they all have their own unique filtration process, and irrigation does not require special cleaning. For domestic use and ground replenishment, the first filtration involves removing any other forms of trash or rubbish brought by leaves or runoff. Can be combined with the following equipment and systems for preliminary filtering

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2.2.1Preliminary filtration

It is mainly to separate the first dirt from the water. There are many methods for separation, the following is a brief description.

2.2.1.1 Screen:

Screens can be utilized to hold bigger trash, like leaves; they can be introduced in the sewer pipe or at the passageway of the water tank. They are easy to install and are easily available locally at a low price. The filter screen should be made of a material that will not corrode when in contact with water. They need regular maintenance, but it is not difficult to maintain and can be easily completed by amateur personnel.

There are various sizes of screens on the market. Choose the size of the holes, the purpose is to make the water flow easily and quickly, and at the same time prevent leaves and other debris.

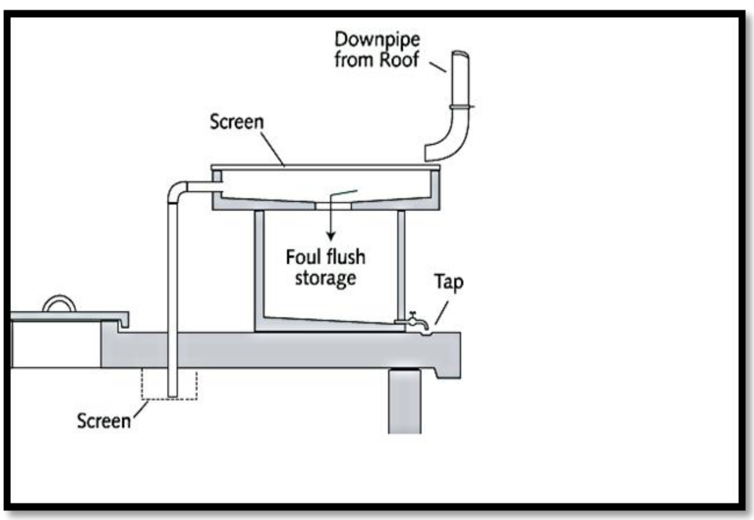

Fig 2.1 Screen Used Before First Flush and Storage Tank

2.2.1.2 Stainless steel sieve:

Another way to separate debris from clean water is to use a stainless steel screen, which is very similar to a screen, but the main difference lies in the way the screen is used. The basis of this technology is very similar to the tubes used in tube wells. A tube with holes is inserted in the tube well to prevent soil particles from flowing together with water, but in this case, our target is larger particles, so the pore size may Let water pass freely without clogging.

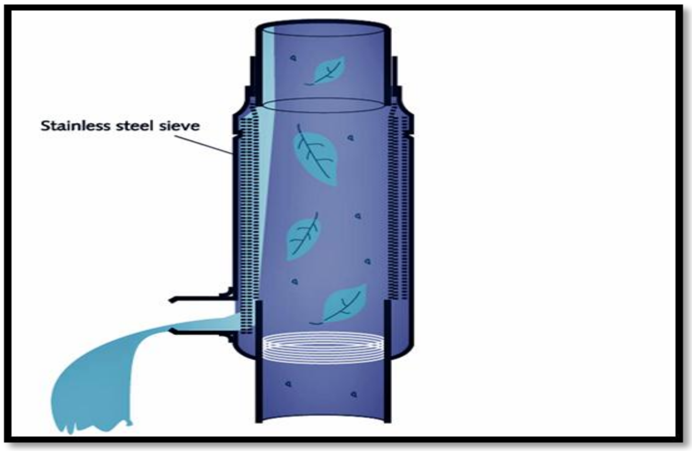

Fig 2.2 Stainless Steel Sieve

The water will pass through the screen to the water storage tank, and the debris and larger debris will move down and be collected. A variety of these tubes are available on the market, and they differ not only in the size of the holes, but also in the shape, arrangement and cleaning process of the holes. People can choose any channel based on its usability and ease of use.

2.2.1.3 First Flush

The most common and widely used technique for removing debris from rainwater is to flush first. In this method, the initial running water containing most of the debris and garbage is usually discharged into a special gallon. When the gallon is completely full, the rest of the water can be stored or further purified. A simple first flushing water trap can have a pipe or any other small water storage device, and when it rains, they will be filled with the original dusty water. As the water in the vertical pipe rises, the plastic balls in the pipe rise and stop flowing to the diverter. When the rain stops, the water in the shunt pipe will slowly drain through a small drain. The bottom should include a removable plug or cover for maintenance. The shunt chamber needs to be cleaned between rainy days to eliminate the accumulation of debris and dust.

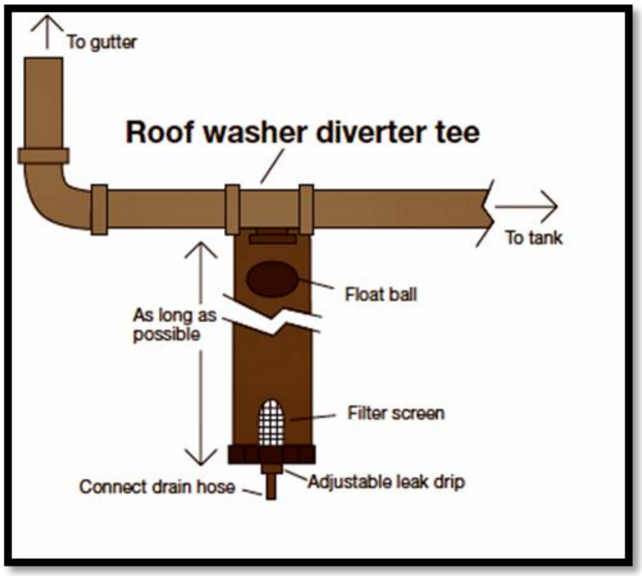

Fig 2.3 An Example Of Simple First Flush

The basic principles used in all first flushing systems are almost the same, and the types of materials used have hardly changed. By adopting simple technology, the efficiency of the first flush can be improved, and the water loss of the first flush can be improved.

2.2.1.4 LEAF TRAP:

Another simple method commonly used to prevent debris from entering the drain is a leaf collector. A funnel shaped leaf trap can be set in an in an upward direction descending line with a lattice at the highest point of the line. The screen forestalls little leaves, twigs and different materials from entering the line and hindering the line or obstructing the channel. On the off chance that important, the material gathered on the gatherer (assuming any) should be eliminated routinely and day by day during the blustery season.

Fig 2.4 Commonly Used Leaf Traps

2.2.2 Filter

There are various systems that can be used to treat water before, during, and after storage. The filter is basically a screen that can capture particles in the water and still let the water flow through. A filter with a smaller mesh or pore size will trap more debris, but a smaller filter will restrict the flow of water, and the filter will block more quickly and must be cleaned or replaced more frequently. The amount of particulate matter captured in the system also determines how often we need to clean or replace the filter. Filters can breed bacteria, so it is important to maintain and replace them regularly. The standard of coarse filter is once a month, but it varies according to the size of the filter and system conditions. The water pressure forces the larger particles through the normally small pores. As the pressure behind the dirty filter increases, more particles will be pushed through the filter. Therefore, the pore size and filtering function are not absolute. As the filter ages, the material in the filter may stretch, wear, or tear. This is another reason for regular filter replacement. Rock, sand and screen channels can be planned and set on the highest point of the capacity tank. This channel is vital to keep the water in the capacity tank clean. It eliminates residue, residue, leaves and other natural matter into the capacity tank. After every precipitation occasion, the channel media ought to be cleaned each day. A stopped up channel keeps water from effectively entering the water stockpiling tank, and the channel may flood. Prior to putting the sand or rock media in the channel, it should be taken out and washed. Common filter types are

- Sand Gravel Filter
- Charcoal Filter
- PVC –Pipe filter
- Sponge Filter

2.2.2.1 Sand Gravel Filter

As shown in the picture, these are regularly utilized channels, made of stone work and loaded up with rocks, rock and sand. Each layer ought to be isolated by silk screen. A common image of coarseness is appeared beneath.

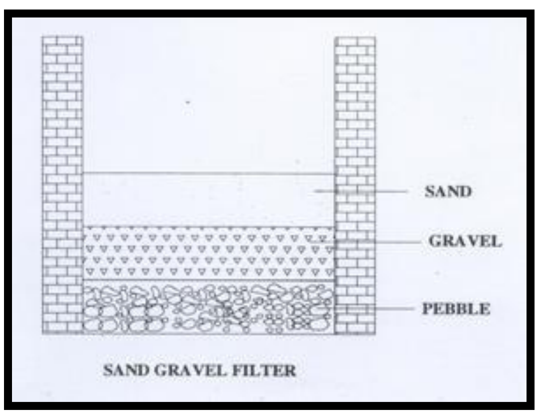

Fig 2.5 Sand Gravel Filter

2.2.2.2 Charcoal Filter

In Situ charcoal filter is made from barrel. The stones, rock, sand and charcoal as demonstrated in the image should fill the pail or burning chamber. Each layer ought to be isolated by silk screen. Slim charcoal is utilized to ingest smells (assuming any). The schematic outline of the charcoal channel is as per the following

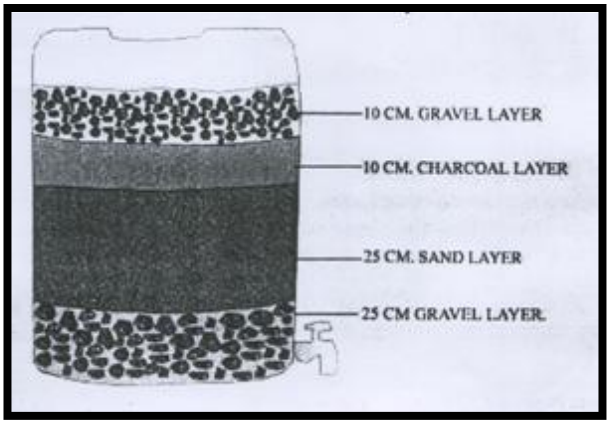

Fig 2.6 Charcoal Filter

2.2.2.3 PVC –Pipe filter

The channel can be made of PVC pipe with a length of 1 to 1.20 m. The line width relies upon the rooftop region. A six-inch breadth pipe is adequate to meet the prerequisite of 1500 Sq. Feet of rooftop and 8 creeps in measurement. The rooftop should utilize pipes bigger than 1500 Sq. Feet partition the line into three compartments with wire network. As demonstrated in the image, every segment ought to be loaded up with rock and sand. You can likewise embed a layer of charcoal between the two layers. The two finishes of the channel ought to diminish the size needed to associate the delta and outlet. The channel can be set on a level plane or in an upward direction in the framework. Figure beneath shows a schematic outline of the line channel.

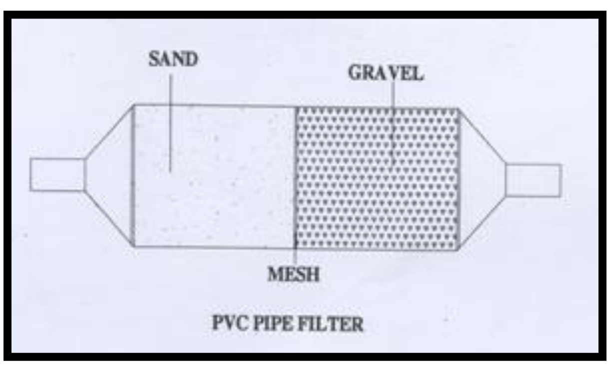

Fig 2.7 PVC pipe filter

2.2.2.4 Sponge Filter

It is a basic channel made of a PVC drum with a layer of wipe in the drum. It is the least complex and least expensive type of channel, reasonable for private units. A normal image of a wipe channel is appeared underneath.

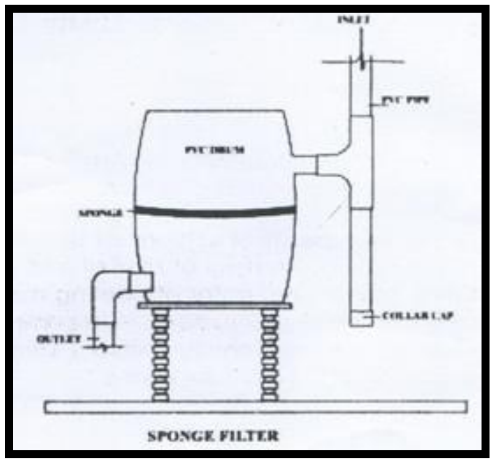

Fig 2.8 Sponge Filter

Preparing soft drink is utilized for buffering. The creation and pH of water are not quite the same as artificially treated city water and mineral-rich well water. For each 100 gallons of water gathered, by adding a tablespoon of preparing soft drink to the capacity tank, the pH of water can be effortlessly constrained by buffering. (For each 1,000 gallons of water gathered, there are around 4 ounces of preparing pop.) A basic strategy is to blend a specific measure of heating soft drink into a jar of water and empty it into a water tank. Blending will normally happen inside a little while, or a spotless oar can be utilized to accelerate the interaction, yet try not to upset the material that has settled at the lower part of the tank.

STORAGE AND TREATMANT OF RAINWATER

Rainfall is a natural phenomenon that may occur at any time. In most parts of the world, it does not rain throughout the year, but most of the rainfall during shortest time, which leads to the need to store water during this period. It is abundant, so it can be used when water is scarce.

The storage method depends on the use and the amount of water required, as well as the time when the supply is less than the demand. As for surface replenishment, there is no need to store water because it is automatically stored in groundwater. Therefore, we have household reservoirs and irrigation reservoirs.

3.1 Storage for household:

Family water stockpiling tanks can be of various sizes and can be made of an assortment of materials, like polymers, fiberglass, concrete or locally accessible crude materials like bamboo. To pick the size of the capacity tank/water tank, a few factors ought to be thought of, for example, water supply (neighborhood precipitation), water interest, anticipated length of dry period without downpour, catchment region, style, individual inclinations, and the main piece, everything being equal, .

Throughout the long term, there have been different changes away tanks and water tanks in various geographic regions, for example, earthenware water tanks in India, enormous ceramics in Africa, lacquer pools on the ground in Hawaii, cement or block water tanks in the focal US, Electrifies steel stockpiling tanks and on location stone and mortar stockpiling tanks in Texas and Colorado.

The tank can be above or beneath the ground. Factors like soil, outer temperature reach, and cost ought to be utilized to decide if to put the tank above or beneath the ground. Some water tanks are appropriate for putting on the ground, for example, vinyl-lined pools, while other water tanks can be utilized above and underneath the polyethylene. Particular sorts of water tanks are covered very much like covered polyethylene water tanks.

Since the parameters involved vary greatly and are of great variety, knowing all the information about the available options is essential for the correct decision on the type of fuel tank you want to buy, and it should prove that it is something you will use for a long time *(Eng & Eng, 2018)*.

Generally, in most areas of Pakistan, people usually build underground water storage tanks, which can even be used for rainwater.

Discussed below are the most common types of storage tanks based on the most accessible manufacturing materials and storage capacities used around the world.

3.1.1 Fiberglass

It is light in weight, sensibly valued and strong. They have standard limits, from little 50-gallon drums to bigger 15,000-gallon stockpiling tanks, and are accessible in both vertical and low-level chamber arrangements. More modest fiberglass stockpiling tanks (that is, under 1,000 gallons) are costly in size. Capacity tanks utilized for drinking water ought to have a food-grade gum lining, and the capacity tanks ought to be dark to restrain green growth development. The sturdiness of fiberglass stockpiling tanks has been altogether verified to keep going for a long time and is not difficult to fix. The fittings on the fiberglass stockpiling tank are a basic piece of the capacity tank, wiping out a typical potential issue fitting spillage.

Fig 3.1 A Fiberglass Tank

3.1.2 Polyethylene

Polyethylene water tanks are presumably the most widely recognized water tanks utilized today and are accessible at most retailers. They shift enormously in size, shape and shading, and can be utilized above or underground.

Most water tanks are normally utilized for ground establishment. For covered establishment, an uncommonly planned and built up capacity tank should have the option to withstand the extension and constriction of the dirt. Polyethylene stockpiling tanks are generally modest, lightweight and strong, and have limits going from 50-gallon barrels to 10,000-gallon barrels. They are lighter than different kinds of capacity tanks, including fiberglass, so they are less expensive and simpler to ship.

Polyethylene tanks often do not retain paint well, so it is recommended to use pre-coated tanks, that is, colored tanks or tanks made of opaque plastic. Black and dark water tanks absorb heat, so they should be covered or buried. These tank accessories and other aftermarket modifications are easy to manufacture, and the vertical line is also easy. However, there may be problems with accessories, and you should check occasionally for leaks.

Fig 3.2 Polyethylene Tank

3.1.3 In-ground polyethylene

The cost of underground polyethylene storage tanks is higher for two reasons:

- Excavation cost
- The cost of a more enhanced tank.

If you want to bury the tank more than two feet deep, you need to use the latter. Due to the expansion and contraction cycle of clay, it is not recommended to bury storage tanks in soils with high clay content. For underground installation, the wall of the polyethylene storage tank must be made thicker, and sometimes an internal support structure must be added. This is not recommended because it will affect the cost.

Fig 3.3 Polyethylene tank

3.1.4Metal

Stirred sheet jars may likewise be an alluring choice. They range in size from little 150-gallon stockpiling tanks to 2500-gallon medium-sized capacity tanks. They are lightweight and simple to move on a case by case basis.

Most capacity tanks are layered electrifies steel inundated in hot zinc to improve consumption obstruction. These tanks ought to be fixed with food-grade linings, normally polyethylene or PVC, or covered with epoxy paint within. Paint or coating will broaden the existence of the metal.

These water tanks are utilized on the ground. Old or reused stockpiling tanks may contain lead and ought to be stayed away from. Metal and bronze fittings ought not be straightforwardly associated with the capacity tank as they can cause consumption. Care should be taken when cleaning these water tanks, in light of the fact that a film will normally frame inside the water tank, which will cover the water tank and repress erosion.

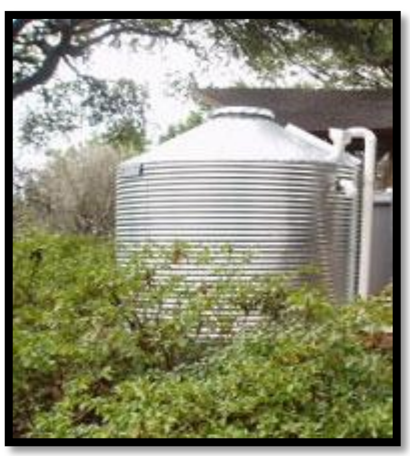

Fig 3.4 Aluminum Tank

3.1.5 Concrete tanks

Substantial tanks can be worked above or underneath the ground. They can be worked by the proprietor or by the worker for hire. The cast set up water tank is exceptionally appealing and can be handily coordinated into the new construction.

For instance, the water tank can be put under the patio or storm cellar. Once filled a substantial tank, it is viewed as a perpetual tank.

A unique advantage of pouring concrete is that over time, the concrete will soak into the water, thereby reducing the corrosiveness of rainwater. This advantage of the concrete tank makes the calcium in the concrete dissolve in the slightly acidic place of the rainwater, thus giving the water an ideal taste. For portable systems, it is essential that the inside of the tank should be smeared with high-quality materials approved for portable use.

Underground substantial tanks are inclined to breaking and spilling, particularly in mud soils. Breaks are not difficult to fix, maybe albeit the water tank ought to be depleted to fix. In the event that you assemble the capacity tank yourself, it is prescribed to request the expert information from the primary designer to decide the size and separating of the steel bars to coordinate with the underlying heap of the cast set up concrete.

Fig 3.5 Concrete Tank

3.1.6 Ponds

They are common or man-made stale water, typically more modest than lakes. A wide range of man-made water are named lakes, including water gardens intended for stylish beautification, fish lakes intended for business fish cultivating, and sun oriented lakes intended for putting away nuclear power.

Ponds can be used for a wide range of purposes such as irrigation, fishing and livestock, and can also be used for recreational sports such as fishing.

3.2 Water treatment

Prior to choosing which sort of water treatment technique to utilize, the water ought to be tried by an authorize lab and decide if the water can be utilized for drinking water or non-drinking water. The treatment types talked about are filtration, sterilization and cradles to control pH. Regardless of whether configuration highlights, for example, rooftop gaskets, sifters and tight-fitting covers are introduced accurately, earth, rust, scale, residue and other suspended particles, bird and rat excrement, airborne microorganisms and sores can incidentally enter the water tank Or water stockpiling tank. . Water might be unacceptable, however it isn't protected. In this manner, if the water is to be utilized for human utilization (drinking, brushing, or cooking), the suggested least treatment strategy is filtration and some type of sterilization. The most widely recognized sort of handling unit utilized in water frameworks is a channel, which eliminates stores and joins UV or substance sterilization (*Gould, J. and Nissen-Petersen, E. , 1999).*

3.2.1 Quality of Stored Water

Rainwater collected from the roof does not contain mineral contaminants normally found in groundwater, such as fluoride and calcium salts but may contains Air and surface contaminants like silt, dust etc

3.2.2 Measures to Ensure Water Quality

Many organizations are concerned about the quality and high cost of rainwater harvesting in modern houses. It is generally accepted to use rainwater for gardening, cleaning and dispersing leakage. In any case, a few group continue utilizing water for drinking. For rooftop assortment, the rooftop material may influence the nature of the gathered water. Certain roofing materials (like black-top) add undesirable natural synthetics to the water. Consequently, the water from the rooftop should go through a channel to eliminate leaves and other particulate soil prior to entering the water stockpiling tank. Since the nature of water is of most extreme significance, the framework ought to be intended to guarantee that solitary qualified water is siphoned into the repository. To guarantee the assortment and siphoning of excellent water, fitting frameworks ought to be intended to guarantee that lone better quality water is gathered, and water quality observing ought to be led consistently.

3.3 Disinfecting Water at Household Level

3.3.1 Boiling

To remove harmful bacteria and viruses boil water for 10 to 20 minutes

3.3.2 Chemical Disinfection

- Chlorination: Utilize stable fading powder (calcium hypochlorite-$CaOCl_2$) for chlorination, which is a combination of chlorine and lime. Chlorination can murder a wide range of microscopic organisms and make drinking water protected to drink. Around 1 gram (around 1/4 teaspoon) of dye is sufficient to treat 200 liters of water.

- Chlorine tablets: Chlorine tablets are effectively accessible on the lookout. A 0.5 gram tablet is sufficient to disinfect 20 liters (a can) of water.

On the off chance that the gathered water is utilized for washing garments, water plants or different assignments that are not straightforwardly in direct contact with people or devoured medicines other than screening and expulsion of residue are discretionary. Be that as it may, if water is filled the house for general indoor use, like drinking, washing, and cooking, it should be sanitized. Chlorine is the most widely recognized sanitizer because of its unwavering quality, water solvency and accessibility. Accessible in granular or tablet structure (calcium hypochlorite), yet the suggested application for water sterilization is a fluid arrangement (sodium hypochlorite)

APPLICATIONS OF RAINWATER HARVESTING

The collected rainwater can be effectively used for many beneficial purposes. The following are some of the main applications of rainwater harvesting

- Mini dams
- Artificial ground water recharge
- Roof top harvesting

4.1 Mini dams

The height of the micro dam is less than 15 feet, or the storage capacity is less than 50 acre feet. These are barrages across the flow of water for collection, storage and reuse.

4.1.2 Mini dams and rainwater harvesting

Rainwater runoff can be stored in small dams and ponds in areas where rainwater and groundwater are the only source of water. The stored rainwater can be further used for irrigation and household purposes. Further small dams can effectively control soil erosion caused by rainfall. In areas where rainwater is used for irrigation, the technique of using micro-dams for storage and then using rainwater for irrigation is very effective.

In a country like Pakistan, where there is a large area of fertile land, the only source of water is rainfall. Therefore, the use of micro-dams to collect rainwater can be used as a means of effective water volume. According to a study, if collected and stored improperly, approximately 30% of rainfall will be lost. Rainwater not only washes away the fertile soil from the top, but also consumes soil nutrients. Adequate management of rainwater may be useful for controlling soil erosion, rainwater loss and maintaining land fertility *(Lee, Michael D. and Visscher. , 1992)*.

Micro dams are built in areas with abundant rainfall and are regularly distributed in different seasons. Regional topography also plays a very important role in its construction, because it helps reduce construction costs.

Fig 4.1 Mini Dam

4.1.3 Study of Pothwar Plateau

There are three major sources of water

1. Rainfall
2. Runoff
3. Groundwater

The water stored in the micro dam is used for irrigation, domestic water and reserve water. If managed properly, small dams can be a very successful intervention. . Simply giving foundation to miniature dams won't tackle the issues related with inundated horticulture in the Pothwar Level, on the grounds that the change from Barani to a flooded climate isn't programmed. It requires incredible consideration from strategy producers and advancement organizers to settle future arranging issues for the development of new little dams. As of now, in these activities, the speculation is just utilized for the development of little dams, while the water for irrigated agriculture is reserved for farmers. The owners of small dams are not even provided with technical knowledge about land cultivation, irrigation system design and layout, and irrigated agricultural productivity. Farmers have always tried their best and knowledge to use the stored water. In addition, research institutions have never assigned any research work related to the impact of small dams on increasing farmers' incomes to any priorityThe examination additionally distinguished likely choices for expanding the efficiency and supportability of little dams around there.

The only source of water in the Barani area is rainfall, which varies between 300 and 1,000 mm, and the total runoff is 9 MAF. About 30% of the rainfall was lost, and if harvested properly, this would be enough to irrigate 2 million acres. Rainwater not only washes away the fertile topsoil, but also consumes soil nutrients. Approximately 12,000 acres of land are affected by rainwater eroding the soil and forming ravines every year. Moving soil from one place to another through high rainfall can cause soil erosion. In addition, high-intensity rainfall, steep slopes and erodible soils were not properly protected, resulting in soil erosion in the Pothwar Plateau and a decline in agricultural productivity. Soil insurance innovation has developed, however albeit different public divisions and ventures have burned through billions of rupees in the previous 54 years, soil disintegration is as yet a genuine danger. To forestall soil disintegration, water saving is a significant factor. It can store water, yet additionally forestall soil disintegration. The construction of dams is believed to protect the land from the threat of soil erosion in a small area. During the dry period (1997-2003), there was very little rainfall, especially farmers in the Barani area began to install more tube wells. In this way, groundwater assets were misused aimlessly, and the groundwater level diminished at a pace of 0.6 to 2.5 m each year, bringing about salt water interfering into the freshwater layer and seriously restricting the creation of oil wells. One of the approaches to take care of this issue is to successfully oversee groundwater and misleadingly re-energize the groundwater spring by developing deferred activity miniature dams with sinking bowls, which will help increment groundwater re-energize and raise the groundwater level. In the Barani area, the scope of such development work is large. Another goal of small dams is to reduce the rapid consumption of groundwater. If not managed properly, a lot of rainwater will be wasted. In order to save runoff water in the Pothwar area, the construction of small dams is the most suitable option. Storing runoff in small dams has good potential for irrigated agricultureSurface stockpiling may not be conceivable anyplace, however the perpetual and non-lasting waterways and streams going through the Pothwar Level convey a lot of water, particularly during the rainstorm season. In addition, for small dams, there is no need for a large catchment area, which makes it more feasible to build small dams instead of small dams in the area. The construction of micro dams is highly subsidized. The subsidy rate for most micro-dam projects is between 40% and 80%. Farmers' share accounts for 20-60% of total costs.

4.1.8 Storage Capacity of Mini Dams

In the Barani district, water is the primary restricting element for manageable farming turn of events. The potential water sources here are precipitation, groundwater and overflow. The principle reason for building little dams is to reap as well as utilize surface overflow to enhance episode precipitation to increment rural efficiency. The size of the dam is an element of the overflow accessible in the waterway and the potential order region. As a rule, miniature dams have a capacity limit of somewhere in the range of 30 and 50 AF, utilizing the idea of supplemental water system, above or more the accessible episode precipitation, adequate to inundate a normal directed space of 25 to 32 sections of land. The principle reason for a little dam is to address ranchers' issues for advantageous water system of Barani's developed land.

4.1.9 Analysis of Cost and Subsidy

Cost of a small dam ranges from Rs. 0.4 to 1 million is unaffordable for farmers, so the Punjab government provides 80% of subsidies. As different cost-sharing mechanisms have been adopted in the past two decades, the auxiliary data analysis on subsidies provided by the provincial government is quite different. On average, the subsidy ranges from 41 to 77. The last column of Table 1 shows the percentage of cost shared by the government. The government's share varies depending on the subsidy mechanism for farmers and the government to share costs

4.1.10 Economic Benefits of Mini Dams

The potential benefits of micro-dams are far greater than the actual benefits. In other words, the actual benefits that can be achieved from dam construction are suppressed. Among the total number of samples surveyed, most farmers have a small area of land development. Most of them think that after spending a lot of money to build the dam, they don't have much money left, so they can't even develop the land by hiring bulldozers. Many farmers are not interested in farming because agriculture does not seem to be their priority. The greatest economic potential lies in certain activities, which require less investment, but like aquaculture, the benefits are high. Aquaculture is one of the most profitable activities, because aquaculture requires very little input, but if harvested properly, the benefits will be high. In the surveyed dams, farmers mostly use the seeds of silver grass, forest, Lahe and ordinary military species. Even if the farmers do not put fish feed, the growth rate of the ordinary military species is faster than other species, and the fish of this species grows to 0.80- 1.0 kg. However, if you apply fertilizer and take proper care of its nutrition, you can gain 2.5-3 kilograms in one year. Many farmers are planting silver grass carp seeds. One of the main reasons for planting this seed is that there is a wild weed, called Konder in the local language, and wild weeds grow around almost all the dams and reservoirs investigated. The specialty of this fish is that it eats this weed. Konder quickly absorbs water and is annoying during growth. Even if harvested, it will grow again. The entire investment in the dam can only be recovered from aquaculture within a few years. Among the dams surveyed, 61% of farmers are engaged in aquaculture, but the scale is very limited. Most of them started this activity just to entertain friends and family. If you consider the situation before and after the construction of the dam, there are obvious differences. This is because the water quality of the farmers who ensure the water supply (especially those interested in agriculture) has been improved and they benefited from the storage of water. As the water supply and return water are ensured to be much higher than before, the yield has increased. Another financial advantage is the backwoods manor in the order region. The cost of wood is extremely high, and the development of high-esteem woodland wood has carried better yields to ranchers. Timberland plants are additionally utilized as a watershed the board apparatus. Albeit the capability of miniature dams is far more prominent than the potential that most dams can accomplish, scarcely any ranchers are endeavoring to acknowledge financial advantages, which might be a lot higher than the genuine circumstance

4.1.12 Conclusion

Small dams have had a very good impact on agricultural activities in the Potswa Plateau. Thanks to the construction of micro dams, rainwater is effectively stored in the reservoir, even in periods when there is no rainfall, rainwater can be used by farmers.

After a small dam is built, it can also control soil erosion caused by runoff and maintain soil fertility.

Although the initial construction cost was high, it was affordable due to government subsidies. Such plans should also be introduced in other parts of the country where water is scarce and rainfall is the only source.

4.2 Artificial ground water recharge

4.2.1 Introduction

Manual recharging of groundwater is an interaction by which groundwater supplies are expanded at a rate surpassing that acquired under regular conditions. Any man-made program or office that adds water to the spring can be viewed as a fake renewal framework. To guarantee that water saturates the ground as opposed to being released from the surface, different re-energize constructions can be utilized. Designs, for example, re-energize ditches and porous asphalts advance the infiltration of water through the dirt layer at shallow profundities. Different offices, for example, supply wells, carry water to more noteworthy profundities from where it merges with groundwater. In numerous spots, existing constructions, like wells, pits, and capacity tanks, can be changed to fill in as recharging structures, killing the need to fabricate any new designs. There are not many techniques for manual renewal. Advancements and blends of these strategies are conceivable.

Water can be infused into the groundwater spring through any reasonable design (for instance, burrowed wells, bored wells, re-energize jettison and re-energize pits). Artificial replenishment technology can be roughly divided into the following categories:

Direct surface technology/spreading method

- Flood technology
- Pool
- Stream enhancement/channel method
- Ditch system
- Over-irrigation

Direct underground technology/pit method

- Injection wells or make-up wells
- Supply pits and shafts
- Dig well for replenishment
- Flooding of boreholes
- Natural opening, cavity filling.

The combination of surface and subsurface technology

- Pools or percolation tanks with shafts or wells.

In addition to the above, groundwater protection structures such as underground dams and underground dams are very common and can prevent groundwater flow. Likewise, in hard rock regions, rock cracking methods including organized impacting of boreholes with proper strategies have been utilized to associate breaks to one another and increment re-energize. Concrete fixing of breaks through exceptionally built wellbore has been utilized to save underground stream and increment wellbore creation.

4.2.2 Artificial Recharge Structures

Recharge Pits

These designs are utilized to re-energize shallow springs. These are typically fabricated 1 to 2 m. The width is 2 to 3 m. profound. After exhuming, the pit will be loaded up with rocks, stones and harsh sand. The uncovered pit is fixed with consistently separated block/stone dividers, and the block/stone dividers have openings (water drainage openings). The highest point of the pit can be covered with an opening cover

Percolation pits

These are one of the simplest and best approaches to gather water. These pits are typically close to 60 x 60 x 60 cm and are generally planned by the normal spillover. They are loaded up with rocks or block jam and waterway sand, and covered with punctured substantial pieces when important.

There is a drainage pit, so water can straightforwardly enter the spring. The design is covered with permeable substantial sections on the cleared region. On the off chance that the profundity of the mud is more noteworthy, it is ideal to recharge it through a punctured break pit. The opening can be situated in the focal point of the square pit and loaded up with stones, and the top is loaded up with stream sand and covered with permeable substantial chunks. As per the lithology, the essential packaging can be given in the recharging great to keep away from blockage. The rooftop water and surface water of the structure can be moved to the leakage pit. It really is great that to have in any event one drainage pit for each 20 square meters in each house with empty land.

Soak away

It is an opening with a distance across of up to 30 cm in the ground and a profundity of 3 to 10 m. Except if hard rock is found at a shallow profundity, a manual drill can be utilized to penetrate through. In the event that there is a steady soil layer like dirt, you can forget about the eye. For this situation, the drenched water might be loaded up with channel media like blocks. In temperamental arrangements (like sand), PVC or MS pipe covering ought to be utilized to drench to forestall vertical surface breakdown. The cylinder can be opened/punctured to advance permeation through the sides. A little puddle is worked at the highest point of the splashing zone to hold a specific measure of overflow before it enters through the drenching zone. Since the sump additionally goes about as a cushion zone in the framework, it should be planned by the normal spillover.

Precautionary measures ought to be taken to guarantee that actual substances, for example, ooze and coasting garbage in the spillover don't enter the well, as this may cause blockage of the renewal structure. Ideally, the uncovered or penetrated very much utilized for renewal is shallower than the groundwater level. This guarantees that the water re-energized through the well has a dirt vehicle of adequate thickness, which should go through the medium prior to being added to groundwater. Any old well that has fizzled can be utilized for recharging in light of the fact that the profundity of such wells is over the water level.

4.2.3 Mini Artificial Aquifer System (MAAS)

This is an exceptional counterfeit renewal structure, which is truly appropriate for open regions, particularly low-lying regions. This construction is additionally reasonable for the intersection of streets, traffic intersections, leaves, arenas, sports fields, transport terminals, theaters, public structures, schools, universities and other open regions. In an open region, when the dirt and earth some portion of the ground ought to be exhumed, the uncovered part can be loaded up with locally accessible rocks of different sizes in climbing request from the top. The top might be brimming with stream sand. A few recharging shafts can be developed at the lower part of the uncovering segment. These renewal wells with explicit area measurements can be developed to infiltrate impenetrable layers to forestall stopping up.

Recharge Trenches

Contrasted and recharging through wells, renewal through renewal channels, recharging pits and drenching techniques is simpler. Less insurances should be taken to keep up the nature of precipitation spillover. For these sorts of constructions, there is no limitation on the kind of catchment region from which water is gathered, that is, cleared and unpaved catchment regions can be exhumed.

The re-energize ditch is a ceaseless trench dove in the ground. At the point when porous developments are free at shallower profundities, build them. The score might be 0.5 to 1 m. The width is 1 to 1.5 m and the profundity is 10 to 20 m. The time span relies upon the accessibility of water. It is refilled with channel materials like rocks, stones or broken blocks. In the event that a mud layer is experienced at a shallower profundity, different drill openings can be developed and refilled with fine rock. The length of the inventory ditch relies upon the normal overflow. The trash collected in the stock trench ought to be eliminated routinely to keep up the air consumption. As far as renewal rates, the viability of recharging ditches is moderately low, since soil layers with a profundity of about 1.5 meters are by and large less porous. To re-energize through the re-energize ditch, less insurances should be taken to keep up the nature of precipitation overflow and can exhume spillover from cleared and unpaved catchments.

Recharging through defunct open wells, bore wells and Hand pumps

Because of the extreme consumption of groundwater levels, many open-pit wells, boreholes and hand siphons have gotten dry. There is no compelling reason to dispose of these wells, however they can be changed over into valuable renewal wells. Rooftop water and overflow water can be moved to these wells in the wake of being loaded up with rocks and stream sand. Prior to moving the water to the well, the well ought to be totally dug. These can be straightforwardly re-energized through rooftop overflow. The water gathered on the top of the structure is moved to the sedimentation tank or channel tank through the seepage line, and afterward moves from the sedimentation tank to the inventory well (penetrated or burrowed). On the off chance that a cylinder well is utilized for recharging, the packaging (external cylinder) is ideally an opened or punctured cylinder to permit more surface region for water to enter. The improvement of the borehole will expand its recharging limit (the advancement cycle is to squeeze water or air into the well under the gun to extricate the dirt development around the borehole and make it more porous).

On the off chance that an unearthed well is utilized for recharging, the well covering ought to have openings (water infusion openings) routinely dispersed to permit water to leak out from the side. Uncovering wells ought to be covered to forestall the reproducing of mosquitoes and the section of leaves and flotsam and jetsam. The lower part of the inventory well ought to be desilted consistently to keep up the water admission limit.

4.2.4 Merits and Demerits of Different Methods

Contrasted and the infusion strategy, fake recharging through dispersion enjoys the accompanying significant benefits. Invasion is practically similar to the penetration of common precipitation, without the immaculateness of invasion water. Typical tempest spillover or starter treated seepage (evacuation of hurtful synthetic parts and suspended substances) can be utilized for counterfeit renewal. At times cleaning the wetted surface of the renewal structure is a basic cycle since it just includes starting to expose what's underneath. Be that as it may, dispersion techniques are just valuable for recharging unlimited springs. Because of the insignificant descending spillage of the water base and the sluggish horizontal development of groundwater in the ground, it is uneconomical to falsely fill the kept or semi-restricted spring through the descending or parallel penetration of the recharging zone. The burden of fake renewal through dissemination is that the deficiency of surface water because of vanishing, the testimony of residue in the source water, the statement of residue in the environment, and the development of vegetation in the penetration structure decrease the porousness of the dispersion structure. Transmission strategies including water stagnation now and then reason natural issues. In this manner, it is important to change the water supply to these constructions in a manner that doesn't produce a lot of stale water. It is likewise important to control the renewal rate, in light of the fact that a higher groundwater hill will decrease the penetration rate. Re-energize by infusion is the best way to falsely re-energize restricted springs or profound springs with helpless porousness. The recharging is prompt, with no transportation and vanishing misfortunes. The infusion strategy is additionally viable when hard rock and cast limestone are profoundly broken. Nonetheless, the necessity of amazingly high immaculateness of the source water and the similarity of the source water and the water in the spring to be infused is vital essentials. Something else, the successive blockage of the infusion structure because of the development of microscopic organisms, compound precipitation or slop statement will bring about a lot of use in well cleaning. Since siphoning wells are naturally cleaned, double reason infusion wells (ie, streaming and siphoning) wells are more proficient.

For counterfeit re-energize, it is important to decide if the nature of groundwater and surface water are viable. With the difference in temperature and the reversible stream course of particle trade, the dissolvable salt tends to hasten, which will cause the blockage of the pore space in the dispersion basin and the blockage of the gap in the injection well, thereby reducing the artificial replenishment rate. Although it is impossible to distinguish a good source of water from a poor source, for the purpose of artificial replenishment, water with a sodium content of less than 50% or calcium and magnesium content of more than 60 ppm is generally considered satisfactory. However, the blockage can be removed by the following methods: scraping the scattered basin and chemically treating the injection well, but at an additional cost.

The feasibility of artificial groundwater recharge depends on the following factors:

- Mainly out of topographical and cultural considerations, suitable venues are established to establish supply facilities.
- There is a suitable water source that can supply the required quality of water in the required quantity.
- The lithological creation, thickness and porousness attributes of the stone in the air circulation zone
- Ensure the hydrodynamic conditions in the spring to guarantee adequate lift.
- Cost-viability contemplations.

- Social interests and lawful impacts, including water rights

4.3 Roof top rainwater harvesting

In this innovation, water is gathered from the rooftop and afterward put away in a water stockpiling tank or moved to a counterfeit recharging framework. This is a less expensive and powerful technique. The right plan of the situation can give sufficient homegrown water in regions where the traditional water supply framework can't meet the prerequisites. This is particularly significant in regions where fluoride, nitrate, iron or salt are available in groundwater and subsequently not reasonable for utilization. In these spots, water assortment tanks can give sans mineral water to utilization. The measure of water gathered relies upon the rooftop region, the limit of the water stockpiling tank and the precipitation at the area. For instance, in where it downpours 500 mm and the rooftop region is 100 square meters, the downpour water falling on the rooftop is 50,000 liters. Some of them will be consumed by the rooftop, and some will be lost during the assortment cycle. In the event that we accept that 80% of the water can be gathered, 40,000 liters of water can be gathered. Contingent upon the size of the water tank and the appropriation of precipitation, even a 3,000-liter water tank might be sufficient to gather each of the 40,000 liters of water.

RAINWATER HARVESTING AROUND THE WORLD

The expanding interest for water has sped up the speed of individuals, and with the advancement of innovation, the past water stockpiling framework has additionally been created. The possibility of water reaping has been acknowledged by numerous urban communities, government offices, society, and individuals in numerous nations on the planet. They give instances of RWH frameworks. In Asia, Africa, Latin America, the US, Japan, Germany, Singapore and other creating and created nations, there are numerous effective instances of RWH. These contextual analyses will additionally speed up the reception of water reaping and future procedures to diminish worldwide water emergencies for incorporated water assets the board

5.1.1 Bangalore, India

Bangalore (Bangalore) is a small town with more than 270 lakes and tanks, and it has fallen all the way to around 80. The town is located at an altitude of 920 meters. In addition, due to the impact of nitrate pollution, the drop in groundwater levels also poses a threat. The Bangalore Facilities and Wastewater Treatment Bureau manages the town’s water supply. The two principle sources are the Akavasi Stream and the Cauvery Waterway. The last is at present the primary cause of supply; however it is around 95 kilometers from the city and around 500 meters beneath the city, which requires enormous siphoning costs and energy utilization. Due to the high water shortage rate, a large part of the population is addicted to the well water in the wellbore.

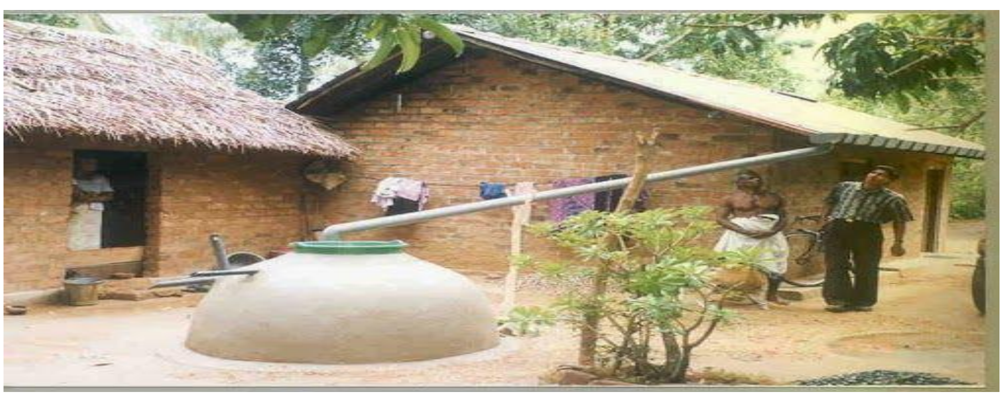

Fig 5.1 An Example of Rain Water Use

The town of Bangalore generates nearly 3 billion liters of rain every day, covering an area of 1,279 square kilometers. This is usually in stark contrast to the 1.5 billion liters of water per day, and these two-day improvement projects are being implemented. The study pointed out that rainwater collection can meet 20% of the city's water demand, as long as the method can affect the transfer of a certain maximum amount of rainwater collection by homeowners, in addition to maintaining good maintenance of ground storage structures such as lakes and ponds. The replenishment structure to enhance the aquifer and its use in a sustainable manner will benefit the town a lot *(K S Umamani and S Manasi. , 2013).*.

Coordinate the water assortment framework into the local plan: A local location in Bangalore, covering a space of around 4 square kilometers, has figured out how to set up a suburbanized water the executives framework that gathers water, which is superior to the plan. Two little lakes, Narasipura 1 and Narasipura 2, gather water and go about as permeation tanks to renew the spring. At that point, around 15 wells provided water to the state of around 2,000 houses. The biodegradable toxins released from every family are gathered, actually and organically treated through an engineered land framework, and afterward shipped off Naracipla. The pattern of water framework and biodegradable contamination treatment is finished in a little geographic region in an environmentally and monetarily worthy way

5.1.2 Thailand

The Thai Government's "Thailand Tank Undertaking" is as yet the solitary water collecting effort on the planet. In the years beginning in 1985, the nation made 6 million jars to gather water for drinking. Thusly, around 36 million individuals drank a limited quantity of excellent beverages in their families.

Fig 5.2 Jar For Storing Rain Water

Presumably no non-industrial nation gives perfect and safe refreshments to most of the populace thusly, and the creation productivity is extremely high. As per a study of 513 families in 1985, the accompanying ends are drawn:

- Everyone needs to drink 5 liters of water every day
- The average number of people in each family is six
- One hundred and fifty days of the year, the water in the jar must be used
- These household tanks with a capacity of 2,000 liters are sufficient

The joint review shows that the rooftop space of houses goes from 50 square meters to 150 square meters, with a normal space of 80 square meters. For a 80-meter rooftop, 25 mm of breakdown is sufficient to recharge 2 cubic meters (2,000 liters) of water. The normal yearly pace of destruction in the Realm of Thailand is 1,000 millimeters. Thusly, even in generally dry years, the measure of precipitation at whatever period of the blustery season is adequate to give drinking water consistently. It is assessed that there are 6,000,000 families in rustic Siam. Assuming one should give 80% of this reach a can, a sum of 4 jars are required, that is, 80,000. The objective of one board of trustees is to give 5 million containers.

It was concluded that once the Ruler of Thailand commended his 60th birthday celebration, this objective ought to be accomplished inside 1987. A public arrangement on drinking water and homegrown water has been drawn up. Albeit this course of action is for a five-year time span, the objective has been set at 80% in the initial two years. A board of trustees has been set up to be answerable for innovation improvement, preparing, advertising and advancement, reserve securing and observing advancement. Rhythms with water tests on the rooftop are assembled in containers to make the nation's limited scale gatherings held in the towns in transit. The public authority will give concrete, data sources and direction. The work and worth, everything being equal, should be borne by the client.

Bricklayers got preparing at the region level. The Checking and Examination Subcommittee watches out for the advancement of the program. In every aspect of Thailand, from April to October, the precipitation is acceptable. November to Walk (150 days) is a dry time. In this season, they will pour a ton of water from the tank since they can make certain to top it off rapidly. In October, they need to affirm that the container is full so it tends to be utilized inside the following five months. The southern district is fortunate to cause substantial downpours in November and December. This implies that they will just have a dry time of around 90 days.

The worth of a container of two cubic meters of materials is somewhere in the range of fifteen and twenty dollars (where it is set). Each container requires two worker hours to make. To give help to townspeople to help themselves, the Thai government dispatched an asset. It works like this: the public authority can give 10,000 baht as introductory financing. Every family taking an interest in the venture should pay 400 baht to the asset to take care of the expense of materials. Townspeople's preparation on tank development strategies is financed by the Thai government and led by common colleges. Every town sent two learners to present advancement innovation, activity and upkeep innovation to them. Once prepared, they will show this information to others in the town. The thought is to profit clients who are worried about the stock of drinks so they can acquire the gifts and certainty they need in future activities.

Notwithstanding government gifts, the non-government and individual areas have additionally given generous assets. Three private concrete organizations gave 1.503 huge loads of concrete. The executing organizations likewise have motivations. Regions where everything families can utilize the container administration were granted the recognized "brilliant container" title. Mahasurakham Area was quick to win the honor. Afterward, Phayakaphumpisai, Nakhon Ratchasima Buriham and Phetchaburi Region stuck to this same pattern. By 1986, 1.3 million containers had been finished. By 1987, this number had ascended to 9 million, giving drinking water to 75,000 families. Considering the huge limit and little limit jostles that have been made (around 14 million), by 1987, the same limit added up to 5.7 million containers. Thusly, 80% of families are covered.

5.1.3 Germany

As of now, in Germany, particularly at the public authority level, individuals are progressively keen on advancing family water grouping. Because of serious mechanical air contamination and severe guidelines identified with refreshment principles, the inventory of family water is restricted to non-drinking water utilizes, like latrines, launderable articles and nursery watering. As well as decreasing by and large family water interest, the benefits of water use additionally incorporate the need to control and lessen the capacity to release water. When utilized related to impenetrable wells, any flood can be gotten back to the surface, and these frameworks will likewise upgrade groundwater re-energize. Most family water tanks are made underground. A new plan is to introduce a punctured ring on the highest point of the water tank, so once the water tank is the greater part full, the water will saturate the base.

The primary benefit of preparation a water order framework along these lines or with splashing wells is that numerous German urban communities charge property holders a yearly water release expense, which is deferred if freshwater spillover is held or gotten back to the base, which can save you A great deal of cash. For instance, in Bonn, the current yearly charge is 1.80 USD per square meter of rooftop space and encased environmental factors (König, 1998)

Fig 5.3 Gardening Using Rain Water

In several cities in Germany, subsidies and subsidies are provided to encourage homeowners to build fresh water tanks and seepage wells. In Wessels, R.'s Osnabruck, reported in 1994 that each family there could receive a subsidy of between US$600 and US$1,200, while an additional subsidy of US$3 per square meter of roof space was used to drain water to any well-permeable water tank. According to this subsidy, water costs (US$0.56 per cubic meter) are saved, and rainwater discharge fees of US$1.30 per square meter per year are drained. It is estimated that the investment payback period during the construction of the oil tank seepage well system in the new house is twelve years . Even without subsidies and building systems on existing houses, the investment will be recovered within 19 years. If the homeowner is prepared to take on some work on his own, then the price and return on investment will be greatly reduced.

5.1.4 Brazil

In the previous ten years, some non-administrative associations and grassroots associations in Brazil have zeroed in their work on the assortment of water from drinking water mining, and consequently utilizing underground stockpiling tanks to flood limited scope agribusiness. In the semi-bone-dry tropical locale of northeastern Brazil, the yearly precipitation changes from 200 mm to 1,000 mm, and the precipitation is unevenly conveyed. Generally, people utilized water gathered close by burrowed rock catchments and stream bedrock catchments. To tackle the issue of problematic water supply in the rustic spaces of northeastern Brazil, numerous NGOs and the public authority have cooperated to dispatch a venture that will foster 1 million water tanks inside 5 years, profiting 5 million individuals. The vast majority of these tanks are results of precast substantial sections or wire network concrete *(D Sant'Anna)*.

As of now, the assortment and utilization of water is a basic piece of the feasible life instruction program in Brazil's semi-dry districts. The idea of water usage has likewise been reached out to different pieces of Brazil, particularly metropolitan regions. Another illustration of the developing interest in water reaping and use is the Brazilian Water Catchment Affiliation set up in 1999, which held the third Brazilian Water Use Meeting in the pre-winter of 2001.

5.1.5 Botswana

Neighborhood schools all through the Republic of Botswana, metropolitan chambers under the Service of Grounds and Lodging (MLGLH) have made great many rooftop constructions and water tank frameworks in the places of thousands of different rooftop schools and sterilization frameworks and government offices. The underlying tanks were pre-assembled electrifies steel tanks and block tanks. The presentation of excited steel tanks is poor, and the short help life is around 5 years. Block tanks are disliked because of breaks brought about by breaks and high establishment costs. In the mid 1880s, MLGLH supplanted these capacity tanks with iron concrete stockpiling tanks of 10 to 20 cubic meters advanced by the Specialized Focus of the Republic of Botswana in certain spaces. In the Republic of Botswana, the experience of utilizing ferroalloy concrete stockpiling tanks has been blended. Some performed well, yet some spilled, conceivably because of poor inward control.

RAINWATER HARVESTING IN PAKISTAN

5.2.1 Cholistan

Pakistan has 70 hectares of dry and semi-bone-dry land, representing about 80% of its complete geographic region. Among the 41 Mha parched districts, 11 Mha have a place with the principle deserts with incredibly bone-dry environment (Kahlown and Majeed, 2004). These deserts are: Cholistan (2.6 Mha), Thal (2.3 Mha), Thar (4.3 Mha) and Chagi-Kharan (1.8 Mha). Cholistan is an enormous desert in Punjab Region, comprising of sand rises, sandy soil, topsoil and saline-salt earth. The number of inhabitants in the desert is around 110,000, and the number of inhabitants in domesticated animals is around 2 million. The populace is dissipated in various pieces of the drinking water supply. Low and inconsistent precipitation (yearly normal of 166 mm), high temperature (up to 55 degrees Celsius in summer), low mugginess, high dissipation rate and solid summer rainstorm are the principle qualities of the environment. Groundwater is primarily salt water, which isn't appropriate for people and animals to drink. Because of these limitations, the neighborhood populace is migrant is as yet searching for water and feed to discover creatures.

The principle wellspring of new water in the Cholistan Desert is water, which is gathered in characteristic sorrows or fake lakes called tobas locally. There are more than 1500 tobas in the desert, of which just 500 are being used. A large portion of these tobass are not in the proper spots, as these areas have not been resolved dependent on logical data. Because of the great porousness and temperature in the sandy soil in summer and the impact of solid breezes, a large portion of the water gathered in tobas is lost because of penetration and dissipation. Sedimentation of Tobas is another major issue, which can rapidly decrease its stockpiling limit, particularly during the storm season. To advance the present circumstance, PCRWR (Pakistan Water Exploration Gathering) has been effectively taking part in different innovative work (Research and development) exercises to improve the financial status of occupants.

Precipitation is the solitary wellspring of new water in the desert. As per the review, around 350 million cubic meters of overflow can be put away in the desert. The consequences of the exploration led at Dingal Station show that by gathering water deductively, the drinking water needs of occupants can be effectively met (*PCRWR* | *Pakistan Council of Research in Water Resources*).

Develop water collection system

Because of field research on water gathering innovation, PCRWR started a four-year innovative work (Research and development) program in 2001 to make water in the desert accessible for drinking. Exercises completed include: overview studies to distinguish reasonable catchment regions; direct segment studies to evaluate water interest; lead hydrological exploration to survey the overflow capability of the catchment regions; lead geographical reviews to decide the incline of spillover; Build up an organization of trenches, lead soil profile studies to decide the physical and substance properties of catchment regions/lakes, and plan and examine water assortment frameworks to appraise the measure of common works

Collect rainwater

To handle the issues looked by the desert people, 92 water gathering systems have been made on a pilot scale. Each structure fuses fragments like supplies, energy dissipators (steps), limit dividers, buildup lakes, lining channels, and an association of channels in the watershed.

The archive is proposed to assemble approximately 15,000 cubic meters (4.0 US million gallons) of water. The significance of the lake is 6 m. Polyethylene sheets (0.127 mm) are given on the bed, and earth of slag mortar (3.81 cm), quicklime, wheat straw and substantial mixes are given on the pool divider to restrict spillage. The proportion of mortar in a lake fuses 6 cubic meters of mud, 100 kilograms of lime, 970 kilograms of wheat straw, and 0.06 cubic meters of cement. The size of the energy dissipater is 1m wide, and the length and height along one side of the lake are 23 cm independently, which can guarantee the different sides of the lake and the stream bed from the typical strong water breaking down. The cutoff divider limits untamed life and creatures, yet also gives a block to hold sand and buildup back from moving under strong summer winds. A little buildup lake controls the part of profound residue and rubbish in the lake. Each lake is related with the catchment area through a fixed channel with an association of channels. It has been seen that during the swirling season (winter or tempest), all phony lakes are totally filled. Examination of the water idea of the picked lakes showed that the water quality was inside quite far, excepting turbidity. For the most part, trained creatures drink water directly from the lake. Regardless, inhabitants add alum preceding drinking water, which can be set in a mud pot for a couple of hours.

Impacts of the rainwater harvesting project

All these pilot exercises have stirred the familiarity with individuals of the desert and the pertinent improvement organizations working around there, subsequently achieving an upheaval. The undertaking harvests around 368 million gallons of new water every year to meet the drinking water needs of people and animals. Also, because of the decrease of animals relocation, mortality, sickness and yield harm, the venture saved 6 billion rupees for each dry spell as animals creation. As well as lessening the movement of people and domesticated animals from deserts to inundated regions, it additionally expanded domesticated animals creation as meat, milk, and different employments.

Achievements

- Of the 350 million cubic meters of runoff potential, 92 experimental rainwater collection systems that have been scientifically designed have successfully utilized 1.35 million cubic meters. By adopting it, the remaining potential can be easily utilized.
- The annual average can provide about 368 million gallons of fresh water. However, it is recommended that local people maintain the system to make it sustainable (*PCRWR | Pakistan Council of Research in Water Resources*)..

5.2.2 Faisal Mosque (Islamabad)

As the population of Islamabad grows, the reserve groundwater reserves of these capitals are declining. The Faisal Mosque collected rainwater to solve this problem

Fig 5.4 The Faisal Mosque in Islamabad

At the point when it down-poured intensely on the top of Faisal Mosque in Islamabad, around 3 million liters of water moved through its waste lines each day. The biggest mosques in Pakistan and South Asia are not, at this point simply a motivation for devotees. It has as of late become a wellspring of individuals' prosperity.

In the past two decades, when monitoring oil wells throughout Islamabad, it was found that the groundwater level was dropping by one to two meters every year. Therefore, the Pakistani government cooperated with the United Nations Development Program (UNDP), which initiated a pilot project at the Faisal Mosque to collect rainwater.

Drain pipes are installed to carry water to the nearby perforated forest

Fig 5.5 Drainage pipes laid to collect water

Filtering the rain water

The waste organization of the Faisal Mosque was set up prior to shielding the structure from flooding. Be that as it may, water research specialists didn't squander water, however created another framework to change over water into clean drinking water. Covered up under a metal cover in the backwoods close to the mosque, there is a tremendous repository. Here, the water is separated with the guide of a sand channel bed. After the channel is separated, the water streams down the upward line to the groundwater level.

Two boreholes were installed, just like tube wells, allowing rainwater to flow into the well by gravity. The direct result of the notice is that after 3 days of rain, the local groundwater level has risen by 14 feet. Therefore, this is a huge success(*PCRWR* **|** *Pakistan Council of Research in Water Resources*).

5.2.3 AJK and KPK Rainwater Harvesting by ERRA

Before the 2005 earthquake, AJK and KPK's EQAA (Earthquake Disaster Area) had 55% water coverage. The devastating earthquake on October 8, 2005 severely affected more than 4,000 existing water supply plans and almost all water sources in the area were damaged. According to reports, water production has dropped by about 40%.

In response to the high demand for water in the EQAA, ERRA (Earthquake Reconstruction and Restoration Agency) is prioritizing the reconstruction and repair of the affected water supply plan. However, the completion of these facilities will take several years, and the repair and reconstruction of the affected projects is not enough to solve the problem of depletion of water sources. This has indeed brought benefits to people who did not have any water supply plans before the earthquake.

Few EQAAs (Bagh, Rawalakot, Muzaffarabad and Abbottabad) are practicing rooftop RWH technology, these technologies require technical improvements and require large-scale promotion *(ERRA* **|** *S Zaheer Gardezi)*.

Fig 5.6 Roof water harvesting

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Fig 5.7 Pond for livestock (Muzaffarabad)

ERRA not only helps alleviate water shortages, but also helps promote hygiene by building toilets with each house. According to estimates, it saves at least 3-6 hours of women's time every day, who spends a lot of time collecting water from remote water sources in hilly areas. This period of time can in turn be used for other livelihood activities, and will certainly help increase the enrollment rate of female students.

DESIGN MODEL FOR CENTER OFFICERS MESS

Risalpur is one of the most water-stressed areas in Pakistan. The water provided is hard water, not suitable for drinking or domestic use. For drinking purposes, water is shipped from Nowshera, which not only increases the cost, but also increases the difficulty and hard work of the management system.

The amount of rainfall is not very high, but making the catchment area larger can increase the amount of water available. As rainwater, the water has good quality and no chemical impurities, so it can not only be used in households, but also can be used for drinking by applying additional purification steps. The design process that will be used will be based on Agrodok 43.

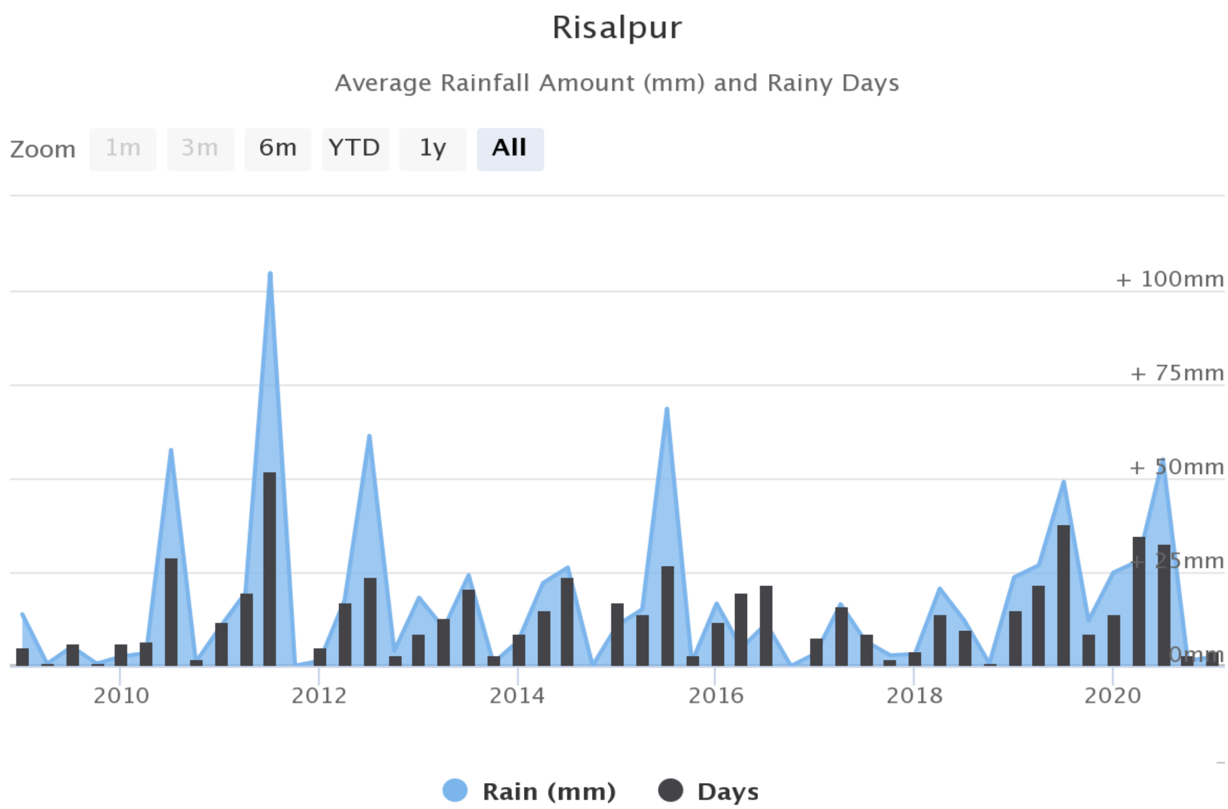
7.1 Total amount available rainwater

7.1.1 Available water:

Name of location: Risalpur, Pakistan
Latitude: 34.06400 (decimal degrees)
Longitude: 71.99443 (decimal degrees)

Table 7.1 Rainfall Data(10 Years Average)

Month	**Rainfall (mm)**	**Rainfall Days (Nos)**
January	6.2	2
February	11.9	3
March	13.7	5
April	10.8	6
May	17.8	6
June	17.1	6
July	44	10
August	51.6	10
September	24.8	5
October	2	1
November	1.4	1
December	2.8	1
Monthly Average	**17**	**5**



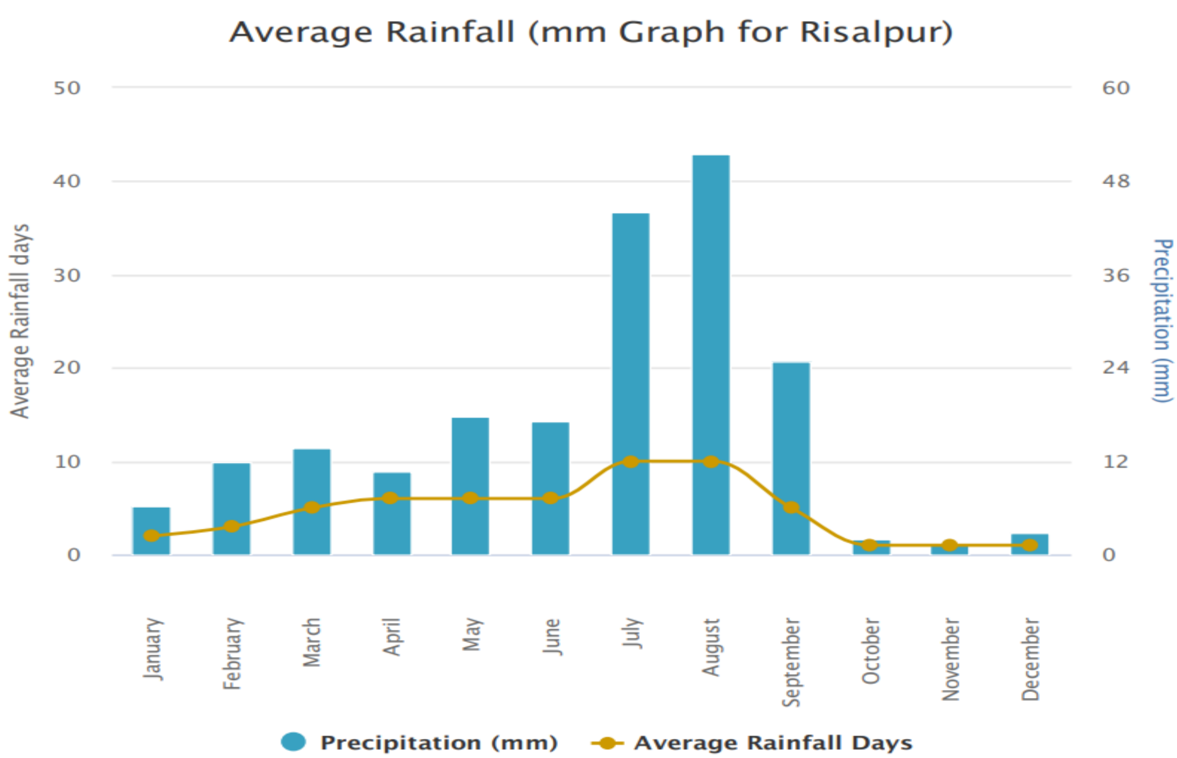


Fig 7.1 Rain Fall Chart

7.1.2 Calculations

$S = R \times A \times Cr$

Supply = Rainfall × Area × Run-off coefficient (RC)

Where:

S = Mean annual rainwater supply (m3)

R = Mean annual rainfall (m)

A = Catchment area (m^2)

Cr = Run-off coefficient

Assume Cr = 0.7 (for concrete roof Cr=0.7 – 0.75)

Area for designing is 1900 m^2 (Center officers mess Roof Area).

A = 1900 m^2

Mean annual rainfall = 1.7 in = 43.2 mm = 0.0432 m

Run-off= $S = R \times A \times Cr$

$S = 0.017 \times 1900 \times 0.7$

= 22.61 cubic meter

Co-efficient for evaporation, spillage and first flush = 0.8

The assortment productivity represents the way that all water falling in a specific region can't be gathered adequately due to evaporation, overflow, and other reasons. The first flush is wasted, that is, the first rainwater is flushed away, and evaporation and overflow do not enter the system, so a constant coefficient of 0.8 can be used in all cases. This was done in light of the fact that the main downpour was joined by a moderately enormous measure of poisons from the air and water assortment surface.

Amount of rainfall available for use = 22.61 × 0.8

= 18.1 cubic meter

Table 7.2 Monthly Run-Off Values

Month	Monthly Water Available(m^3)
January	6.59
February	12.66
March	14.57
April	11.49
May	18.93
June	18.2
July	46.81
August	54.9
September	26.38
October	2.12
November	1.45
December	2.97
Monthly Average	18.1

Water supply = 18.1 cubic meter

7.2 Selection of the catchment area

As long as the roof is clean, the roof can provide an ideal water collection surface for collecting rainwater. The roof of the center officials is a cement roof. There is no debris or rubbish on the roof because it is not easy to enter and there is much less leaf rubbish due to the height of the structure.

Fig 7.2 Center officers Mess Roof

7.3 Designing delivery system

Drain pipes are usually installed on the roof to supply rainwater. The extra work is to connect the collector piping to our purification and storage system.

For the case of the center staff Mess, we connected the PVC pipe to the existing water collection pipe, and then led it to the designed filter system and then to the storage tank.

Fig 7.3 Delivery System

First flush

For an area of 100 square feet, 1 gallon is required for the first flush, but we are neglecting this because of less rainfall so the container we use has a capacity of 30 liters, which is equivalent to 8 gallons.

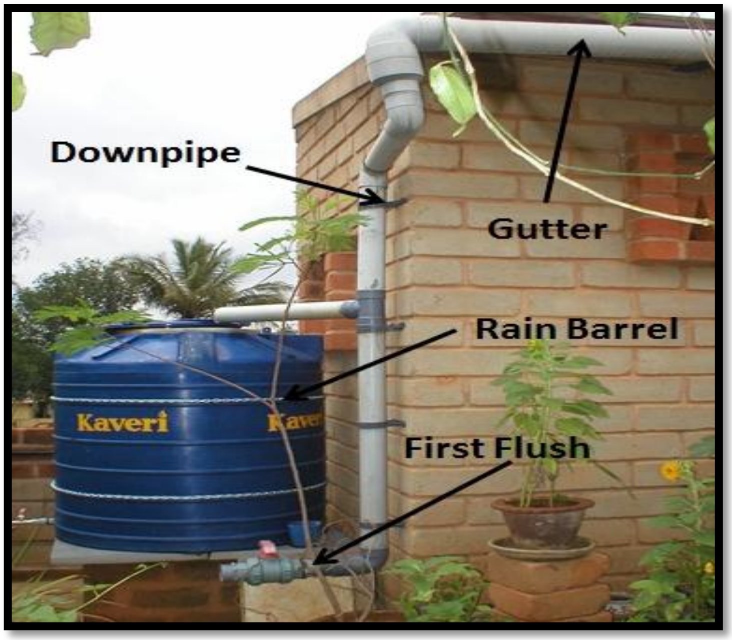


Fig 7.4 First Flush Apparatus

7.4 Selection of storage reservoir

Due to sufficient storage capacity and meeting our requirements, we chose a simple and easy traditional storage method using 300 gallon fiberglass storage tanks.

Fig 7.5 Fiber Glass Water Tank

BENEFIT COST RATIO

Average Water Requirements

- **Lawn Irrigation (By Calculations)**

  1-1.5 in per week (Average)   (1 in = 0.0254m)

  Front Lawn Area = 2826 m^2

  Take 1.3 in for our calculations   (1 month = 4.28 week)

  1.3 x 0.0254 = 0.033m

  Or,

  Total Irrigation required = 0.033m x 4.28 x 2826m^2 = 399.14 m^3/month

- **Lawn Irrigation (By Crop Water Irrigation)**

  1708.9mm/ year = 1.7 m/year

  1.7m x 2826 m^2 = 4804 m^3/year

  Or

  4804 / 12 = 400 m^3/month

- **Sanitation**

  15 L per capita per day (Average)

  For our calculations we take 30 persons as mess staff

  15 x 30 x 30 = 13500L / Month (30 x persons)

  Or

  = 13.5 m^3/month

- **Car Wash**

  120 – 150L per Wash (Average)

  We assume 3 x cars per week

  150 x 3 x 4.2 = 1890L/ month

  Or

  = 1.89 m^3/month

Water Calculations

- **Total Water Required**

  (338.67+400)/2 + 13.5 + 1.89 = 369.33 m^3/month

  Or

  = 15.39 m^3/month (Excluding irrigation)

- **Water Available (From Rainwater Harvesting)**

  = 18.1 m^3/month

- **Water Saved (After Consumption)**

  = 18.1 – 15.39 = 2.71 m^3/month (can be utilized for irrigation)

RECOMMENDATIONS

- Since a lot of water is required for irrigation purposes, rainwater alone cannot meet its demand so it must be discarded as long as irrigation of lawn is concerned.

- We can use succulents plants which use less water for irrigation like cactus.

- This method must be applied to provide water for household sanitation purposes, which will greatly help alleviate water shortage.

- It is difficult to achieve rainwater harvesting at the individual level, so it should be achieved at the group level.

- Pakistan should implement a strong institutional foundation for community-based organizations and support organizations, currently there is no dedicated rainwater institute in Pakistan.

- Water reaping ought to be utilized for money creating exercises in light of the fact that the framework will take care of the speculation inside 2-4 years.

- Funds should be provided directly to community groups in an effective way. For small rainwater enterprises, microfinance should be considered.

- In broader usage, rainwater collection should be carried out in the catchment area leading to the reservoir storage area. The main advantage of this is that it can reduce the sediment pressure on dams (such as Mangla and Tarbela) by controlling a large amount of runoff.

- Groundwater recharge technology should be adopted in areas with very low groundwater levels, and this step should be taken at the government level.

- The provisions in building codes should be introduced at the government level to make it necessary to incorporate rainwater into houses. For a model, Islamabad's building codes have been revised to include rainwater collection design codes for buildings covering more than 400 square yards.

- It must be effectively utilized for billion tsunami tree project thereby reducing their dependence on fresh water provision through other sources.

CONCLUSION

Pakistan is one of the nations where the water emergency is imminent. Up until this point, just restricted consideration has been given to enhancing the water executives framework. Among different advancements to build water assets, Rainwater harvesting might be a decentralized technique that can keep at bay huge scope projects that concerned environmental strategies. There are numerous explanations behind utilizing RWH, from drinking water to homegrown use, water system purposes, animals and groundwater recharging. It can not just meet the UN's SDGs goals, yet additionally make Pakistan a country with plentiful water assets. Moreover, whenever utilized appropriately, we can likewise send out water to water-scarce nations, subsequently improving and assisting with satisfying worldwide water need.

REFERENCES

- The Water Crisis in Pakistan. Retrieved Jan 9, 2021, from http://www.worldwatersolar.com/

- Clean Water and Sanitation. (SDG 6). Retrieved Feb 21, 2021, from http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-6-clean-water-and-sanitation/

- Sustainable Development Goals. Retrieved Feb 22, 2021, from http://www.un.org/sustainabledevelopment/water-and-sanitation/

- CAWST, Nov 2011, Introduction to Household Rainwater Harvesting.

- Aftab, T. B., Khattak, B. N., & Hasnain, S. A. (2011). Rainwater Harvesting System in Ajk, Pakistan. Van Haren Publishing.

- Ali, S., Zhang, S., & Yue, T. (2020). Environmental and economic assessment of rainwater harvesting systems under five climatic conditions of Pakistan. Journal of Cleaner Production, 259, 120829.

- Rainwater Harvesting Project at the Development Technology Unit of School of Engineering, University of Warwick, UK.

- Abbas, S., Mahmood, M. J., & Yaseen, M. (2021). Assessing the potential for rooftop rainwater harvesting and its physio and socioeconomic impacts, Rawal watershed, Islamabad, Pakistan. Environment, Development and Sustainability.

- Ahmed, T., Sheikh, A., Shah, S., Khan, M., & Afzal, M. (2019). Rainwater harvesting Scenarios and its prospective in Pakistan. Meteorology Hydrology and Water Management.

- Sanewe, A. J., & Backeberg, G. R. (2012). Overview of Research on Rainwater Harvesting and Conservation by the Water Research Commission. Irrigation and Drainage, 61, 1–6.

- Annual Water Report. Pakistan Council of Research in Water Resources

- Rain Water Harvesting, Practical Action Technical Brief

- Gould, J. and Nissen-Petersen, E. (1999) Rainwater Catchment Systems for Domestic Supply: Design, construction and implementation. IT Publications, London.

- Shafique, M.; S. Ahmad and M. Aslam (1994). Potential for Water Harvesting under Medium Rainfall zone of Potohar, Pakistan. Science Technology and Development,13(3): 45-49

- Ahmad, S. 2008b. Pakistan Water Apportionment Accord: Water Entitlements and Key Issues –National and Baluchistan Perspectives. Vol. (4), No. (4), TA-4560 (PAK), Quetta, Pakistan.

- PADMU, 1983, Country report Pakistan - Desertification problems, extent and remedial measures.

- PCRWR, 2004a, Research study on evaluation of impact of research and development projects implementation on desertification in Cholistan. Final Report. Pakistan Council of Research in Water Resources (PCRWR). Publication No. 129.

- Pakistan Council of Research in Water Resources (PCRWR). Publication No. 130.

- “Promotion of Rain Water Harvesting - RWH” in Earthquake Affected Areas (EQAAs) of NWFP / AJK By: S. Zaheer Gardezi (Director WatSan – ERRA)

- Agrodok 43: Rainwater harvesting for domestic use; Janette Worm, Tim van Hattum.