"Rainwater Harvesting System in Ahmadpur City"

A dissertation Submitted to

Tilak Maharashtra Vidyapeeth, Pune

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IN

GEOGRAPHY

Under the Faculty of Moral and Social Sciences

BY

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JUNE-2011

CERTIFICATE

*This is certified that the dissertation entitled **“Rainwater Harvesting System in Ahmadpur City”** which is being submitted herewith for the award of the Degree, of Master of Philosophy in Geography of Tilak Maharashtra Vidyapeeth, Pune is the result of original research work completed by Shri. **Parmeshwar Vishwanathrao Poul** under my supervision and guidance. To the best of my knowledge and belief the work incorporated in this dissertation has not formed the basis for the award of any Degree or similar title of this or any other University or examining body.*

Date: 21 /06/2011

Place: Ahmadpur

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DECLARATION

I hereby declare that the dissertation entitled, ***"Rainwater Harvesting System in Ahmadpur City"*** *completed and written by me has not previously formed the basis for the award of any Degree or other similar title of this or any other University or examining body.*

Date: 15/06/2011

Place: Pune *Research Student*

Poul Parmeshwar Vishwanathrao

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Date: 15/06/2011

Place: Pune *Poul Parmeshwar Vishwanathrao*

CONTENTS

Contents

List of Figure

List of Map

List of Table

List of Graph

List of Chart

List of Photo

List of News Snap

Abbreviation

RWH– Rainwater Harvesting

RWHS– Rainwater Harvesting System

DRWHS– Domestic Rainwater Harvesting System

RRWH–Roof Rainwater Harvesting

RSRWH – Road Rainwater Harvesting

UN– United Nation

Cm– Centimeter

FAO– Food & Agriculture Organization

BCM – Billion Cubic Meters

GOI– Government of India

LPCD– Liters per capita per day

Mm– Millimeter

ML– Million Liter

₹ – Indian Rupees Symbol

GIS- Geographical Information system

RS – Remote Sensing

GPS – Global Position System

SOI – Survey of India

PVC– Polyvinyl chloride

UV– Ultraviolet

GI– Galvanized iron

HDPE– High Density Poly Ethylene

HRF – Slow sand filter

SSF– Horizontal roughing filter

MLD– Million Liter Daily

CGWB– Central Ground Water Board

NGO– Non Government Organization

Chapter I

INTRODUCTION

1.1 Introduction: Water is significant natural resource for human being. We use water for agricultural, industrial, domestic, recreational and environmental activities & Today's fresh water is a scarce resource. The reality of global water crisis cannot be ignored and India being poor in water resources management, the scarcity of water is a well-known fact in India. Most of the rain falling on the surface tends to flow away rapidly, leaving very little for there charge of groundwater level. As a result, most parts of India experience lack of water. Even for domestic uses Surface sources fail to meet the rising demands of water supply in urban areas, groundwater reserves are being tapped and overexploited resulting into declination in groundwater levels and deterioration of groundwater quality.

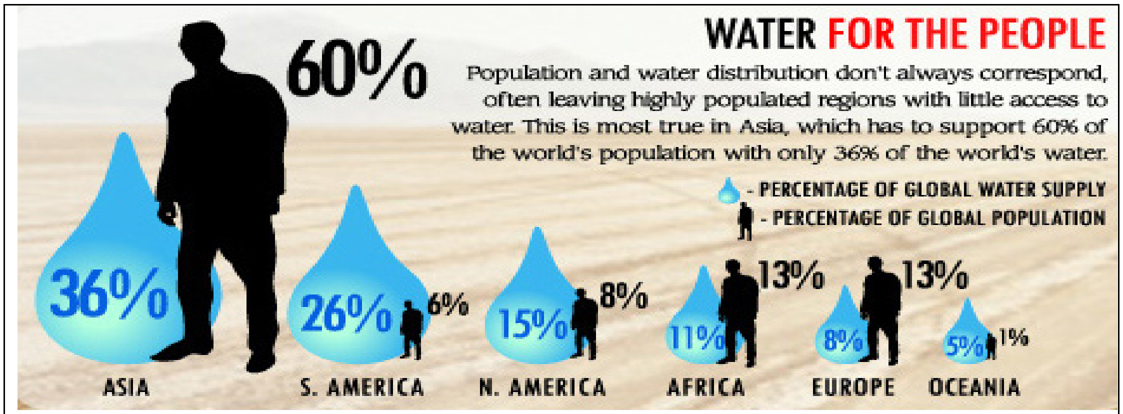
Majority of Indian city demand of water is already outstripping the supply. Ahmadpur city is one of taluka place in Latur district of Maharashtra experiencing same water scarcity due to lack of proper water management. This precarious situation needs to be rectified by immediate recharging of the depleted aquifers. Hence, the need for implementation of measures to ensure that rain falling over a region is tapped as fully as possible through rainwater harvesting, either by recharging it into the groundwater aquifers or by storing it for direct use. This study focuses on Ahmadpur's water situation, water demand trend, future water situation & water related issue. Main aim of this study is to check out how rainwater harvesting system can help to control the water scarcity.

1.2 Statement of problem: It is known that human requires fresh water. On Earth 97% of water is salty and only 3% as fresh water of which slightly over two thirds is frozen in glaciers and polar ice caps. The remaining unfrozen fresh water is mainly found as groundwater, with only a small fraction present above ground or in the air. Fresh water is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. Water demand already exceeds supply in many parts of the world and as the world population continues to raise rapid population growth, combined with industrialization, Urbanization, agricultural intensification and water intensive lifestyles is resulting in a global water Crisis.

About 20 per cent of the population currently lacks access to safe drinking water, while 50 per cent lacks access to a safe sanitation system. The world supply of freshwater cannot be increased. More and more people are becoming dependent on limited supplies of freshwater that are becoming more polluted. Water security, like food security, is becoming a major national and regional priority in many areas of the world. Map 1.1 shows that water crisis is increasing day-by-day and majority water shortage will accord in high populated area.

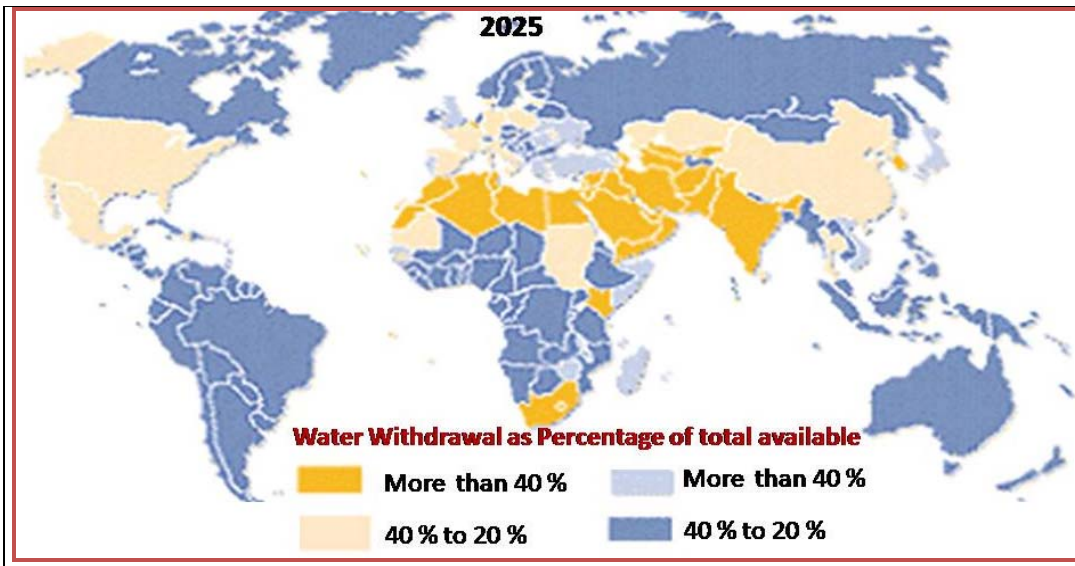
Map 1.1 Global Water scenario (Source – UNESCO)

Another thing world population and water distributions don't always correspond i.e. Asia.



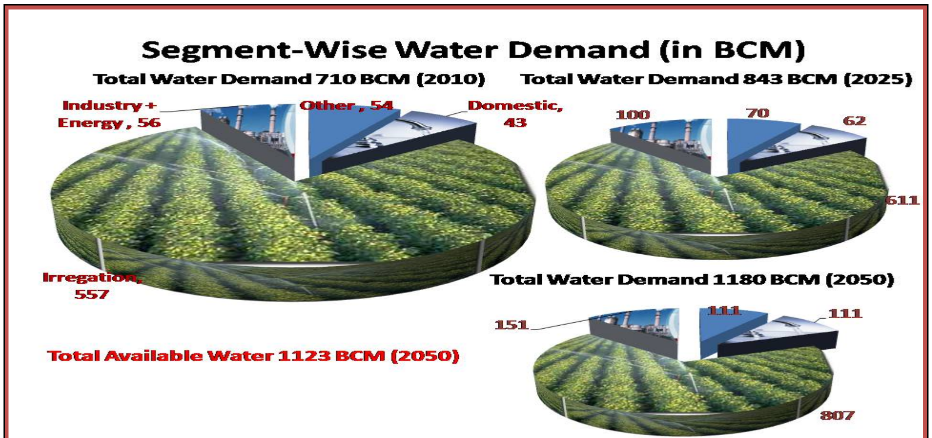
Graph 1.1 Water Source and Population Ration (Source – UNESCO)

Also it is trend that people are withdrawing groundwater than recharge, due to it groundwater level is continuously going down. Some countries have withdrawal more than 40 per cent of groundwater if this situation will continues after some decades we will loss groundwater resources. And after 2025, two thirds of the world population may be subjected to water scarcity.



Map 1.2 Global Groundwater Water Withdrawal Percentages (Source – UN)

It is estimated that the India's population will increase to about 1.26 billion by the year 2016. The projected population indicates that India will be the most populous country in the world and China will be ranking second in the year 2050. India has 18% of the world's total population & 2.4 % area of world's total area. Huge population pressure has been increased on its natural resources. The Government is also putting strong emphasis on this sector towards achieving the UN Millennium Development goal of safe drinking water and proper sanitation coverage for the entire population by 2015.The present per capita availability of water in India is 1,750 cubic meters (cm). This signifies 'scarcity' as defined by United Nations (FAO). The total water potential from surface and ground sources is around 1,123 bcm. By 2050, as projected by Ministry of Water Resources, Government of India (GOI).

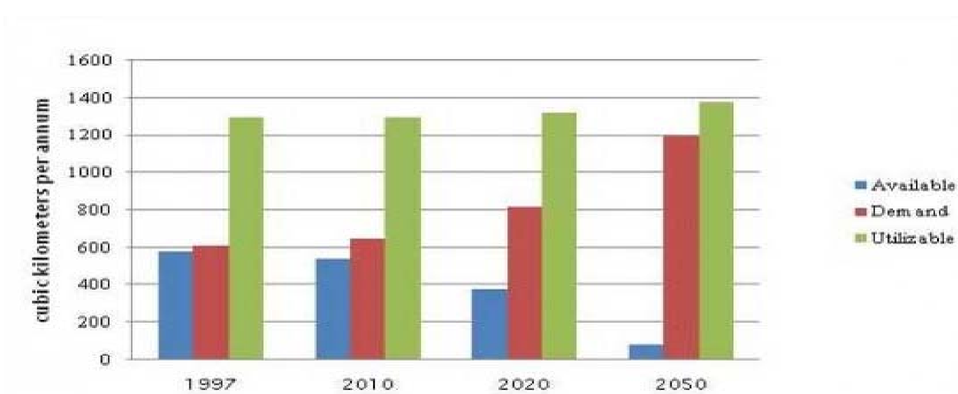


Graph 1.2 Segment-wise Water Demand of India

(Source- Source: Ministry of Water Resources, GOI)

In 1.2 Graph has been shown that today's water potential is (1,123 bcm) and it will be (difficult) to supply for the 2050's demand. In India utilizable water is good and it can fulfill today's water demand but due to the lack of water management Indian people are facing water shortage problem. Graph 1.3 shows overview of availability, demand & Utilizable water in India.

Available Water – Water Demand –Utilizable Water Status of India



Graph 1.3 Available Water – Water Demand –Utilizable Water Status of India

Sources: World Bank Report on Water in India

Demand of water is growing in most cities as every urban citizen requires almost double the amount of water that a rural citizen requires. Moreover, India is rapidly urbanizing.Urban population in India has grown almost five times in five last decades from 1951 (62.44 million) to 2001 (286.08 million). Not long ago, most of Indian cities were self sufficient in meeting their water needs from the extensive urban water bodies to supply water to citizens. Today these water bodies have completely disappeared. Municipalities have been stretched to their limits to find water for the growing urban populations. Groundwater is being extracted by the government as well as the private parties. This has not only resulted in increased per capita demand for water but also growing aspirations of people in terms of accessibility, reliability and quality of water supply.

The same situation is in Ahmadpur water source. As per collected information Ahmadpur Municipal is unable to supply 70 lpcd by traditional way and water demand is increasing day by day. It is true that Ahmadpur people have to face big water problem in the coming decade. As per projection, after 2050 Ahmadpur city water demand will be 3813702 liter per day and at that time water scarcity will become serious issue. So to overcome this situation, we should take precaution from today.

1.3 Need of Study: After over view of water crises there is a need to improve the water supply system across the India, both in terms of quality and quantity. Then so many things come in mind to solve this problem like water management, soil & land development, modified agriculture, watershed development etc. Rain water harvesting is one of the best solutions for it. Rinawater harvesting is the activity of direct collection of rainwater, which can be stored for direct use or can be recharged into the groundwater. Rain is the first form of water that we know in the hydrological cycle; hence it is a primary source of water for us. Rivers, lakes and groundwater are all secondary sources of water. In present times, we depend entirely on such secondary sources of water. In the process, it is forgotten that rain is the ultimate source that feeds all these secondary sources and remain ignorant of its value. Rainwater harvesting is to understand the value of rain, and to make optimum use of rainwater at the place where it falls. Here we assume that rainwater harvesting can help to solve water shortage problem but we should check out following thing because everywhere human admit only appropriate things. Therefore this type of study is needed.

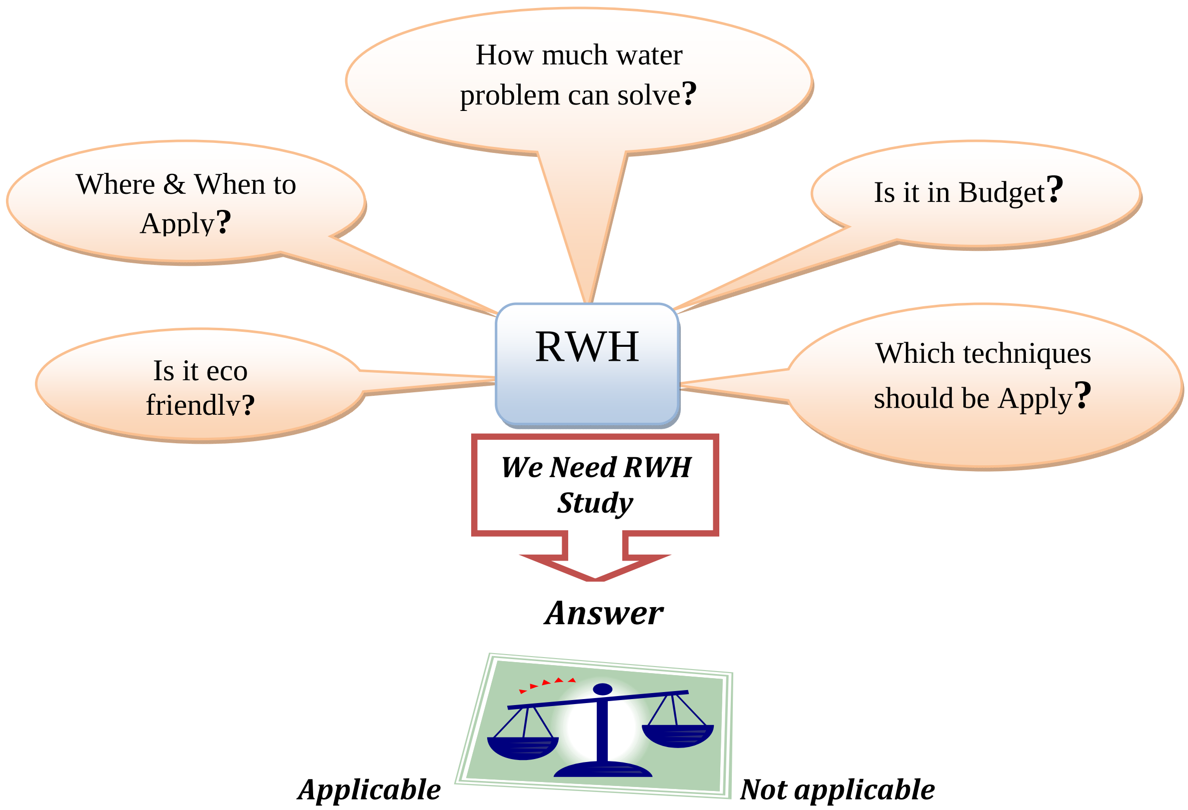


Chart 1.1 Need of RWH Study

1.4 Objectives: The main goal of this study is check out RWH potential of Ahmadpur and how RWH can help to solve water shortage problem of Ahmadpur. To achieve above goal following objectives are considered.

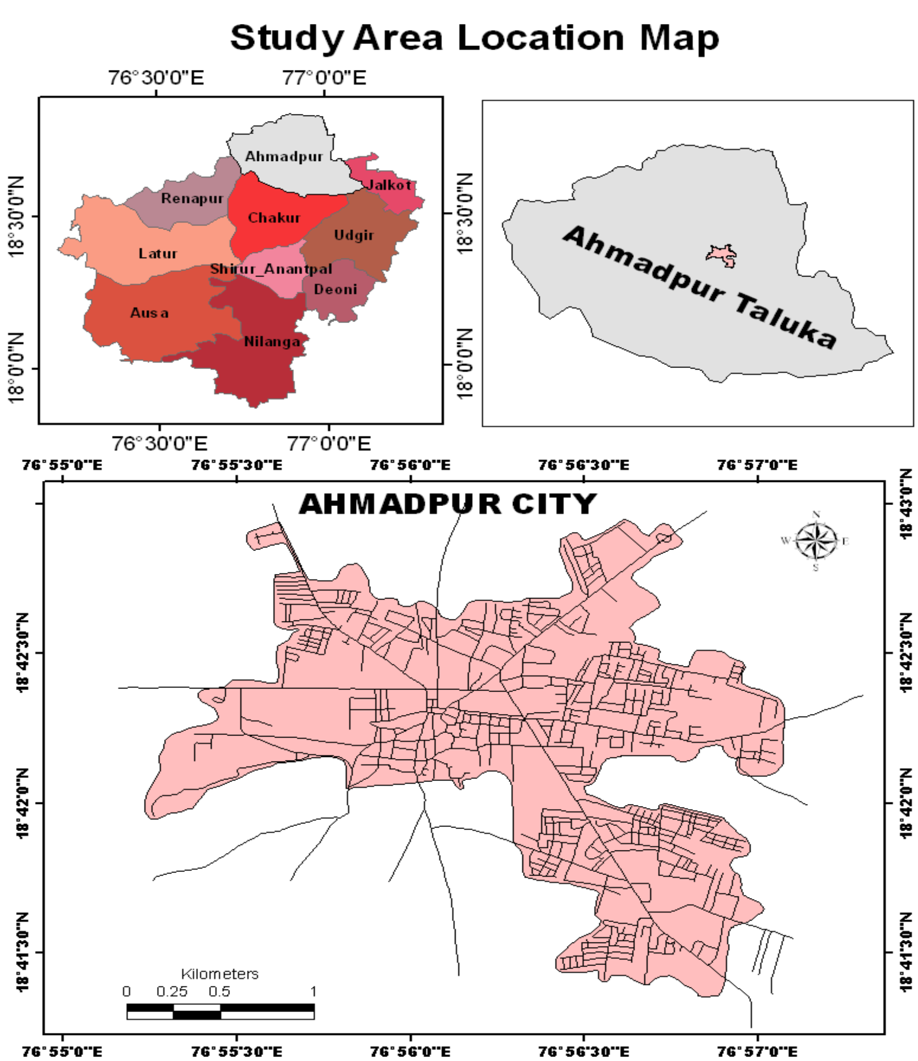
- Estimate need of water
- Calculate roof runoff coefficient
- To estimate roof runoff
- To develop model for increasing groundwater level
- To estimate cost of rainwater harvesting system

1.5 Assumptions:

- Ahmadpur average rainfall is 887 mm will remain constant.
- Ahmadpur population will grow as per study projection figure and its equivalent construction will increase.
- Ahmadpur daily available water is 3.5 (ML) will remain constant.

- In Ahmadpur currently per person daily minimum 70 liter water is require and as per life style and urbanization water demand will increase.
- Captured all features geometry (line, point & polygon) are correct.
- Data published on Government and other authentic Website is true and authentic.
- The information given by the responder is proper and true.
- Spatial and Temporal element can change the installation cost of RWH.

1.6 Study Area: Ahmadpur city is selected as a study area, which is one of the taluka in Latur District. Its latitude & longitude extends is about 18° 41' 20" to 18° 43' 00" North latitude and 76° 55' 34" to 76° 57' 50" East longitude covering an area of 17.1 sq. Km.



Map -1.3 Study Area Location Map

It is situated on Balaghat plateau at 500 to 550m above mean sea level. Ahmadpur city falls in monsoon climate region. The average maximum temperature is 39°C and average minimum temperature is 23°C. The rainy season start after mid June and continues till September. There annual rainfall is 887 mm. As per 2001 India census Ahmadpur population is 35,786. Males constitute 53% and females 47% of the population.

1.7 Justification for the selection of Study Area: Like other Indian city in Ahmadpur rapid development is taking place due to there good education center and its centrality location. The reality of water shortage problem cannot be ignored in Ahmadpur .It is fact that in summer Ahmadpur people have to pay average ₹ 30 per house to get daily required water it means that about 7000 houses will have to pay around ₹ 2,10,000 per day. There having 887 mm annual average rainfall. It is quiet well than dry region but still there having major water crisis. It is due to poor water resources management. Most of the rain falling on will flow, leaving very little for the recharge of groundwater. As a result Ahmadpur experiences lack of water even for domestic uses. Today majority of the population in the Ahmadpur depends on dam and groundwater. Most people use tube wells to complete their daily water needs. Its result, the groundwater table is falling down at an alarming rate. Surface water sources fail to meet the rising demands of water supply. Groundwater reserves are over-exploited resulting into turn down in groundwater levels. Extraction of groundwater is being done without planning viability, demand & Utilizable. This has resulted in: (a) Hydrological imbalance (b) Deterioration in water quality (c) Decrease ground water level (d) Rise in energy requirements for pumping (e) Decrease in vegetation & animal (f) Waste of time & money to collect require water (g) Lack of sustainable development.

There are many projects established to supply water for city but they have failed to supply required water. This precarious situation needs to be rectified by immediately recharging the depleted aquifers. There all factor support for there urbanization and sustainable development except water recourse. Today there having water crises and it will become major problem in coming decade. Government is making various policies to overcome water problem but get limited success. Only government can’t solve Ahmadpur water problem public should be involve in these activities. This study helps to examine Ahmadpur water shortage problem and its solution. Study can motivate public to use RWH and save them from water scarcity and also this type of study has not been done.

1.8 Literature Review: A research must have some idea in advance of what has been done so far in the field of inquiry. It is reinventing the wheel if we do not know what our predecessors have done in the filed of our interest. Here, an attempt has been made to review few scholarly works to understand the intricacies of being chosen for this research work.

Global water crises overview information has been extracted from USAID (2010). Summary of the World Water Crisis and USG Investments in the Water Sector, USAID**;** UN-HABITAT (2002).Rainwater Harvesting and Utilisation, UN-HABITAT, pp.1-8; Indian Water sources scenario information has been collected from Infrastructure (2009): H2O – The Next Mega Opportunity, Infrastructure Today, pp.1-2.

RWH concept, component, method & its Advantage-disadvantage information has been derived from Janette Worm Tim van Hattum (2006). Rainwater harvesting for domestic use, The Netherlands, pp.6-15**;** Guelph Water services group (2010): "Residential Rainwater Harvesting Design", African Development Bank, pp.1-17**;** Adrienne LaBranche, Hans-Otto Wack David Crawford, Ed Crawford, Nickolas J. Sojka, DVM and Cabell Brand (2007).Virginia Rainwater Harvesting Manual, The Cabell Brand Center, pp. 2-21**;** T.H. Thomas and D.B. Martinson (2007).Roof water Harvesting -A Handbook for Practitioners, The Netherlands ,pp. 15-69.

Research method such as estimation of rainwater harvesting potential, tank size, run-off co-efficient related work has been carried out from Arjun Bhattacharya & O’Neil Rane.Rainwater harvesting, Centre for civil society and Environment, pp.426-427**;** Shafiul Ahmed (2008).Rainwater Harvesting, Practical Action, pp.8-10**;** Prof. Bancy’s (2006). Potential for Rain Water Harvesting in Ten African City, RELMA & UNEP, pp.8-8.

1.9 Background of study:

The main goal of this study is to check out how much rainwater harvesting can help to work out for water scarcity of Ahmadpur. To achieve desire goal advance tools and techniques had been used like GIS, RS and Computer based model. The GIS techniques are applied to examine rain water potential and its use. Web page and RWH tools have been developed for RWH user. This study will help to gain RWH potential information & its method for Ahmadpur. It is useful for water recourses planning, environment & layman. This study aim is to show RWH essential for Ahmadpur stainable development. This study awakes Ahmadpur people for RWH techniques & its benefit.

Chapter II

DATA AND METHODOLOGY

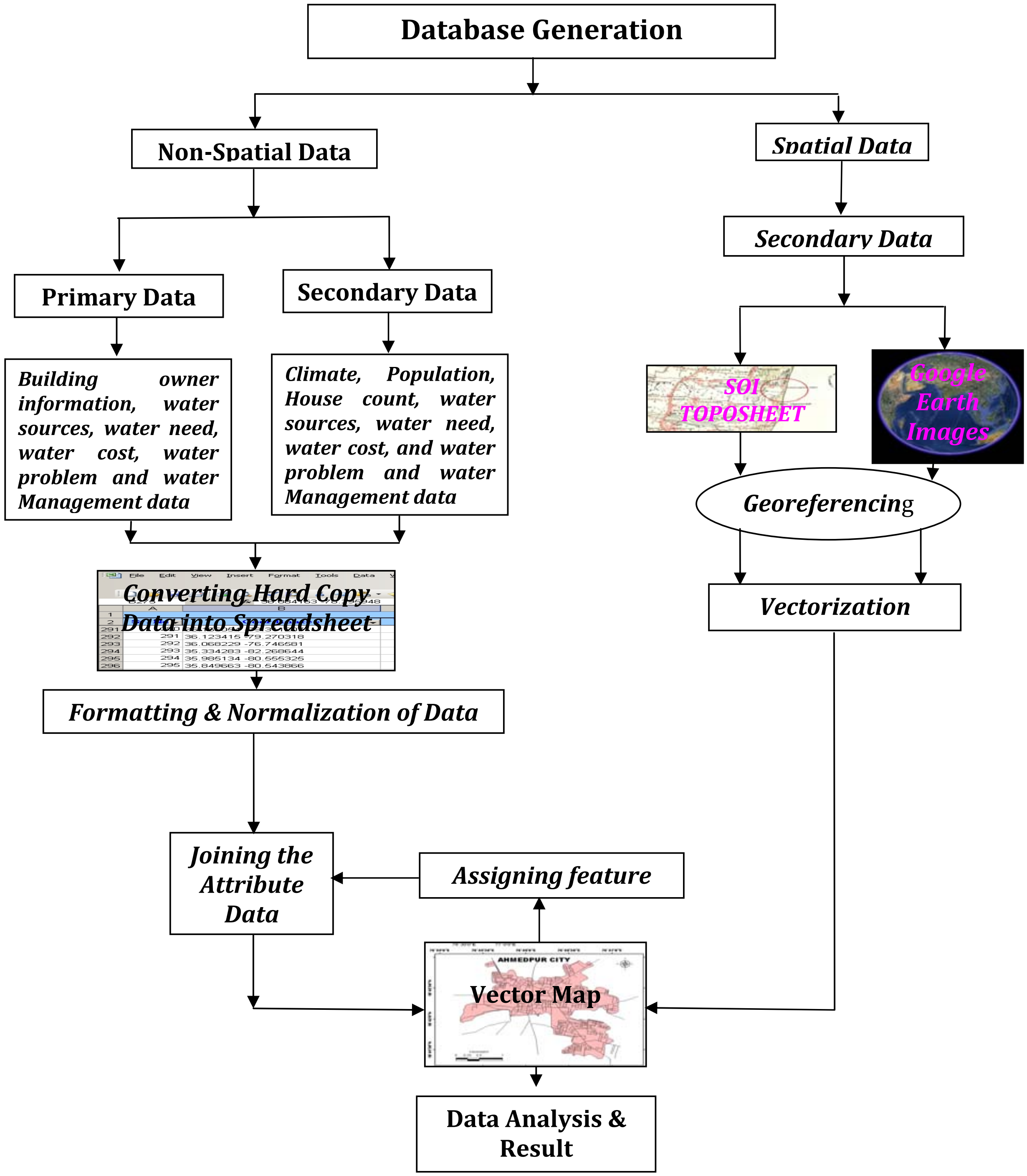


Chart 2.1 Database generation

2.1 Data Sources: The success of any research project highly depends on availability of up-to-date and authentic data. Data is the soul of any research and development activity including planning. For the present study, the data has been gathered from various sources.

2.1.1 Spatial Data:

2.1.1.1 Primary Data:

- Ground Control Points.

2.1.1.2 Secondary Data:

- Toposheet of study area at 1:50000 scales obtained from SOI, Pune.
- Google Earth's Satellite Image.(2005 & 2007)
- Google Map data
- Wikimapia data

2.1.2 Non spatial Data:

2.1.2.1 Primary Data: Primary data such as building owner, water sources, water need, water cost, water shortage problem and water management data has been collected by using '*random sampling data collection method*' to understand field situation.

1.1.2.2 Secondary Data: Secondary data such as climate, population, house count, water sources, water need, and water cost, water problem and water management data has been collected from Ahmadpur Nager Palika & Population Census (2001).

2.2 Hardware and Software requirements:

2.2.1 Hardware:

- Intel Pentium 4 (2.92 GHz) processor
- 80 GB hard disk
- 1 GB RAM
- 21" colour monitor
- GPS

2.2.2 Software:

- Microsoft Office 2003
- Arc GIS 9.3
- Google Earth
- Global Mapper 12
- Autodesk map

2.3 Methodology: To achieve this study objective, following methodology has been adopted.

2.3.1 Pre field Work: Pre-fieldwork involves literature review, problem identification of water, data collection and demarcation of study area. Preplanning of field works such as making questionnaires, Satellite Image map printing etc.

2.3.2 Field Work: In fieldwork attribute data has been collected by visiting the study area with the help of questionnaire. Discussion and question answer method is applied to collect data. Study area consists of more than 7000 building and collecting information of each building was not possible due to limitation of study budget and time. To overcome this situation, random data collection method is applied. Overall Situation of the study area is collected by discussing with authentic and native people.

2.3.3 Data processing work:

2.3.3.1 Data Downloading: Google Earth, Google map, government report & Census data has been downloaded via internet sources.

2.3.3.2 Georeferencing: Georeferencing means assign Earth location to the image. This task has been done over Google Earth image and toposheet in global mapper software

2.3.3.3 Digitization & Attribution: Digitization means capturing feature(s) with the help of GIS tool and store in polygon, line and point element. In this study city area, Building roof, Water body, road, Drainage, Stream, well and places are digitized on map and satellite images. Also some attribution also has been done while digitization such as ID and Name of feature.

2.3.3.3 Data Conversion & Joining: Data collected from field and other sources has been converted from hard copy to digital format using Microsoft excel software. Excel sheet data was converted in dbf format and this table has been joined to the vector data with the help of unique ID in Arc GIS software.

2.4 Data Analysis: After completion of desire digital data set following analyses have been done for getting the desire result .While analyzing some formulas are applied which is discussed bellow.

2.4.1 Calculation of runoff Coefficient: Runoff coefficient plays an important role in assessing the runoff availability and it depends upon catchment characteristics. It is the factor that accounts for the fact that not all rainfall falling on a catchment can be collected. Some rainfall will be lost from the catchment by evaporation and retention on the surface itself.

Formula:

$$\text{Runoff Coefficient} = \frac{\text{Collected rain water from catchment}}{\text{Total Rainfall water over the catchment}} * 100$$

General values are tabulated below which may be utilized for assessing the runoff availability

Roof Type	Run-off coefficient
Iron sheets	>0.9
Aluminum sheets	0.8-0.9
Tiles (glazed)	0.6-0.9
Flat cement roof	0.6-0.7
Organic (i.e. thatched)	0.2

Table 2.1 Roof Run-off coefficient

Source: *Janette Worm, Tim van Hattum (ISBN CTA: 92-9081-330-X 2006), "Rainwater Harvesting for Domestic Use" ICCO and AID Environment publication, Wageningen, Netherlands, pg -31*

2.4.2 Catchments runoff or RWH Potential Value:

The runoff should be estimated accurately for designing the recharge structure. It is estimated by following formula.

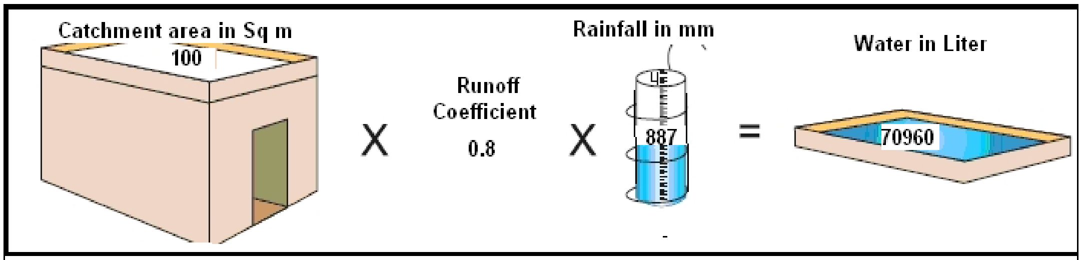


Figure 2.1 Catchment runoff Method

For example: A building with a flat terrace area of 100 sq m. The average annual rainfall in Ahmedpur city is approximately 887 mm and roof runoff coefficient is 0.8.

Area of the plot = 100 sq m

Annual rainfall = 887 mm

Roof runoff coefficient is 0.8

Catchments runoff = Catchments area in sq m * Runoff Coefficient * Rainfall (in mm)

= 100 X 887 X 0.8

= 70960 liters

2.4.3 Population Projection: To estimate future population Geometric Increase Method is used.

Formula: -

$$Pn = Po\ (1 + lg\ /100)$$

- Where Pn = Projection Population after n decades
- Po = population of any time
- Lg = Population growth rate

2.4.4 Tank Size Estimation:

Usually, the storage tank size depends on number of interrelated factors. They include:

1. local rainfall data and weather patterns
2. size of roof (or other) collection area
3. runoff coefficient (this varies between 0.5 and 0.9 depending on roof material and slope)
4. user numbers and consumption rates

There are a number of different methods used for sizing the tank. Some are readily carried out by relatively inexperienced, first-time practitioners while others require computer software and trained engineers who understand how to use this software.

Below 3 different methods are consider for this study.

2.4.4.1 Demand side approach:

A very simple method is to calculate the largest storage requirement based on the consumption rates and occupancy of the building. As a simple example we can use the following typical data:

Consumption per capita per day, C = 40 liters

Number of people per household, n = 5

Longest average dry period = 20 days

Annual consumption = C x n = 200 liters

Storage requirement, T = 200 x 20 = 4,000 liters

This simple method assumes that sufficient rainfall and catchment area, and is therefore only applicable in areas where this is the situation. It is a method for acquiring rough estimates of tank size.

2.4.4.2 Supply Side Approach:

In low rainfall areas or areas where the rainfall is of uneven distribution, more care has to be taken to size the storage properly. During some months of the year, there may be an excess of water, while at other times there could be a deficit. If there is enough water throughout the year to meet the demand, then sufficient storage will be required to bridge the periods of scarcity. As storage is expensive, this should be done carefully to avoid unnecessary expense. This is a common scenario in many developing countries where monsoon or single wet season climates prevail.

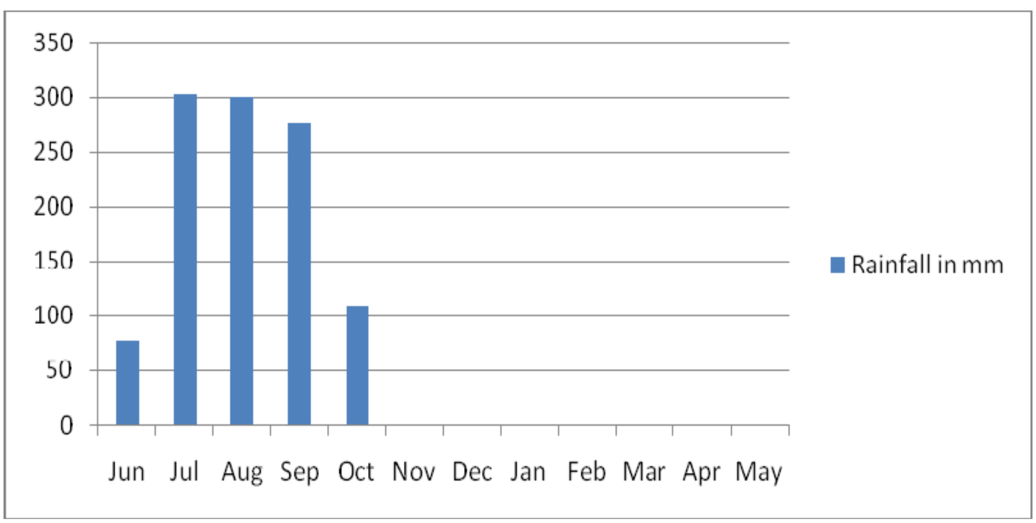
The example given here is a simple spreadsheet calculation for a site in Ahmadpur city (2010). Average figures for the rainfall data were used to simplify the calculation. This is a typical field approach to RWH storage sizing. The example

Number Of Person	4	Roof area	100m2
Water Require	40 lpcd	Runoff coefficient	0.9
Total Daily Demand	(4 * 40) = 160	Average annual rainfall	886
*lpcd - liters per capita per day		Daily available water	(100*886*09)/ 365 = 218.46

Table 2.2 Roof Run-off Sample

Ahmadpur falls in monsoon climate region. In this region people get only four month rainwater and people have to manage this water for whole year. Graph 2.1 graph shows the monthly average rainfall of Ahmadpur.

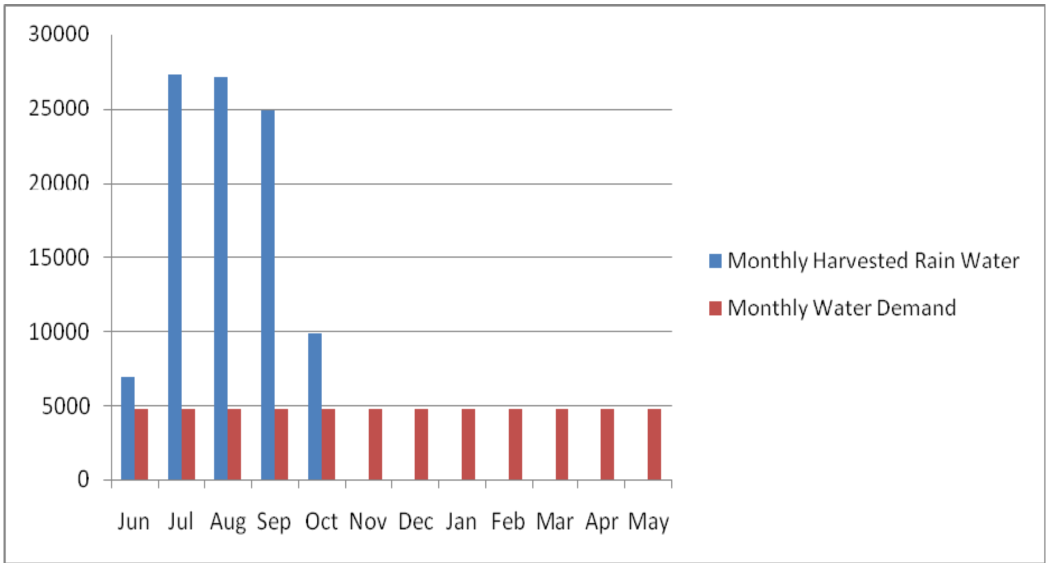
Monthly Average Rainfall of Ahmadpur



Graph 2.1 Monthly Average Rainfall of Ahmadpuur

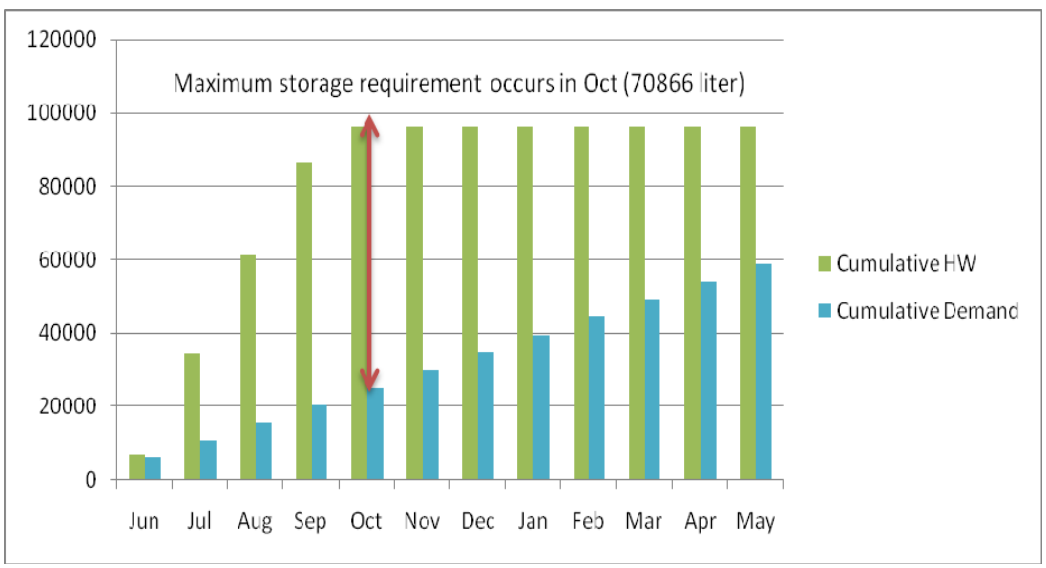
Graph 2.2 shows the comparison of harvested rainwater and the amount that can be supplied to the dispensary using all the water which is harvested. It can be noted that there is a single rainy season. The first month that the rainfall on the roof meets the demand is June. If we therefore assume that the tank is empty at the end of May, we can form a graph of cumulative harvested water and cumulative demand. From this we can calculate the maximum storage requirement for them dispensary.

Monthly Comparison of Harvested water and Water Demand (in Liter)



Graph 2.2 Monthly Comparison of Harvested water and Water Demand

Cumulative inflow and outflow of rainwater from the tank (in Liter)



Graph 2.3 Cumulative inflow and outflow of rainwater from the tank

Graph 2.3 graph shows the predicted cumulative inflow and outflow from the tank. The maximum storage requirement occurs in Oct (70866 Liter). All this water will have to be stored to cover the shortfall during the dry period. In this case the tank should construct 70866 Liter water storage size.

2.4.4.1 Computer model:

There are several computer-based programs for calculating tank size quite accurately. One such program, known as SimTanka, has been written by an Indian organisation and is available free of cost on the World Wide Web. The Ajit Foundation is a registered non-profit voluntary organization.

2.5 Mapping & Result presentation:

Preparation of map, table, chart and graph work has been done with the help of GIS and MS Office softwares.

2.6 RWH Tools & Web page Development:

In this study some tools and web based application has been developed for RWHS user. These tools are developed by using basics formula in Excel sheet and uploaded on net by using cloud computing technology. Web page has been developed using html code.

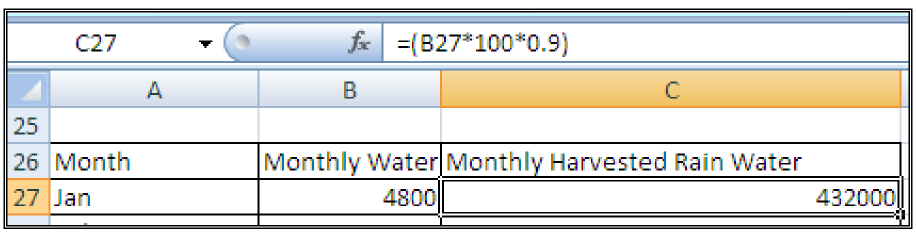


Figure 2.2 RWH tool formations

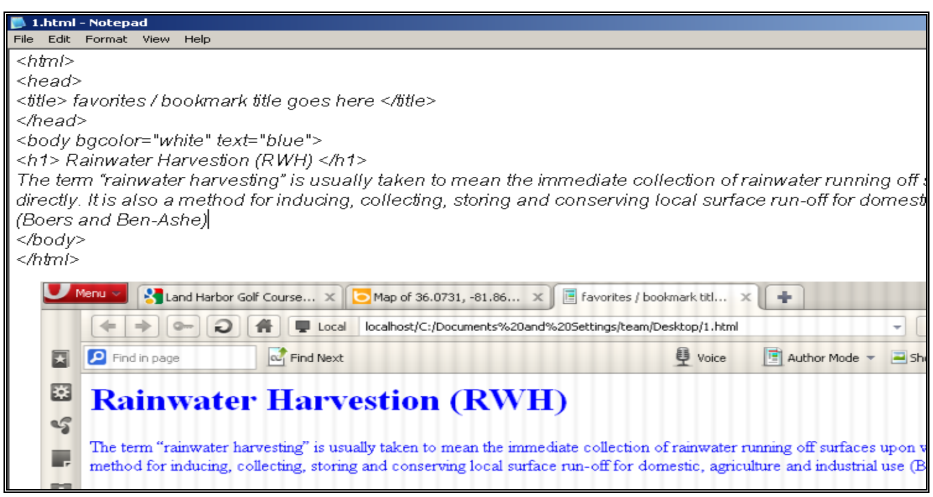


Figure 2.3 Web Page development

Chapter III

Rainwater Harvesting Overview

3.1 Introduction:

Rainwater Harvesting is not new method. It has been utilized throughout time as some irrigation methods have been used by the people of Iraq around 4500 BC and are at present used in India Today rainwater harvesting is being used worldwide for drinking and agricultural purposes. Previously, the concept of rainwater harvesting has received very little consideration (especially for drinking purposes) in larger donor financed projects, but recently, with the increasing pressure on available water resources, renewed interest has emerged.

3.2 What is Rainwater Harvesting?

a) "The term "rainwater harvesting" is usually taken to mean the immediate collection of rainwater running off surfaces upon which it has fallen directly. It is also a method for inducing, collecting, storing and conserving local surface run-off for domestic, agriculture and industrial use" *(Boers and Ben-Asher, 1982)*

b) Rainwater harvesting (RWH) is the practice of collecting rainwater and storing it for future use.

c) The Rainwater harvesting is the simple collection and storing of rainwater through scientific techniques from the areas where the rain falls. In RWH three things are important1) Catchment 2) delivery system 3) Storage / Reservoir

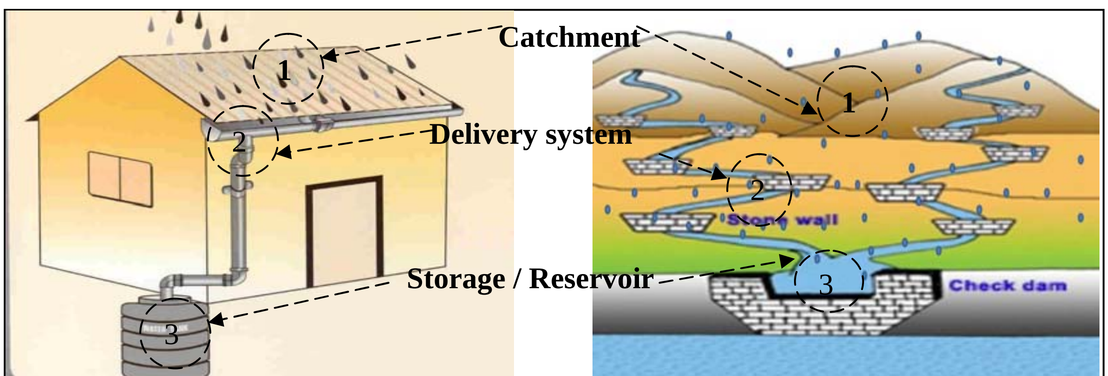


Figure 3.1 RWH Component

d) Its broadest sense can be defined as the collection of run-off rainwater for domestic water supply, agriculture and environmental management. Water harvesting systems, which harvest runoff from roofs or ground surfaces fall under the term rainwater harvesting.

The method of rain water harvesting has been into practice since ancient times. It is as far the best possible way to conserve water and awaken the society towards the importance of water. The method is simple and also cost effective. It is especially beneficial in the areas, which faces the scarcity of water. People usually make complaints about the lack of water. During the monsoons lots of water goes waste into the gutters. And this is when Rain water Harvesting proves to be the most effective way to conserve water. We can collect the rain water into the tanks and prevent it from flowing into drains and being wasted. It is practiced on the large scale in the metropolitan cities now. Rain water harvesting comprises of storage of water and water recharging through the technical process.

3.3 What is Rainwater Harvesting System?

a) A rainwater harvesting system is a collection of components that are used together to collect, store, and distribute the rainwater.

b) A rainwater harvesting system consist mechanism of all RWH components and their management. Simple we can say that arrange all thing in systematic manner to use rainwater that makes profitable. Following things are important in RWHS.

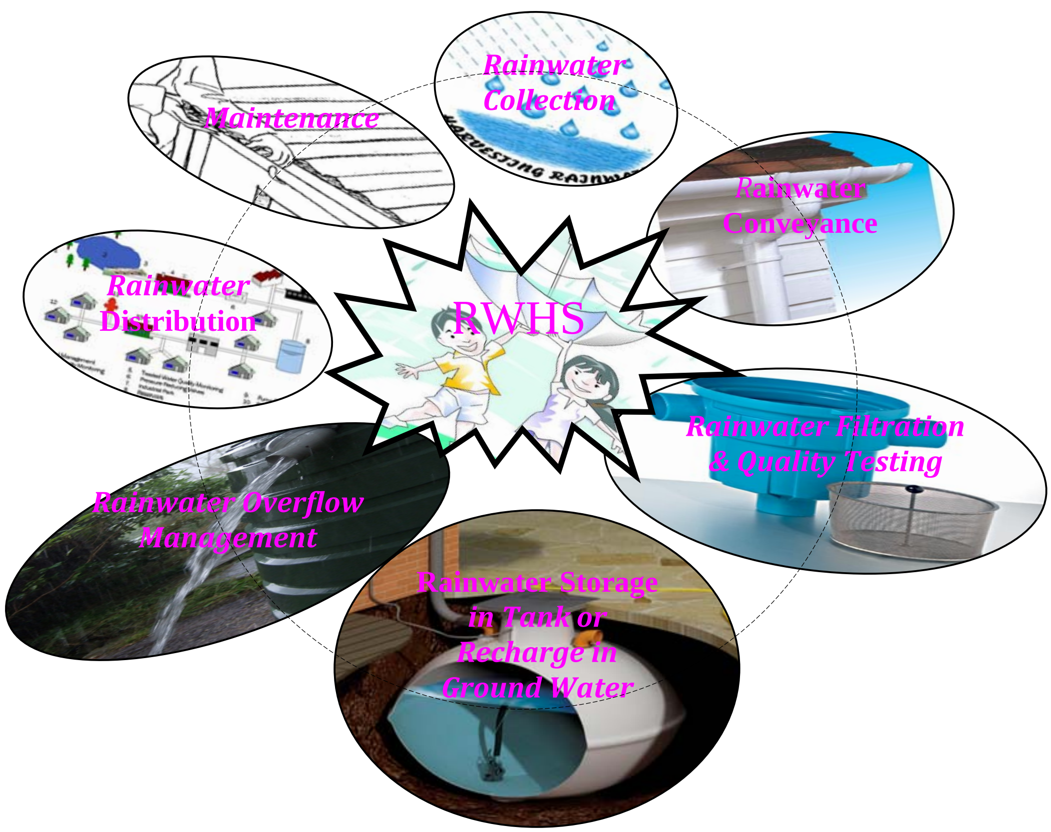


Chart 3.1 Rainwater Harvesting System

3.3.1 Rainwater Collection: It is impotent thing in RWHS because first we need to collect rainwater to store. Generally in RWHS rainwater collects from rooftop and land surface see figure 3.1. The roof of the home is the most common collection surface for rainwater harvesting system. While it is possible to collect rainwater from other surfaces, such as road, lawns, hilly area, play ground etc. The size and structure of catchment will affect the amount of rainwater will be able to collect each time it rains. The relationship between catchment size, structure and rainfall over there is very important in the design of a RWH system. Catchment size is also very important in determining the ideal size of the conveyance pipes and rainwater storage tank / reservoir.

3.3.2 Rainwater Conveyance: Catchment surface rainwater carries through gutter, conduits, stream or nala toward the storage see figure 3.1. Generally in DRWHS Water gutter and conduits are important and stream or nala in other RWHS. Water from sloping roofs could be caught through gutters and down take pipe. Conveyance system consist a) Coarse Mesh b) Gutter and c) Conduits d) Stream / Nala

3.3.2.1 Coarse mesh: At terraces, mouth of the each drain should have wire mesh to restrict floating material.

3.3.2.2 Gutter: Gutter is the Channels all around the edge of a sloping roof to collect and flowing rainwater to the storage tank. Some catchment doesn't need gutter because rainwater directly flows in down pipe channel. Gutters shape can be semi-circular or rectangular and could be made using:

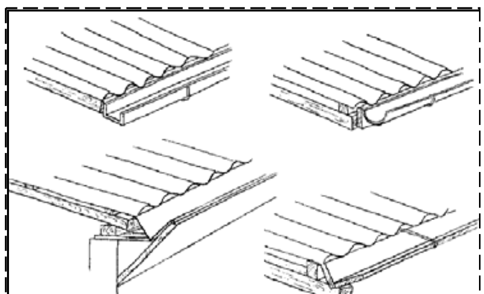


Figure 3.2 Gutter

- Locally available material such as plain galvanised iron sheet (20 to 22 gauge), folded to required shapes.
- Semi-circular gutters of PVC material can be readily prepared by cutting those pipes into two equal semi-circular channels.
- Bamboo or betel trunks cut vertically in half.

The size of the gutter should be according to the flow during the highest intensity rain. It is advisable to make them 10 to 15 per cent oversize. Gutters need to be supported so they do not sag or fall off when loaded with water. The way in which gutters are fixed depends on the construction of the house; it is possible to fix iron or timber brackets into the walls, but for houses having wider eaves, some method of attachment to the rafters is necessary.

3.3.2.3 Conduits: Conduits are pipelines or drains that carry rainwater from the catchment or rooftop area to the harvesting system. Conduits can be of any material like polyvinyl chloride (PVC) or galvanized iron (GI), materials that are commonly available. The following table gives an idea about the diameter of pipe required for draining out rainwater based on rainfall intensity and roof area.

Roof Area in Sq. M	50	75	100	125	150	200
Diameter Of pipe (mm)	Average rate of rainfall in mm/h					
50	13.4	8.9	6.6	5.3	4.4	3.3
65	24.1	16	12	9.6	8	6
75	40.8	27	20.4	16.3	13.6	10.2
100	85.4	57	42.7	34.2	28.5	21.3
125	-	-	80.5	64.3	53.5	40
150	-	-	-	-	83.6	62.7
mm/ h - millimeters per hour Sq. m – Square meters		*Table 3.1 Pipe size as per rainfall intensity & roof area* *Source: National Building Code*				

3.3.2.4 Streams: Stream play conveyance role in other RWHS (RWHS for agriculture, erosion control, and flood control and aquifer replenishment). Streams are natural or manmade.

3.3.3 Rainwater Filtration: Rainwater filtration is important in maintaining rainwater quality and rainwater quality is important because it determines how safe water is for humans. Human use of water can be either in non-direct, like water used for flushing toilets, or direct, like drinking or bathing. Filtration deal with physical, chemical and microbiological properties of the rainwater and includes things like pH, metals (lead, etc.) and bacteria present. In other RWHS use natural filter for filtration and DRWHS consist both artificial and natural filtration technique. Generally DRWHS rainwater filtration consist a) First-flushing b) filter

3.3.3.1 First-flushing: A first flush device is a valve that ensures that runoff from the first spell of rain is flushed out and does not enter the system. This needs to be done since the first spell of rain carries a relatively larger amount of pollutants from the air and catchment surface.

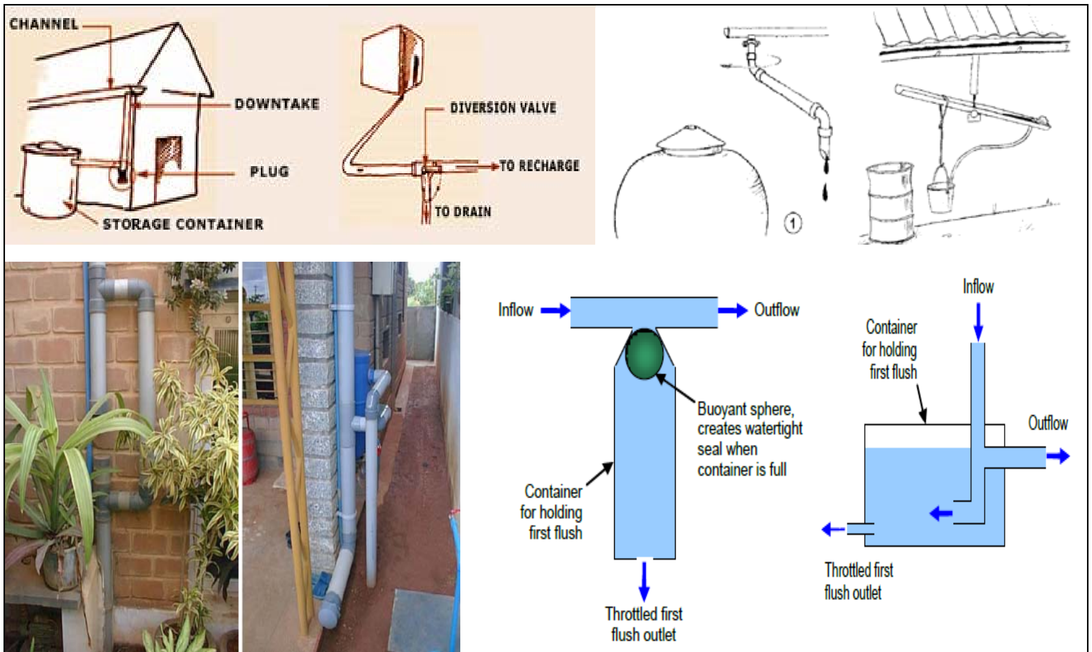


Figure 3.3 First-flushing

3.3.3.2 Filter channel: One square meter in cross-section and eight m in length, laid across the tank embankment, the filter channel consists of three uniform compartments, the first packed with broken bricks, the second with coarse sand, followed by fine sand in the third compartment. The HRF usually consists of filter material like gravel and coarse sand that successively decreases in size from 25 mm to 4 mm. The bulk of solids in the incoming water are separated by this coarse filter media or HRF. At every outlet and inlet point of the channel, fine graded mesh is implanted to prevent entry of finer materials into the sump. The length of a channel varies according to the nature of the site selected for the sump.

3.3.3.3 Sump: A storage provision to collect filtered water from the tank through the filter channel for storage and collection.

3.3.3.4 Filter: The filter is used to remove suspended pollutants from rainwater collected over roof. A filter is a chamber unit of filtering media such as fiber, coarse sand and gravel layers to remove debris and dirt from water before it enters the storage tank or recharge structure. Some filter discussed below which generally use in DRWHS .Which is good? It depends upon advantage and disadvantage of filter.

3.3.3.4.1 Charcoal water filter: A simple charcoal filter can be made in a drum or an earthen pot. Charcoal can be added for additional filtration. The major components of this filter are described below .The filter is made of gravel, sand and charcoal, all of which are easily available.

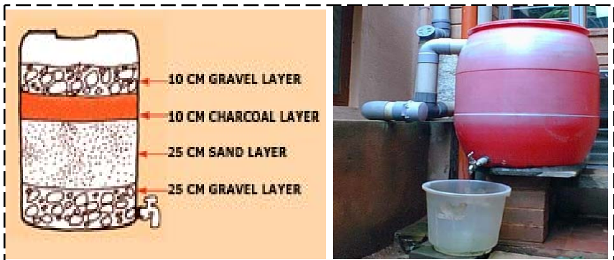


Figure 3.4 Charcoal water filter

3.3.3.4.2 Sand filters: Sand filters have commonly available sand as filter media. Sand filters are easy and inexpensive to construct. These filters can be employed for treatment of water to effectively remove turbidity (suspended particles like silt and clay), colour and microorganisms. In a simple sand filter that can be constructed domestically, the top layer comprises coarse sand followed by a 5-10 mm layer of gravel followed by another 5-25 cm layer of gravel and boulders.

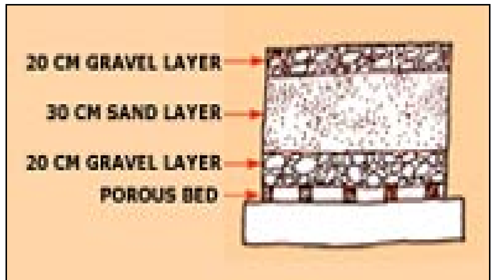


Figure 3.5 Sand Filter

3.3.3.4.3 Dewas / Rao's filter: The rooftop water was collected and allowed to pass through a filter system called the Dewas filter, designed by Mohan Rao, district collector of Dewas, and engineers of the rural engineering services. The water thus filtered is put into the service tube-well.

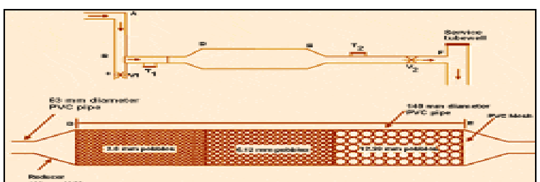


Figure 3.6 Dewas / Rao's filter

The filter consists of a polyvinyl chloride (PVC) pipe 140 mm in diameter and 1.2m long. There are three chambers. The first purification chamber has pebbles varying between 2-6 mm, the second chamber has slightly larger pebbles, between 6 and 12 mm and the third chamber has the largest - 12-20 mm pebbles. There is a mesh at the outflow side through which clean water flows out after passing through the three chambers. The cost of this filter unit is Rs 600.

3.3.3.4.4 Jeyakumar's Filter: This filter made for large rooftop. When rainwater is harvested in a large rooftop area, the filtering system should accommodate the excess flow. A system is designed with three concentric circular chambers in which the outer chamber is filled with sand, the middle one with coarse aggregate and the inner-most layer with pebbles. This way the area of filtration is increased for sand, in relation to coarse aggregate and pebbles. Rainwater reaches the centre core and is collected in the sump where it is treated with few tablets of chlorine and is made ready for consumption. This system designed by R.Jaykumar.

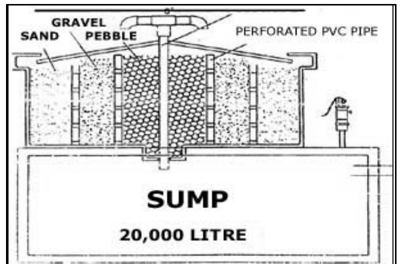


Figure 3.7 Jeyakumar's Filter

3.3.3.4.5 Varun Filter: S. Vishwanath, a Bangalore water harvesting expert, has developed rainwater filter "VARUN". According to him, from a decently clean roof 'VARUN' can handle a 50 mm per hour intensity rainfall from a 50 square meter roof area. This means the product is relatively standardized. For new house builders we therefore can recommend the number of down pipes they have to optimize on and the number of filters they will need. 'VARUN' is made from a 90 liter High Density Poly Ethylene (HDPE) drum. The lid is turned over and holes are punched in it. This is the first sieve which keeps out large leaves, twigs etc. Rainwater coming out of the lid sieve then passes through three layers of sponge and a 150 mm thick layer of coarse sand. Presence of sponge makes the cleaning process very easy. Remove the first layer of sponge and soak /clean it in a bucket of water (which you then don't waste but use it for plants). The sand needs no cleaning at all. The basic cost of the filter is about Rs 2250/-.


Figure 3.8 Varun Filter

3.3.3.4.6 Horizontal roughing filter and slow sand filter: The introduction of horizontal roughing filter and slow sand filter (HRF/SSF) to treat surface water has made safe drinking water available in coastal pockets of Orissa. While HRF acts as a physical filter and is applied to retain solid matter, SSF is primarily a biological filter, used to kill microbes in the water. Both filter types are generally stable, making full use of the natural purification process of harvested surface water and do not require any chemicals.

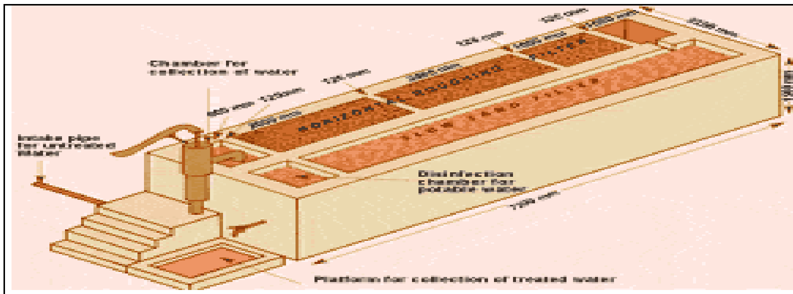


Figure 3.9 Horizontal roughing filter and slow sand filter

3.3.4 Rainwater storing or Recharging Groundwater: Rainwater storing and recharging are essential things in RWHS because collected rainwater should be store or recharge somewhere. There are various options available for storing or recharging groundwater.

3.3.4.1 Rainwater Storage Tank/ Reservoir: The most important part of the rain water harvesting is the storage system. The storage system is designed according to the amount of water that is to be stored. The design and site (location) of the storage or the recharge system should be properly chosen. The areas which receive the rainfall frequently, there a simple storage system could be constructed, to meet the daily water requirements. Otherwise the areas which receive the lesser rainfall, there the storage systems are quite essential. Rain barrels, underground or open tank are mostly used to collect rain water. Some storage tank/ reservoir samples have shown bellow

Photo 3.1 Rainwater Storage Tank / reservoir

When selecting a rainwater storage tank, following factors should be taken into consideration.

- Storage shape

- Storage Size
- Storage Site conditions
- Storage material
- Storage Water storing capacity
- Storage cost
- Storage location

3.3.4.2 Rainwater for recharging groundwater: Rainwater may be charged into the groundwater aquifers through any suitable structures like dug-well, bore-well, recharge trenches and recharge pits. Various recharge structures are possible - some which promote the percolation of water through soil strata at shallower depth (i.e., recharge trenches, permeable pavements) whereas others conduct water to greater depths from where it joins the groundwater (i.e. recharge wells). At many locations, existing structures like wells, pits and tanks can be modified as recharge structures, eliminating the need to construct any structures afresh. When selecting a rainwater recharging structure following factors should be taken into consideration.

- Surface Slope
- Rock type
- Rock & Surface Structure
- Runoff capacity
- Soil type
- Rainfall character
- Evaporation

3.3.5 Water overflow: In RWHS water overflow marinating is important task. No matter how large the rainwater storage and recharge structure, there will occasionally be times when there is too much rainfall, and the storage and recharge structure must overflow. The RWH system must have the capacity to handle overflows and discharge them in an appropriate location. Following things are consider in water overflow stage.

Figure 3.10 Water Overflow

- Handling overflows
- Overflow discharge locations
- Selecting an appropriate overflow discharge location

Generally an overflow pipe on the top of the water tank is made. This allows excess rainwater to flow out of the tank when the tank is full. It is advisable to lead an overflow to a vegetable garden or far enough away from the area of the tank to avoid undermining the construction.

3.3.6 Rainwater Distribution: Stored or recharged rainwater should be distributed properly in both RWHS. In water distribution stage water has distributed all over home and agriculture. Selecting the right rainwater distribution system components (including pumps, pumping motor pressure tanks, etc.) is an involved process, and it is strongly recommended that you contact a pump professional or rainwater harvesting professional for assistance in completing this task. These parties will ask for details regarding your household and your RWH system, and provide distribution system components that best meet your requirements. Following things should be consider in rainwater distribution stage.

1) Pipe Type
2) Pipe size
3) Pumping Motor Type
4) Water distribute Point
5) Pumping Control

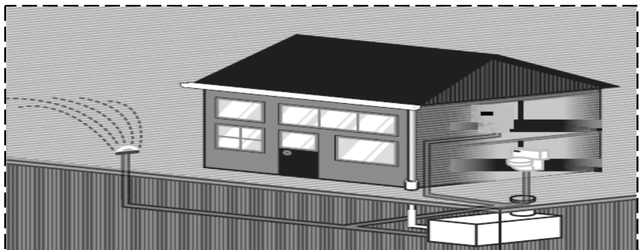


Figure 3.11 Rainwater Distribution

3.3.7 RWH System Maintenance: A key part of improving and maintaining water quality is by performing regular maintenance on the RWH system. To reduce the entry of contaminants from the roof or Eaves troughs, they should be inspected annually, and any accumulated debris (leaves, twigs, etc.) cleaned out. In addition, all pre- or post-storage treatment devices should be inspected regularly to ensure that they are working properly, and to perform maintenance. While performing these tasks, it is important to follow the manufacturer's instructions regarding maintenance frequency, how to perform the maintenance and the replacement parts required. If various components of the RWH system are not regularly cleaned, possible problems are not

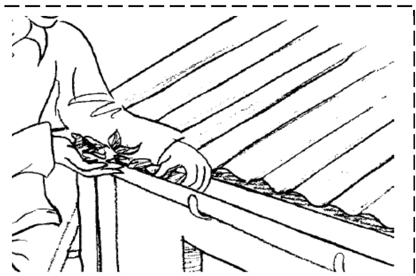


Figure 3.12 RWH Maintenance

identified or necessary repairs are not performed and the system will cease to provide a reliable, good-quality supply of water. The following timetable of maintenance and management requirements gives a basis for monitoring checks.

3.3.7.1 During rainy season: the whole RWH system (roof catchment, gutters, pipes, screens, first-flush and overflow) should be visually checked after each rain and if necessary, preferably at least cleaned after every dry period greater than one month.

3.3.7.2 End of dry season: The storage tank should be scrubbed out and flushed of all sediment and debris at the end of each dry season just before the rain comes. A full service of all tank features is recommended just before the first rains are due to begin, including replacement of all worn screens and servicing of the outlet or hand pump.

3.3.7.3 Year round: The water tank should regularly be checked for leaks and cracks, which need to be repaired. Only small weeping leaks, which may occur on first filling the tank, need not be repaired since they usually seal themselves. If there is any doubt about the presence of organic contaminants in the water source, the water can be chlorinated. Water must not be allowed to leak from tap fittings. Not only will this waste water, but it may also provide a basis for algae growth in the sink or drainage system and lead to development of bacteria, which will be hygiene risk.

3.4 Types of RWHS: I) Domestic RWHS II) Other RWHS for agriculture, erosion control, flood control and aquifer replenishment

3.4.1 Domestic RWHS: Domestic RWH is a simple mechanism to collect and store rainwater mainly for domestic use like Bathing, Washing, drinking and cooking.

Alternative Water availability as per user requirement	Availability budge and other things for DRWHS	Collected rainwater availability As per user requirement	Decision Rainwater should be store or recharge
Available	Available	Available	Recharge
Not Available	Available	Available	Store
Not Available	Not Available	Available	DRWHS Not Applicable
Not Available	Not Available	Not Available	DRWHS Not Applicable
Available	Available	Not Available	Recharge
Available	Not Available	Available	DRWHS Not Applicable

Table 3.2 DRWHS Decision Model Description

It may be based on household or community. The system uses a collection surface such as a roof, gutters to guide the rainwater, storage things to store the water and recharge structure to recharge groundwater. There are various techniques in DRWHS which is good it depend on availability of alternate water sources, user requirement and user budget.

Following decision model helps us to take decision in DRWH. DRWHS decision model description has shown in Table 3.2.

DRWHS Decision Model

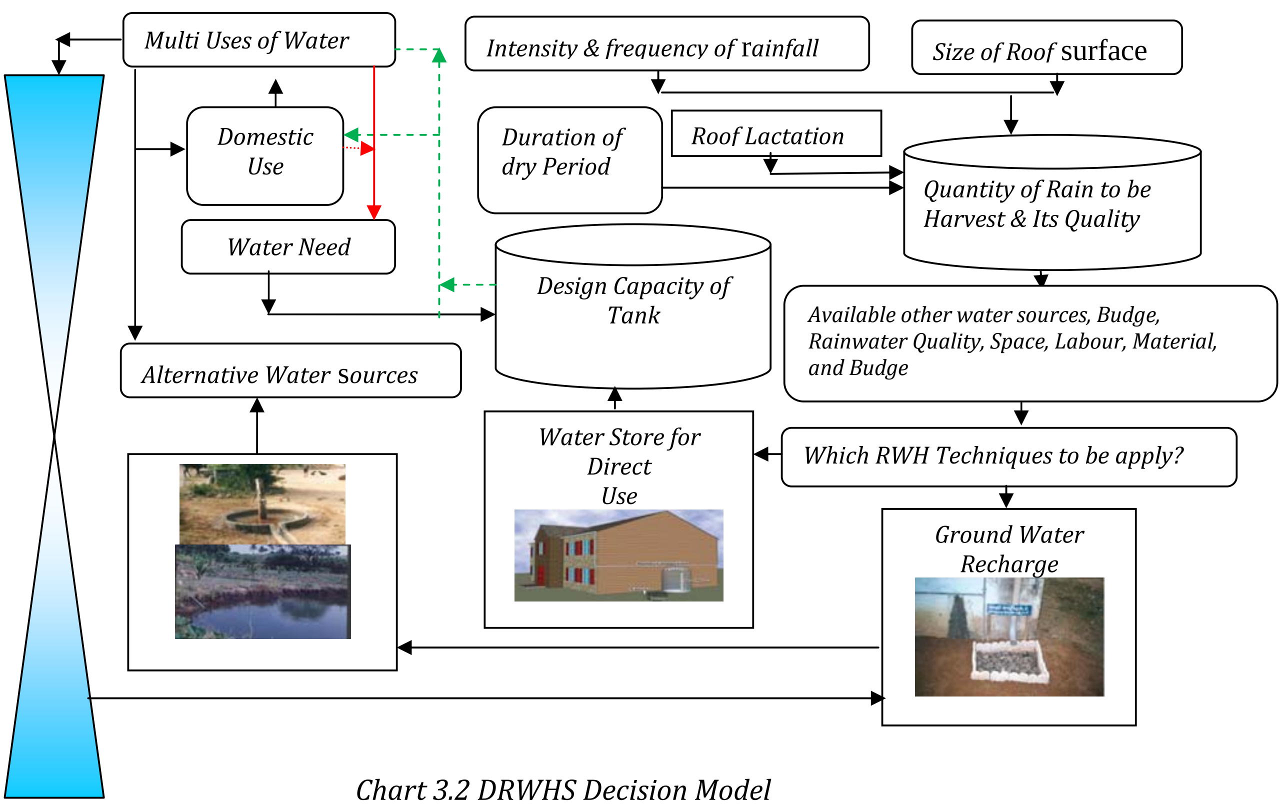


Chart 3.2 DRWHS Decision Model

There are various methods in DRWH. Which is good? It depends upon user need and methods advantage and disadvantage. Some DRWHS method has discussed below.

3.4.1.1 Store Rainwater: In this method collected rainwater is stored in storage for future use Storage may be constructed on the surface as well as underground by utilizing local material. The size of tank depends upon availability of runoff and water demand. After proper chlorination, the stored water may be used for drinking purpose.

The water storage tank usually would be the biggest capital investment element of a domestic RWH system. It therefore requires careful design to provide optimal storage capacity while keeping the cost as low as possible. Here are an almost unlimited number of options for storing water. Common vessels used for very small-scale water storage in developing countries include plastic bowls and buckets, jerrycans, clay or ceramic jars, cement jars, old oil drums, empty food containers, etc. For storing larger quantities of water, the system will require a tank or a cistern. Storage Tank can vary in size from a cubic meter or so (1000 liters) up to hundreds of cubic meters for large projects. The typical maximum size for a domestic system is 20 or 30 cubic meters. The choice of system will depend on a number of technical and economic considerations. Where having water shortage there people select storage DRWHS. Following photo shows the sample of storage.

Photo 3.2 Water Storage Sample

Some storage oriented DRWHS techniques have been shown below

a) Indirectly Pump Technique

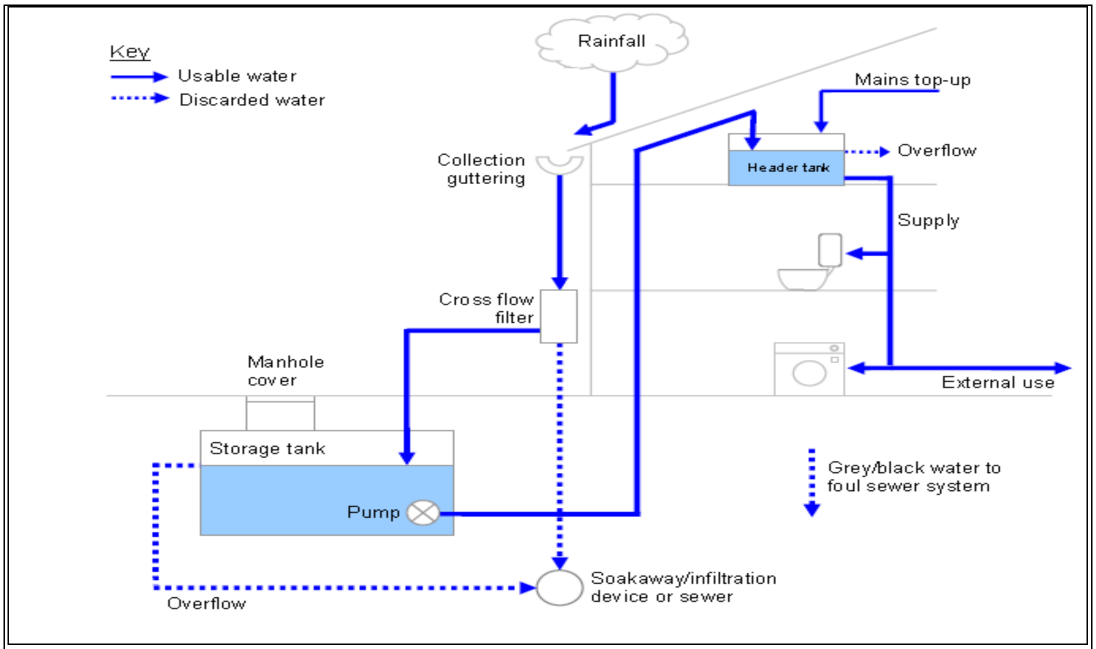


Figure 3.13 Indirectly Pump Technique

b) Directly Pump Technique

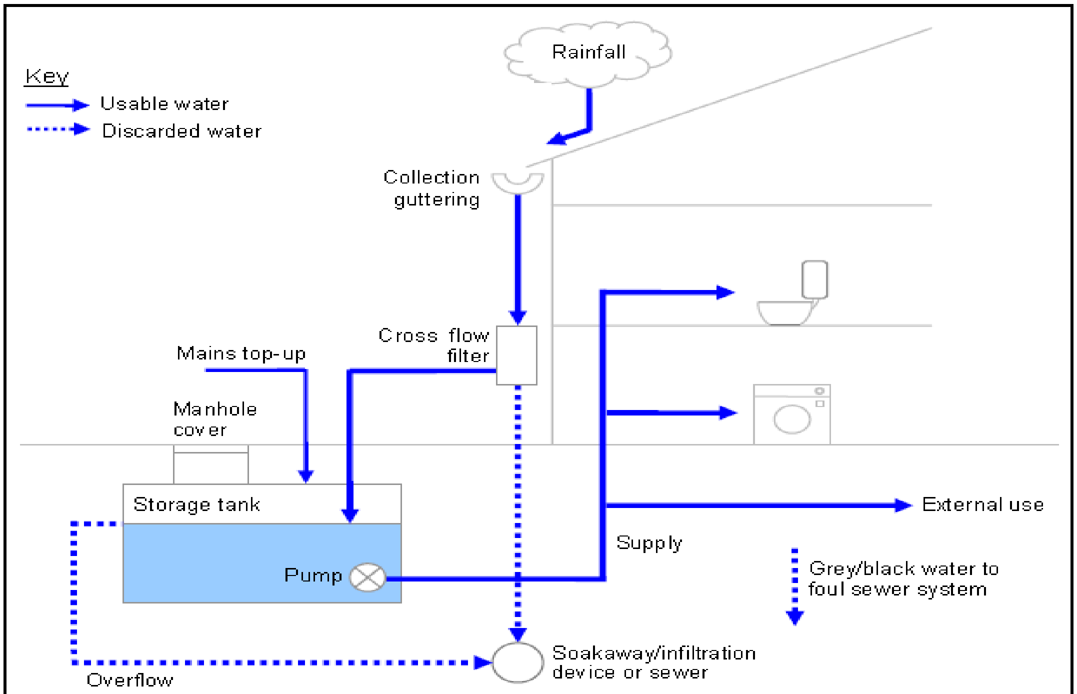


Figure 3.14 Directly Pump Technique

c) Gravity fed Technique

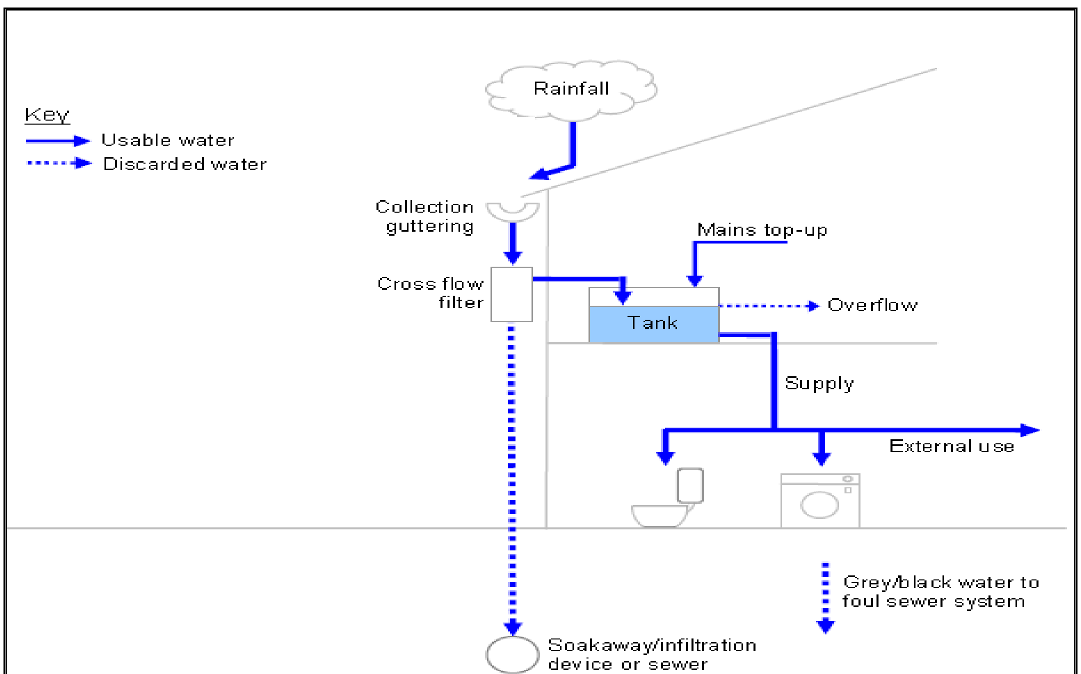


Figure 3.15 Gravity fed Technique

Generally gravity fed system is best because this system save pumping energy but its constriction cost is high that why people prefer direct pump system.

3.4.1.2 Recharge Pit: In alluvial areas where permeable rocks are exposed on the land surface or at very shallow depth, domestic rainwater harvesting can be done through recharge pits. Recharge pits are small pits of any shape rectangular, square or circular, contracted with brick or stone masonry wall with weep hole at regular intervals.

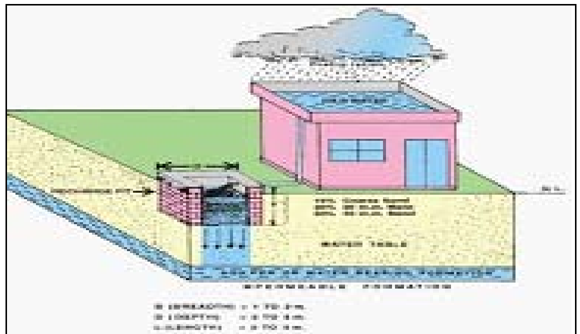


Figure 3.16 Recharge Pit Technique

Pit can be covered with perforated covers. Bottom of pit should be filled with filter media. The capacity of the pit can be designed on the basis of catchment area, rainfall intensity and recharge rate of soil. Usually the dimensions of the pit may be of 1 to 2 m width and 2 to 3 m deep depending on the depth of pervious strata. These pits are suitable for recharging of shallow aquifers, and small houses having a roof area of 100 sq m.

3.4.1.3 Recharge Trench: Recharge trench is provided where upper impervious layer of soil is shallow. It is a trench excavated on the ground and refilled with porous media like pebbles, boulder or brickbats. Trench's top layer of sand should be cleaned periodically to maintain the recharge rate. It is usually made for harvesting the surface runoff. Bore wells can also be provided inside the trench as

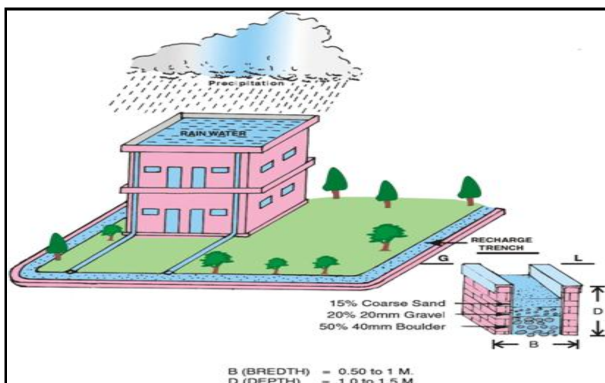


Figure 3.17 Recharge Trench Technique

recharge shafts to enhance percolation. The length of the trench is decided as per the amount of runoff expected. This method is suitable for playgrounds, parks and roadside drains and houses having roof area of 200-300 sq m. The recharge trench can be of size 0.50 to 1.0 m wide, 1.0 to 1.5 m deep and 10 to 20 m. long depending upon availability of water to be recharge.

3.4.1.4 Recharge Tube-well: In this technique the PVC pipes of 10 cm diameter are connected to roof drains to collect rainwater. The first roof runoff is let off through the bottom of drainpipe. After closing the bottom pipe, the rainwater of subsequent rain showers is taken through a T to an online PVC filter. The filter may be provided before water enters the tube-wells. The filter is 1 –1.2 m. in length and is made up of PVC pipe. Its diameter should vary depending on the area of roof, 15 cm if roof area is less than 150 sq m and 20 cm if the roof area is more. The filter is provided with a reducer of 6.25 cm on both the sides. Filter is divided into three chambers by PVC screens so that filter material is not mixed up. The first chamber is filled up with gravel (6-10mm), middle chamber with pebbles (12-20 mm) and last chamber with bigger pebbles (20-40 mm). If the roof area is more, a filter pit may be provided. Rainwater from roofs is taken to collection chambers located on ground. These collection chambers are interconnected as well as connected to the filter pit through pipes having a slop of 1:15. The filter pit may vary in shape and size depending upon available runoff and are back-filled with graded material, boulder at the bottom, gravel in the middle and sand at the top with varying thickness (0.30- 0.50m) and may be separated by screen. The pit is divided into two chambers, filter material in one chamber and other chamber is kept empty to accommodate excess filtered water and to monitor the quality of filtered water. A connecting pipe with recharge well is provided at the bottom of the pit for recharging of filtered water through well. This technique is suitable where the shallow aquifers have dried up and existing tube-wells are tapping deeper aquifer.

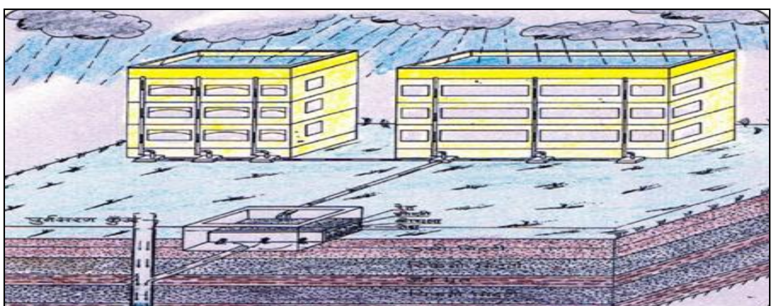


Figure 3.18 Recharge Tube-well Technique

3.4.1.5 Recharge Dug-well: Dug-well can be used as recharge structure. Rainwater from the rooftop is diverted to dug-wells after passing it through filtration bed. Cleaning and desalting of dug well should be done regularly to enhance the recharge rate. The filtration method suggested for tube well recharging could be used or the trench is backfilled with boulders, gravels and coarse sand to act as a filter media for the recharge wells. Recharge well of 100-300 diameter is constructed to a depth of at least 3 to 5 m below the water level. Based on the lithology of the area well assembly is designed with slotted pipe against the shallow and deeper aquifer. A lateral trench of 1.5 to 3m width and 10 to 30 m length, depending upon the availability of water is constructed with the recharge well in the centre. This technique is suitable where the surface soil is impervious and large quantities of roof water or surface runoff is available within a very short period of heavy rainfall, the use of trench/ pits is made to store the water in a filter media and subsequently recharge to ground water through specially constructed recharge wells. This technique is ideally suited for area where permeable horizon is within 3m below ground level.

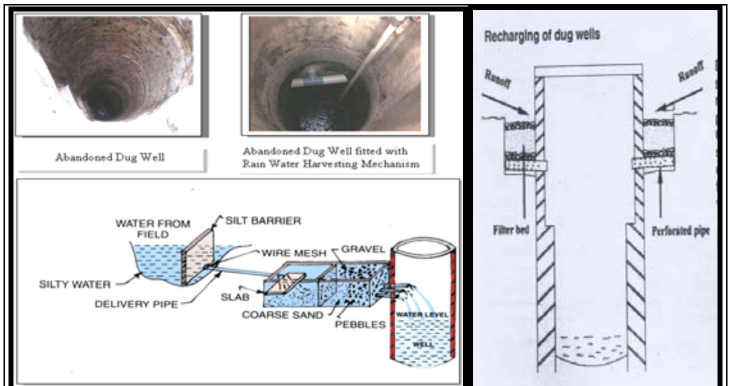


Figure 3.19 Recharge Dug-well Technique

3.4.1.6 Recharge Shafts: Soak away or recharge shafts are provided where upper layer of soil is alluvial or less pervious. These are bored hole of 30 cm dia. up to 10 to 15 m deep, depending on depth of pervious layer. Bore should be lined with slotted/perforated PVC/MS pipe to prevent collapse of the vertical sides. At the top of soak away required size sump is constructed to retain runoff before the filters through soak away. Sump should be filled with filter media.

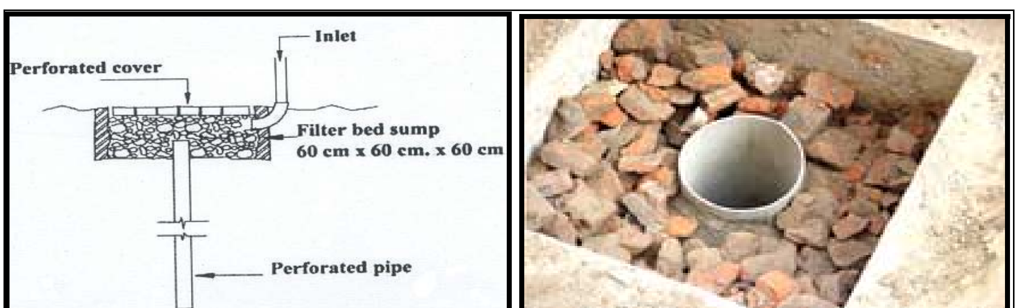


Figure 3.20 Recharge Shaft Technique

3.4.2 Other RWHS for agriculture, erosion control, flood control and aquifer replenishment: Medium or Larger RWH systems are used for water resource management. These systems use vast catchment areas to collect rainwater and store it in reservoirs. The water is then used for irrigation or to recharge aquifers. These systems may also help in flood control and erosion prevention by holding storm water into reservoirs and discharging at a controlled rate. Some DRWHS method has discussed below.

3.4.2.1 Gully Plug: Gully Plugs are built using local stones, clay and bushes across small gullies and streams running down the hill slopes carrying drainage to tiny catchments

Figure 3.21 Gully Plug Technique

during rainy season. Gully Plugs help in conservation of soil and moisture. The sites for gully plugs may be chosen whenever there is a local break in slope to permit accumulation of adequate water behind the bunds. It is suitable in hill area where slope is high.

3.4.2.2 Contour Bund: Contour Bunds are effective methods to conserve soil moisture in watershed for long duration. These are suitable in low rain fall areas where monsoon run off can be impounded by constructing bunds on the sloping ground all along the contour of equal elevation. Flowing water is intercepted before it attains the erosive velocity by keeping suitable spacing between bunds. Spacing between two contour bunds depends on the slope the area as the permeability of the soil. Lesser the permeability of soil, the closer should be the spacing of bunds. Contour bonding is suitable on lands with moderate slopes without involving terracing.

Figure 3.22 Contour Bund Technique

3.4.2.3 Gabion Structure: This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond stream course. A small bund across the ream is made by putting locally available boulders in a mesh of steel wires and anchored to the stream banks. The height of such structures is around 0.5 m and is normally used in the streams with width of less than 10 m. The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders in due course and with growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water runoff for sufficient time after rains to recharge the ground water body.

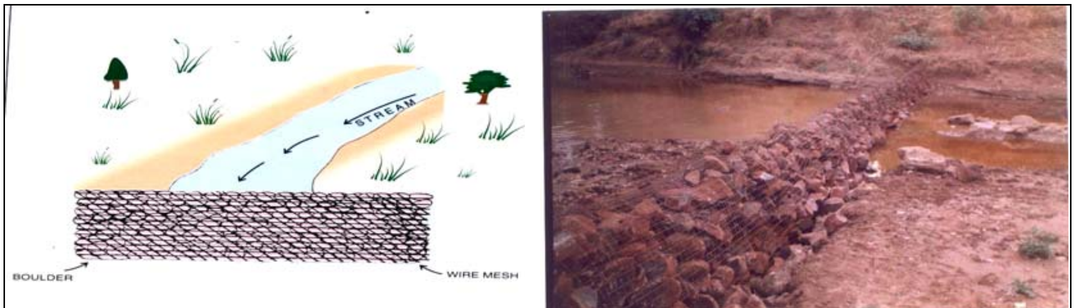


Figure 3.23 Gabion Structure Technique

3.4.2.4 Check Dams /Cement Plugs / Nala Bunds: Check dams are constructed across small streams having gentle slope. The site selected should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time. The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side. To harness the maximum run off in the stream, series of such check dams can be constructed to have recharge on regional scale. Clay filled cement bags arranged as a wall is also being successfully used as a barrier across small nalas. At places, shallow trench is excavated across the nala and asbestos sheets are put on two sides. The space between the rows of asbestos sheets across the nala is backfilled with clay. Thus a low cost check dam is created. On the upstream side clay filled cement bags can be stacked in a slope to provide stability to the structure.

Figure 3.24 Check Dam Technique

3.4.2.5 Percolation Tank: Percolation tank is an artificially created surface water body, submerging in its reservoir a highly permeable land so that surface runoff is made to percolate and recharge the ground water storage. Percolation tank should be constructed preferably on second to third order stream, located on highly fractured and weathered rocks, which have lateral continuity downstream. The recharge area downstream should have sufficient number of wells and cultivable land to benefit from the augmented ground water.The size of percolation tank should be governed by percolation capacity of strata in the tank bed. Normally percolation tanks are designed for storage capacity of 0.1 to 0.5 MCM. It is necessary to design the tank to provide a pond water column generally between 3 & 4.5 m .The peculation tanks are mostly earthen dams with masonry structure only for spillway. The purpose of the percolation tanks is to recharge the ground water storage and hence seepage below the seat of the bed is permissible. For dam's up-to 4.5m height, cut off trenches are not necessary and keying and benching between the dam seat and the natural ground is sufficient.

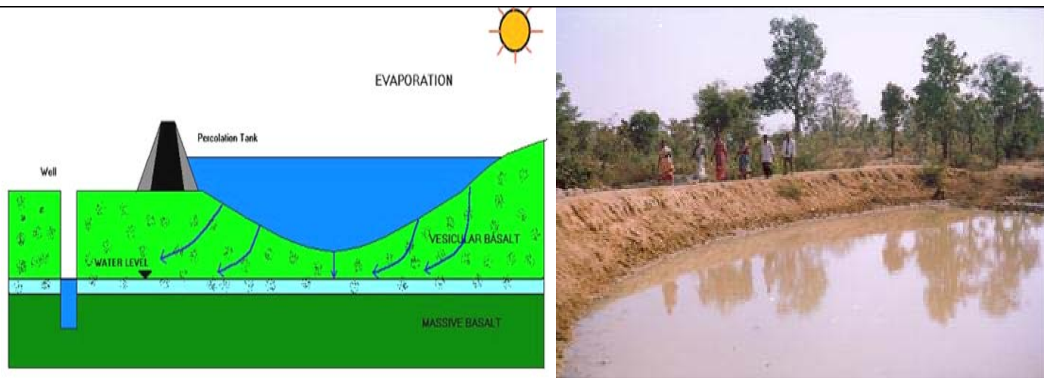


Figure 3.25 Percolation tank Technique

3.4.2.6 Ground Water Dam or Sub-Surface Sykes: Sub surface dyke or under-ground dam is a subsurface barrier across stream which retards the base flow and stores water upstream below ground surface. By doing so, the water levels in upstream part of ground water dam rises saturating otherwise dry part of aquifer. The site where sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow out let. After selection of suitable site, a trench of 1-2 m wide is dug across the breadth of stream down to impermeable bed. The trench may be filled with clay or brick/concrete wall up-to 0.5m below the ground level. For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength at400 to 600 gauge or low-density polythene film of 200 gauges can also be used to cover the cut out dyke faces. Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no Siltation in the reservoir would take place. The potential disaster like collapse of the dams can also be avoided.

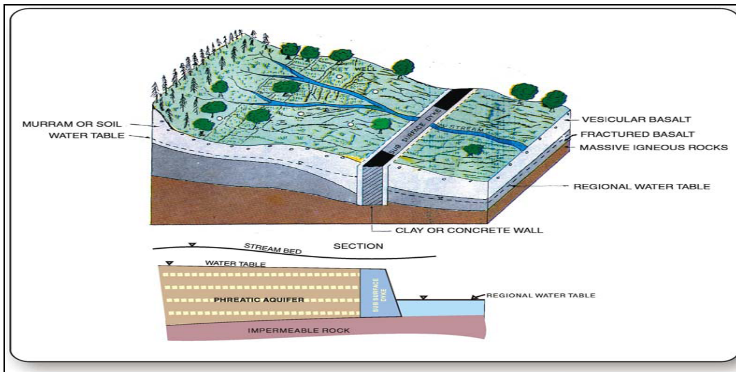


Figure 3.26 Sub-surface dyke Technique

3. 5 Why rainwater harvesting?

3.5.1 Increasing water demands: The increased demand for water results in lower groundwater tables and depleted reservoirs. Many piped water supply systems fail. The use of rainwater is a useful alternative.

3.6.2 Limited Water Source: As per demand water sources are limited and getting it is getting dry due high consumption of water.

3.5.3 Decreasing Groundwater level: Groundwater reserves are being tapped and over-exploited resulting into decline in groundwater levels and deterioration of groundwater quality. This precarious situation needs to be rectified by immediately recharging the depleted aquifers

3.5.4 Quality of water supplies: Water supplies can become polluted either through industrial or human wastes or by intrusion of minerals such as arsenic, salt (coastal area or fluoride. Rainwater is generally of good quality.

3.5.5 Variations in water availability: The availability of water from sources such as lakes, rivers and shallow groundwater can fluctuate strongly. Collecting and storing rainwater can provide water for domestic use in periods of water shortage. Rainwater may also provide a solution when the water quality is low or varies during the rainy season in rivers and other surface water resources.

3.5.6 Advantage of collection and storage near the place of use: Traditional sources are located at some distance from the community. Collecting and storing water close to households improves the accessibility and convenience of water supplies and has a positive impact on health. It can also strengthen a sense of ownership.

3.5.7 Soil Erosion Control: RWH can minimize soil erosion rates because RWH reduces run off speed. Which can help to control soil erosion?

3.5.8 Flood & Drought Control: The widely conducted RWH not only effectively pointed water resources scarcity, minimized soil erosion but also helps to control flood & drought.

3.5.9 RWH is environment friendly and easy approach for water requirements.

3.6 RWH Advantages and Disadvantages:

When considering the possibility of using rainwater catchment systems for domestic supply, it is important to consider both the advantages and disadvantages and to compare these with other available options. RWH is a popular household option as the water source is close by, convenient and requires a minimum of energy to collect. An advantage for household systems is that users themselves maintain and control their systems without the need to rely on other members of ‘the community. Since almost all roofing material is acceptable for collecting water for household purposes, worldwide many RWH systems have been implemented successfully. However, RWH has some disadvantages. The main disadvantage of RWH is that one can never be sure how much rain will fall. Other disadvantages, like the relatively high investment costs and the importance of maintenance, can largely be overcome through proper design, ownership and by using as much locally available material as possible to ensure sustainability (and cost recovery). The involvement of the local private sector and local authorities can facilitate up-scaling of RWH. Some advantages and disadvantages are given in Table 3.3.

Advantage of RWH	Disadvantages of RWH
Simple construction: Construction of RWH systems is simple and local people can easily be trained to build these themselves. This reduces costs and encourages more participation, ownership and sustainability at community level.	High investment costs: The cost of rainwater catchment systems is almost fully incurred during initial construction. Costs can be reduced by simple construction and the use of local materials.
Good Maintenance: Operation and maintenance of a household catchment system are controlled solely by the tank owner's family. As such, this is a good alternative to poor maintenance and monitoring of a centralized piped water supply.	Usage and maintenance: Proper operation and regular maintenance is a very important factor that is often neglected. Regular inspection, cleaning, and occasional repairs are essential for the success of a system.
Relatively good water quality: Rainwater is better than other available or traditional sources (groundwater may be unusable due to fluoride, salinity or arsenic).	Water quality is vulnerable: Rainwater quality may be affected by air pollution, animal or bird droppings, insects, dirt and organic matter.
Low environmental impact: Rainwater is a renewable resource and no damage is done to the environment.	Supply is sensitive to droughts: Occurrence of long dry spells and droughts can cause water supply problems.
Convenience at household level: It provides water at the point of consumption.	Limited supply: The supply is limited by the amount of rainfall and the size of the catchment area and storage reservoir.
Not affected by local geology or topography: Rainwater collection always provides an alternative wherever rain falls.	
Flexibility and adaptability of systems to Suit local circumstances and budgets, including the increased availability of low-cost tanks	

Table 3.3 Advantage & Disadvantages of RWH

Chapter IV

Overview of Water Sources in Ahmadpur

4.1 Available Water sources:

Water resources are considered as source of life which is useful to all living beings on earth. Uses of water include agricultural, industrial, household, recreational and environmental activities. Generally water sources categorized in two parts i.e. primary water sources include rainfall and secondary water sources include ground and surface water. Ahmadpur is receiving 887 mm annual average rainfall which is quite good. This is a dry region but there is a potential to develop the surface water sources. Also the ground water sources are limited hence the water recharge will be less.

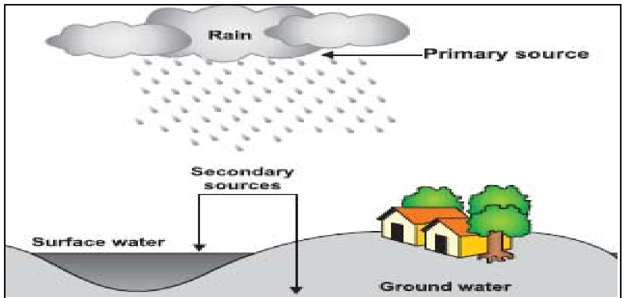
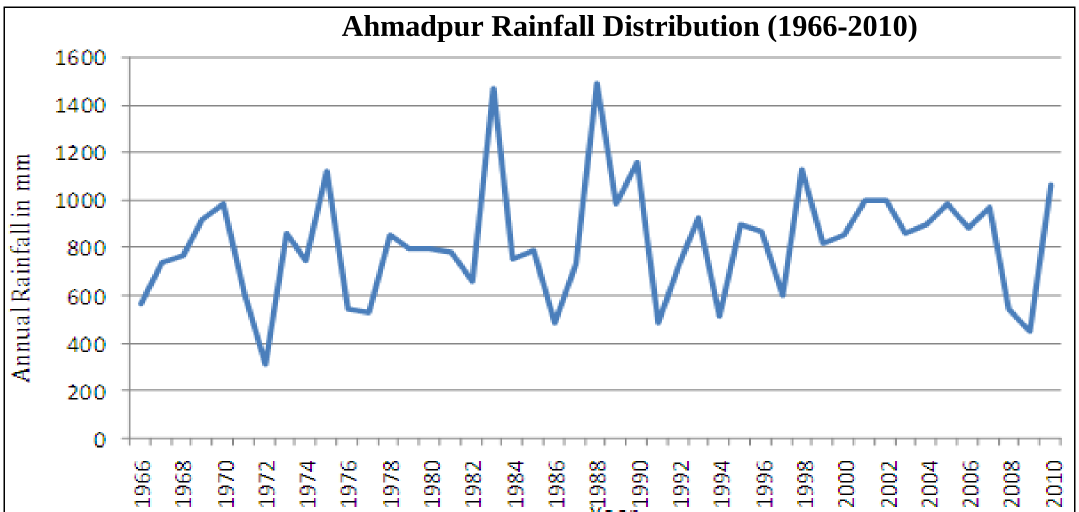


Figure 4.1 Water Resources

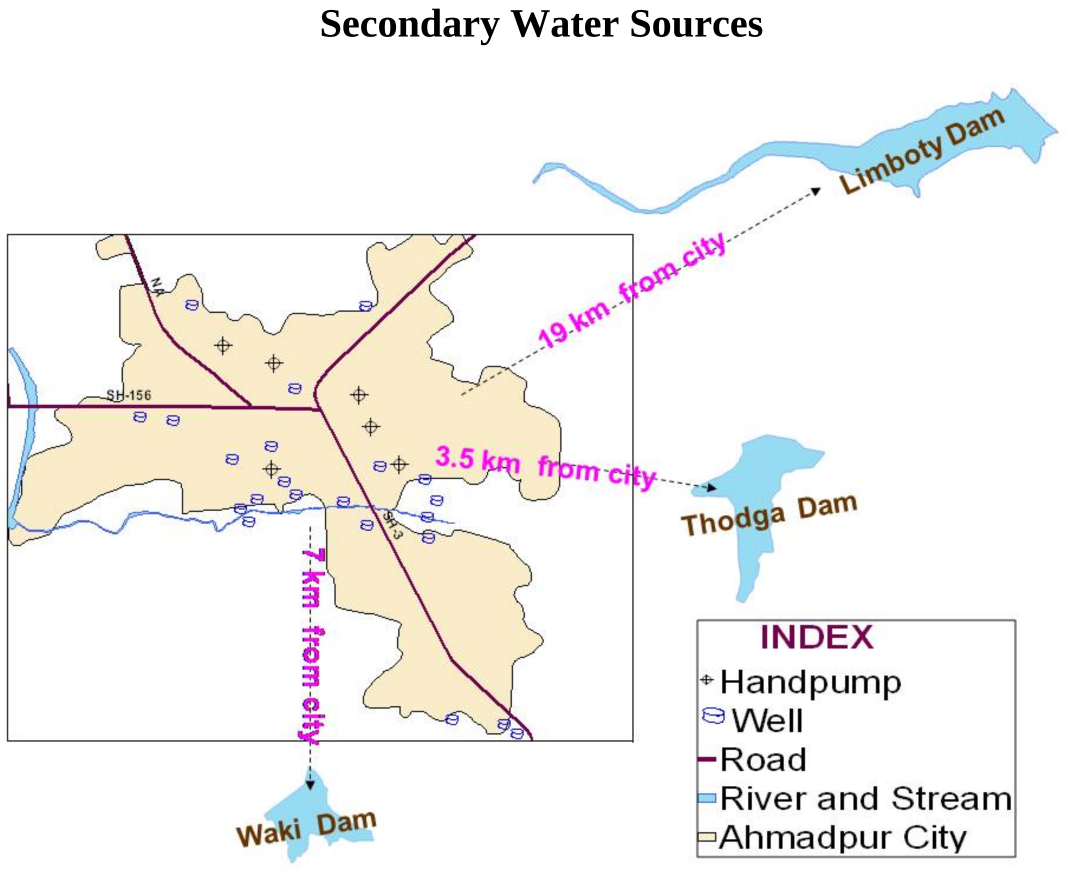
4.1.1 Primary sources:

4.1.1.1 Rainfall: In Ahmapdur most of the annual rainfall is received in the four rainy months of June to September. The average annual rainfall is about 887 mm, but it has great variations in temporal distribution. It is difficult to define the correct temporal pattern of rainfall distribution.



Graph 4.1 Ahmadpur Rainfall Distribution (1966-2010)

4.1.2 Secondary sources:

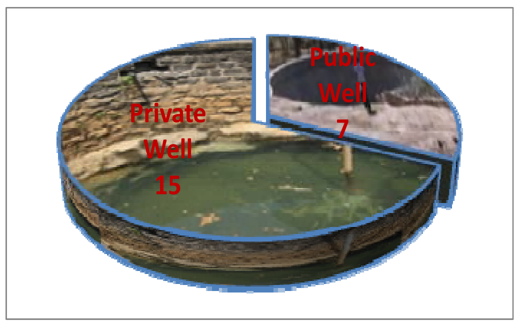


Map 4.1 Ahmadpur City Secondary Water sources

4.1.2.1 Ground water:

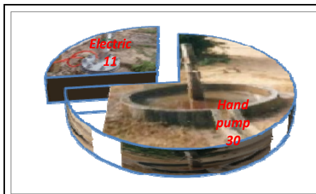
The average ground water level of Ahmadpur city is 9.68 m. the ground water has been utilized through wells and tube wells.

4.1.2.1.1 Well: There are 22 well out of that 7 are public and 15 are private. These well water uses for agricultural and other human daily activity. These well are capable to supply seasonal water because these well get dry in summer due to falling ground water level. Generally the residents of Ahmadpur are not using well water for drinking.



Graph 4.2 Well in Ahmadpur City

4.1.2.1.2 Tube-well: Ahmadpur city is having total 41 tubes well out of that 30 are hand pump and 11 are having electric connection. The water of these tube-wells is used for daily human activities. Some tube well does not get water in summer.



Graph 4.3 Tube-Wells in Ahmadpur City

4.1.2.2 Surface Water:

4.1.2.2.1 Stream: There are 3 major perennial stream flows through Ahmadpur city. The same streams contain waste water drainage of the city.

4.1.2.2.2 River: There Waki is the major perennial river system. It is situated 2 km for west side of Ahmedpur and flow in south to north direction.

4.1.2.2.3 Dam /Reservoir: There are three major dams constructed around Ahmadpur.

4.1.2.2.3.1 Waki Dam (Nandura): Waki dam constructed on Waki River. It is 7 km far from Ahmadpur. Since 1988 the residents of Ahmadpur are using waki dam water.

4.1.2.2.3.2 Thodga Dam: Thodga dam is 3.5 km far from Ahmadpur. Ahmadpur Nagar Plaika has been getting Thodga dam water since 1997.

Sources	No of element	Daily supply (MLD)
Hand pump Tube well	30	0.10
Electric Tube well	11	0.20
Well	22	0.05
Waki Dam	1	1.10
Upper Manar Project	1	1.60
Total		3.05

Table 4.1 Daily water supply sources

Source: Maharshtra Jeevan Pradhikaran

4.1.2.2.3.3 Linboti Dam: Linboti dam is major dam in Ahmadpur water resources. Linboti dam is constricted on Mannar River. It is 19 km far from Ahmadpur .Since 2010 Ahmadpur Nagar Plaika has started getting water from Linboti dam. This dam is having supplying capacity of today's Ahmadpur demand. But in future demand will increase as well as dam water will use for surrounding agriculture field.

Currently Ahmadpur city is getting daily 3.5 Ml water from various sources among those Upper Manar Project (Linboti dam) supply daily 1.6 ML water. Waki dam is one of important water source for Ahmadpur. Water sources and its daily supply capacity have shown in following table (Table 4.2).

4.2 Water Cost: Water is free natural sources but to bring water from its source and purification process over it, for all thing need money .This money decides cost of water. Amount varies from place to place. In Ahmadpur city water cost is shown in following table.

Water category	Cost in Rupees for 1000 Liter
Government Water	10
Commercial Water	50
Commercial Purify Drinking Water	12000

Table 4.2 Water Cost in Ahmadpur City

4.3 Water Need: It is difficult to estimate the amount of water needed to maintain acceptable or minimum living standards. Moreover, different sources use different figures for total water consumption and for water use by sector of the economy.

A range of 20 to 40 liters of freshwater per person per day is generally considered to be a necessary, minimum to meet needs for drinking and sanitation alone, according to Peter Gleick president of the Pacific Institute for Studies in Development, Environment and Security. If water for bathing and cooking is included as well, this figure varies between 27 and 200 liters per capita per day

From above statement let us consider that normally human need average 100 lpcd for drinking and sanitation in Ahmadpur. Ahmadpur municipal has decided to provide 70 lpcd to meet their basic water needs. Today per person about 70 lpcd water is sufficient, but in future as per city growth the need of water will be increasing. For Example

City	water need lpcd
Latur	100
Pune	175
Mumbai	195
Delhi	240

Table 4.3 Various City Water Need lpcd

Table 4.4 values show today's and future water need of Ahmadpur city (* years figures are projected)

Year	Population	As per 48 lpcd Water Need	As per 70 lpcd Water Need	As per 100 lpcd Water Need
2001	35800	1718400	2506000	3580000
2011*	45724	2194740	3200663	4572376
2021*	55648	2671081	3895326	5564752
2031*	65571	3147421	4589990	6557128
2041*	75495	3623762	5284653	7549504
2051*	85419	4100102	5979316	8541880
2061*	95343	4576443	6673979	9534256

Table 4.4 Water Need of Ahmadpur City

4.4 Water Supply: Ahmadpur municipal has been decided to provide 70 lpcd but considering people basic water need's and water availability particularly the Municipality provides 53 lpcd in normal season and 40 lpcd in summer. Its mean Municipal provides average 48 lpcd. Those people do not have tab connection they get water from tube-well and dug-well.

4.5 Water Problem: As we saw in above discussion Ahmadpur municipal is unable to provide average water as per human requirement due to uncontrolled population growth, limited water source and poor water management. Municipality is able to provide average 48 lpcd and also there is no regularity. Sometimes Ahmadpur municipality unable to provide water due to technical problem that time people have to pay 30 rupees for per family for per day, it means 7451 houses have to pay around 210000 rupees for one day. This is usual problem of Ahmadpur. If we ask this "do you have water problem in summer? Question to 10 people of Ahmadpur, out of ten 6 people answer will be **yes**, we have water problem in summer". In future population will grow and then current pattern of water supply will fail to supply require water. Following statistical values show todays and future water situation of Ahmadpur, The figures given in table 4.5 are the estimated and the reality may be different. But it is conform, that Ahmadpur people have to face water crisis due to following things.

➢ Population Growth

➢ Rapid Urbanization

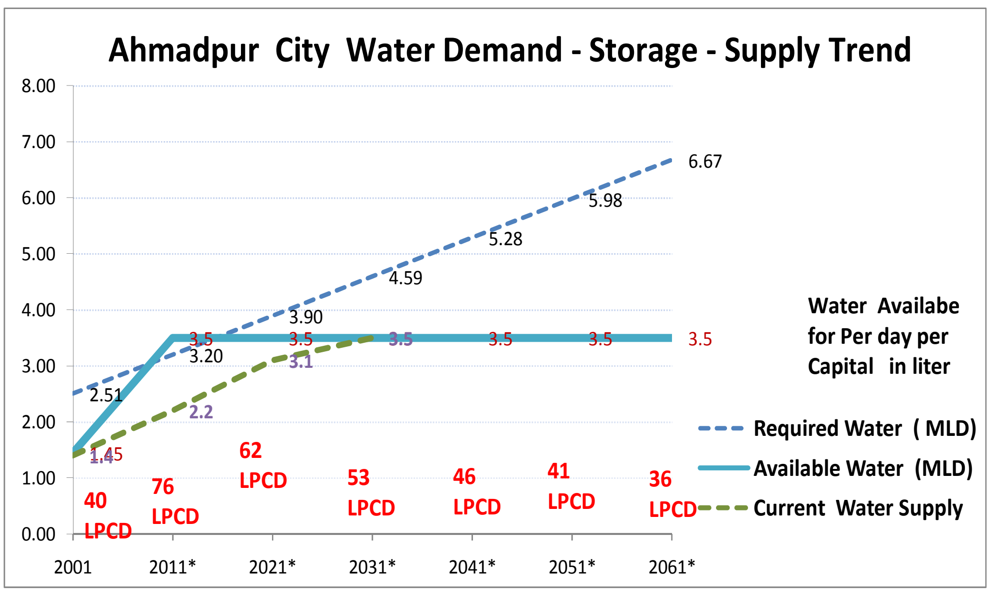
➢ Limited water sources

➢ High living Style

➢ Poor water management

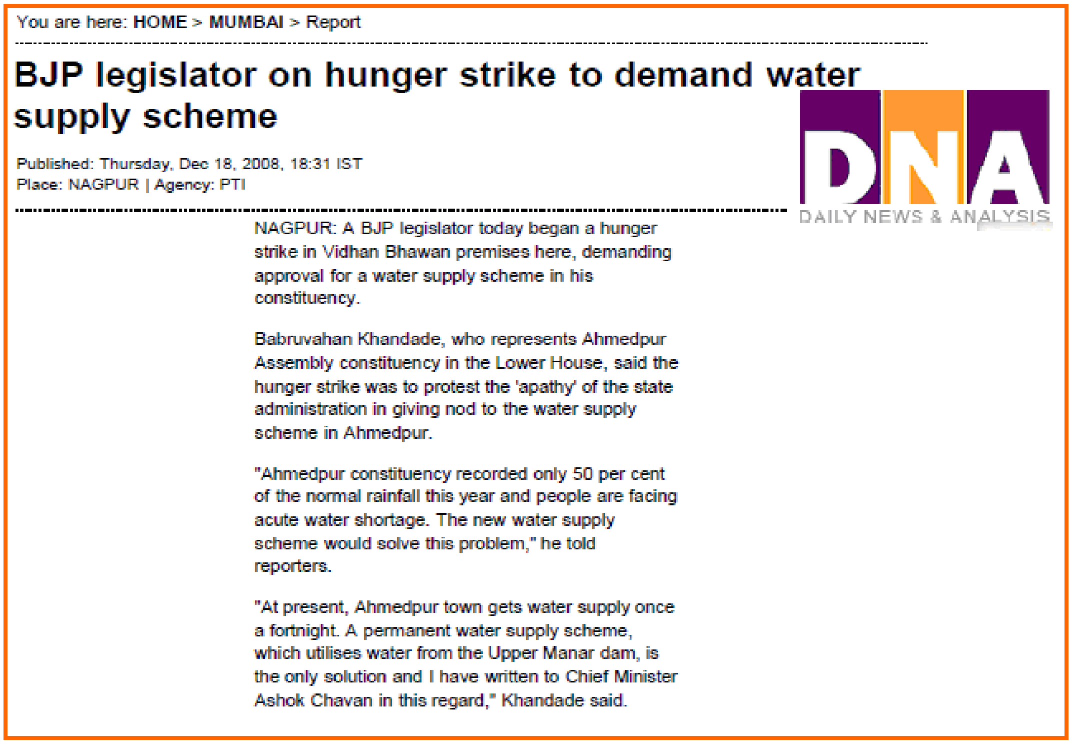
Year	Population	Water Need (MLD)	Available Water (MLD)	Water Shortage	Water (LPCD)
2001	35800	2.51	1.45	1.06	40.5
2011*	45724	3.2	3.05	0	76.5
2021*	55648	3.9	3.05	0.4	62.9
2031*	65571	4.59	3.05	1.09	53.4
2041*	75495	5.28	3.05	1.78	46.4
2051*	85419	5.98	3.05	2.48	41
2061*	95343	6.67	3.05	3.17	36.7

Table 4.5 Water Shortage of Ahmadpur City



Graph 4.4 Ahmadpur City Water Demand – Storage – Supply Status

Above graph shows that today there is a problem because the Population growth is playing important role in water crisis. Ahmadpur is a well known education center due to that there is immigration of people for education. Currently the water problem is under control because since 2010 Ahmadpur municipality has been getting water from Linmboty Dam. But in future farmer will consume the water for agriculture and simultaneously the populations of Ahmadpur will growth that time the water crisis will start in Ahmadpur city. Following news and snaps show the story of water shortage problem.



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BJP legislator on hunger strike to demand water supply scheme

DNA DAILY NEWS & ANALYSIS

Published: Thursday, Dec 18, 2008, 18:31 IST
Place: NAGPUR | Agency: PTI

NAGPUR: A BJP legislator today began a hunger strike in Vidhan Bhawan premises here, demanding approval for a water supply scheme in his constituency.

Babruvahan Khandade, who represents Ahmedpur Assembly constituency in the Lower House, said the hunger strike was to protest the 'apathy' of the state administration in giving nod to the water supply scheme in Ahmedpur.

"Ahmedpur constituency recorded only 50 per cent of the normal rainfall this year and people are facing acute water shortage. The new water supply scheme would solve this problem," he told reporters.

"At present, Ahmedpur town gets water supply once a fortnight. A permanent water supply scheme, which utilises water from the Upper Manar dam, is the only solution and I have written to Chief Minister Ashok Chavan in this regard," Khandade said.

News Snap 4.1 Ahmadpur Water Shortage issue

Photo 4.1 Water Problem issue

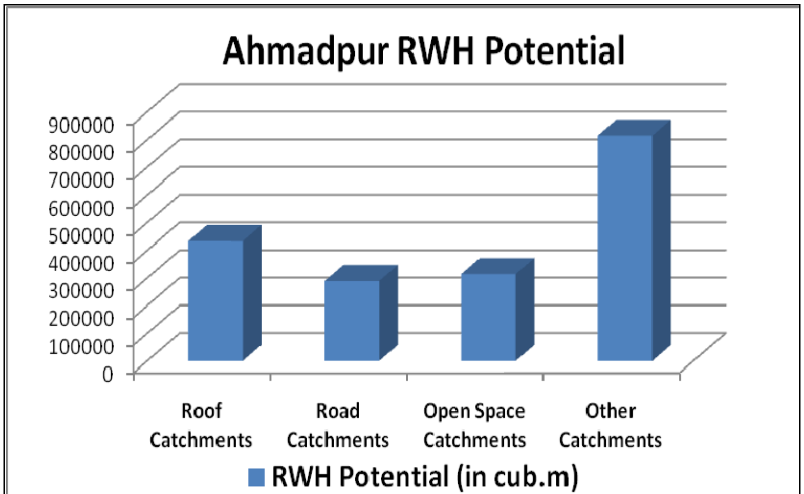
Chapter V

Analysis and conclusion

5.1 Rainwater Harvesting Potential:

The total amount of water that is received in the form of rainfall over an area called the rainwater endowment of that area. Out of this, the amount that can be effectively harvested is called the water harvesting potential. Among the several factors that influence the rainwater harvesting potential of a site, climatic conditions specially rainfall and the catchments characteristics are considered to be the most important.

Ahmadpur receives an average 887 mm rainfall annually and the numbers of rainy days are 40-50. Mostly rainfall receives in forth rainy season June -September, highest amount of rainfall is received during July to August, while the rest of the months receive scanty rainfall. The rock is basalt-Weathered with joints and fractures in abundance due to intense physical weathering of rocks. The depth of weathering varies from 0.2 m to 20 m. This geological set-up offers an immense scope for recharging of ground aquifers. The undulating terrain with gentle slopes and concrete medium size roof offers an ideal situation for rainwater harvesting. But there ground water level continually falling down due to over pumping and be short of recharge. If this situation will remain same then one day Ahmadpur people will lose ground water. So it is not late, these things can be recover using appropriate rainwater harvesting method.



Graph 5.1 Rainwater Harvesting Potential

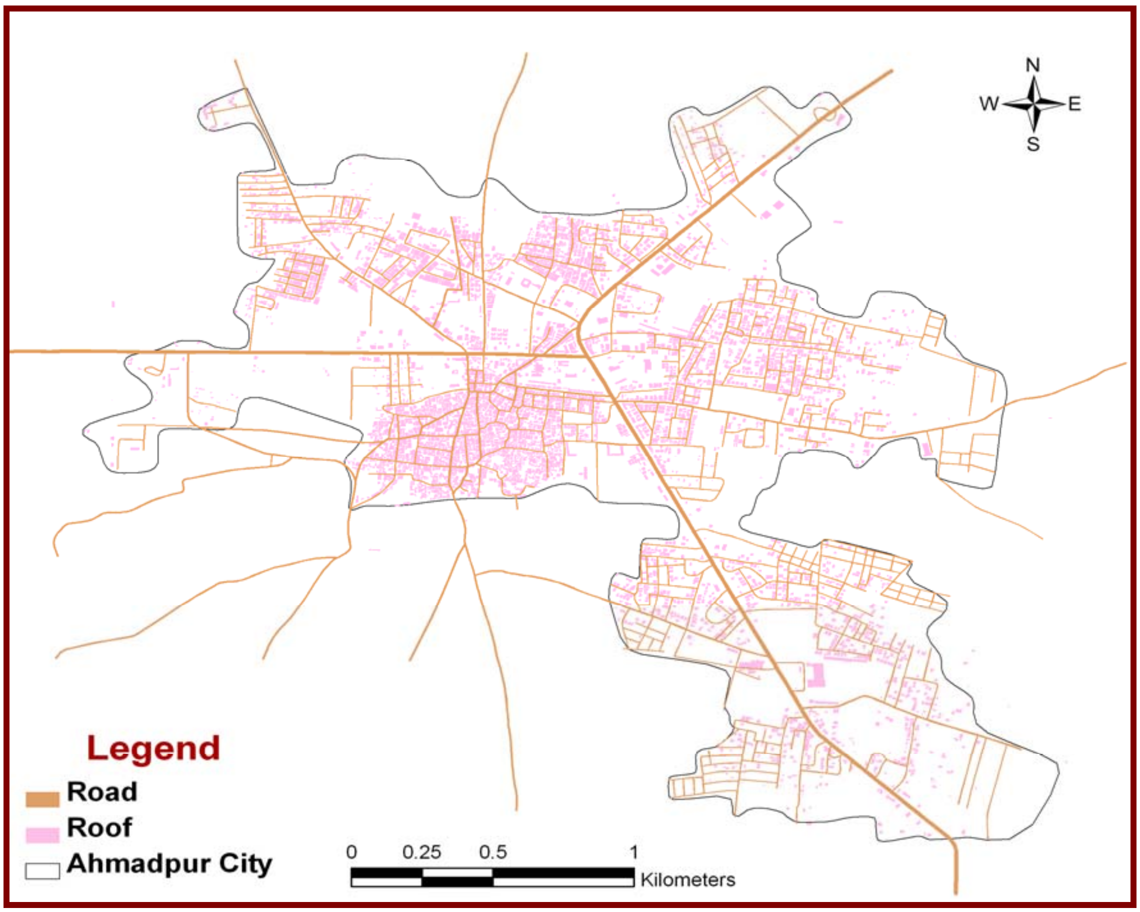
Rainwater harvesting potential has been calculated of Ahmadpur city. It is indicate that the utilizable water can help Ahmadpur sustainable development.

5.1.1 Roof Rainwater Harvesting Potential: In this category all building and house roof are considered as catchment. There are about 5500 roofs in different shape & size. In Ahmadpur building roof area is having between 50 to 200 Sq m and below 50 Sq m area roof are 1119, these small area roofs found in old Ahmadpur located in slum areas.

Roof Area In Sq m	**Roof Count**
Below 50	1119
50-100	1850
100-200	2026
200-300	343
300-400	80
400-500	41
Above 5000	41

Table 5.1 Roof area Size classes

Roof and Road Catchment RWH Potential



Category	Area (in Sq. m)	Rainfall (in mm)	Average Run-off Coefficient	RWH Potential (in cub.m)
Roof Catchment	617979	887	0.79	433036
Road Catchment	435008	887	0.75	289389

Map 5.1 Roof & Road RWH Potential

Study result show that 80 % of roofs are applicable of rainwater harvesting and about 41 roofs are having very high potential of harvesting.

Building Name	Area (in Sq m)	Run off coefficient	rainfall (in mm)	RWH Potential in Liter
Rest House	1029.60	0.80	887.00	730604.16
Government Hospital	623.61	0.80	887.00	442513.66
Z.P Building	501.93	0.80	887.00	356169.53
Ahmadpur Court	781.90	0.90	887.00	624190.77
Z.P Building	571.01	0.80	887.00	405188.70
M.P School	615.89	0.80	887.00	437035.54
M.G.M	4064.20	0.80	887.00	2883956.32
BUS Stand	620.39	0.80	887.00	440228.74
BUS Depo	1045.80	0.80	887.00	742099.68
Chame Marriage Hall	1170.50	0.90	887.00	934410.15
Yeswant School	557.77	0.80	887.00	395793.59
Chorwak College	1037.70	0.80	887.00	736351.92
M.G Cillege	794.03	0.90	887.00	633874.15
M.G.M	1671.00	0.80	887.00	1185741.60
Vijay Chitra Mandir	611.19	0.90	887.00	487912.98
Nagrgoje M.Hall	965.87	0.70	887.00	599708.68
Hostel	687.13	0.80	887.00	487587.45
Chorwak School	719.36	0.80	887.00	510457.86
Thasil	522.47	0.80	887.00	370744.71
Panchyat Samiti	500.88	0.80	887.00	355424.45
Government Hospital	1206.10	0.80	887.00	855848.56
Kale Village RD Majit	965.70	0.80	887.00	685260.72
Market Storage	633.84	0.80	887.00	449772.86
Smrat Hotel	704.90	0.80	887.00	500197.04
ITI College	718.32	0.80	887.00	509719.87
ITI College	850.61	0.80	887.00	603592.86
M.P College	679.22	0.80	887.00	481974.51
M.P School	530.44	0.90	887.00	423450.25
Storage Building	651.63	0.90	887.00	520196.23
Ahmadpur Court	543.30	0.80	887.00	385525.68
Z.P School	843.57	0.80	887.00	598597.27
Majit Near Court	596.07	0.80	887.00	422971.27
Market Line	576.85	0.80	887.00	409332.76
Market Line	735.04	0.80	887.00	521584.38
Market Line	736.15	0.80	887.00	522372.04

Table 5.2 Large Size Roofs RWH Potential

5.1.2 Road Surface RWH Potential: Road rainwater harvesting should be adopted in Ahmadpur because road surface is one of big catchments after building roof. Road surface harvesting can be done by collecting rainwater into a number of collection pits and trench or collected in specific water storage tanks. This method is simple and cost effective for Ahmadpur. A considerable amount of city area road area is around 15 percentages which is available for road rain water harvesting. The situation of road is good so maximum rainwater can be collected. The Ahmadpur Municipal authority is capable of collection, distribution and maintenance of road Rain water, so that the scheme can be effectively funded and the benefits shared among the residents. This method will also help to reduce water logging problem.

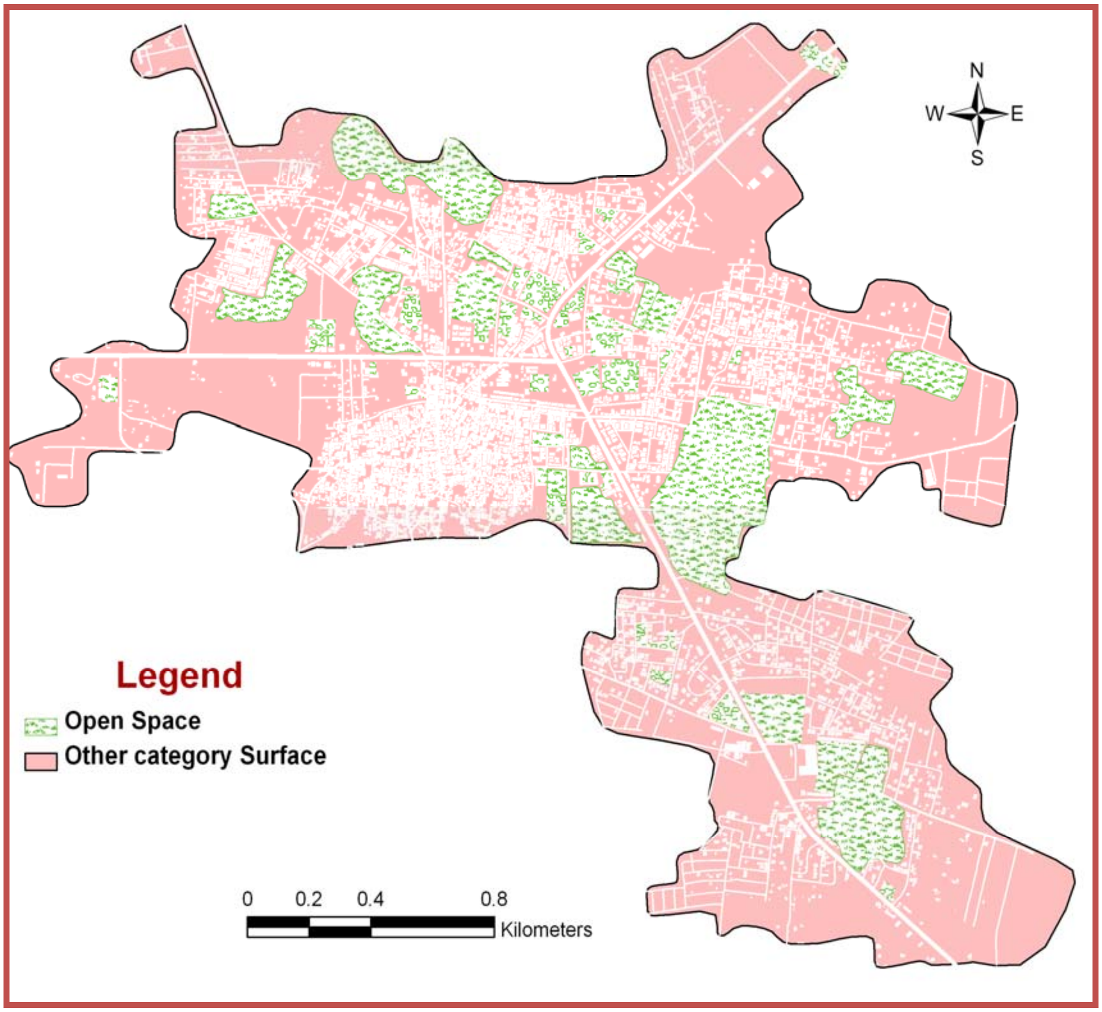
5.1.3 Open Space RWH Potential: Ahmadpur city open space can utilized for rainwater harvesting such as park, play ground, college and school open space and parking area, open plot etc. In Ahmadpur more than 16 percentage area is covered by open space. Rainwater harvesting methods in parks and open spaces involve micro-watershed management methods that allow rainwater infiltration and percolation into the ground. The runoff has to be minimized by providing adequate number of percolation pits and dispersion trenches. In large parks, storage of rainwater in small ponds is also possible since the ponds can be integrated with the landscape of the park. There are more than 50 open space are available out of that 24 open spaces are having very good RWH potential.

Open Space Area	Area (in Sq m)	Rainfall (in mm)	Run-off Coefficient	RWH Potential (in cub. m)
Court Open Space 2	10256	887	0.55	5003.39
Bus Depo	10905	887	0.55	5320.00
Near Rest House open space	13030	887	0.55	6356.69
M.G college ground	16155	887	0.55	7881.22
Open Space Behind The charwak	25184	887	0.4	8935.28
Nagesh Nager Area	20089	887	0.55	9800.42
Kale Gaon road open Space	28548	887	0.4	10128.83
Z.P Ground	21519	887	0.55	10498.04
M.G college Sport ground	23711	887	0.55	11567.41
Hanuman Tekdi Area	23989	887	0.55	11703.03
Indra Nager	27948	887	0.55	13634.43
Near M.G.M College	62592	887	0.55	30535.51
Anand-Wadi Road Area	72971	887	0.55	35598.90
Nijwanti Nager	150058	887	0.55	73205.80

Table 5.3 Open Space Area RWH Potential

5.1.4 Other Surface Rainwater Harvesting Potential: The other surface can also use as catchments surface. This category includes agriculture, forest, and barren land. Ahmadpur city surrounding area is covered by agricultural and barren land.

Open Space and Other Category Catchment RWH Potential



Category	Area (in Sq. m)	Rainfall (in mm)	Average Run-off Coefficient	RWH Potential (in cub. m)
Open Space Catchment	645002	887	0.55	314664
Other Catchment	2298079	887	0.4	815358

Map 5.2 Open Spaces & Other Surface Category RWH Potential

5.2 Applicable Rainwater Harvesting Method for Ahmadpur:

5.2.1 Roof Rainwater Harvesting:

5.2.1.1 Recharge Groundwater through RRWH: Where roof area is having below 100 Sq m in this condition recharge groundwater method is suitable because collected volume is very low form these roof that why it is better to recharge it in ground. In Ahmadpur city these type of roof are more so this method can be used effectively. There are different techniques of Recharge roof top rainwater. The suitable method is depend on roof shape, Open Space available, ground slope, ground surface ,local material and user budge .

5.2.1.1.1 Recharge Groundwater via bore-wells: In Ahmadpur numbers of bore-well are getting dry up which can use for recharge deep aquifers. The people who have bore-well they can apply this technique. In this technique Rainwater collected from rooftop is diverted through drainpipes to filtration tank.

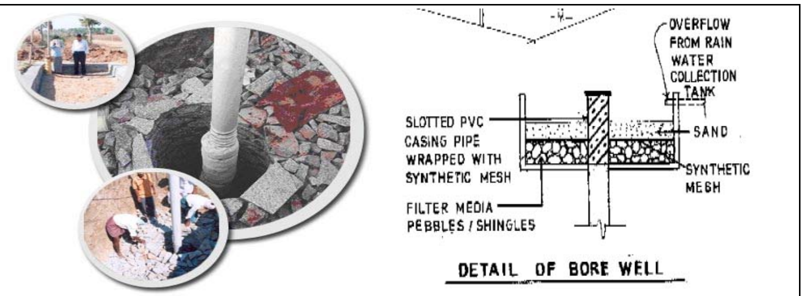


Figure 5.1 Recharge Bore-well

After filtration water is diverted to bore wells to recharge deep aquifers. Abandoned bore wells can also be used for recharge. If a bore well is used for recharging, then the casing (outer pipe) should preferably be a slotted or perforated pipe so that more surface area is available for the water to percolate. For more detail see (RWH Overview-3.4.1.4)

5.2.1.1.2 Recharge Groundwater via Pit: Recharge pits are small pits of any shape rectangular, square or circular, contracted with brick or stone masonry wall with weep hole at regular intervals. Top of pit can be covered with perforated covers. Bottom of pit should be filled with filter media. The capacity of the pit can be designed on the basis of catchments area, rainfall intensity and recharge rate of soil. Usually the dimensions of the pit may be of 1 to 2 m width and 2 to 3 m deep depending on the depth of pervious strata. These pits are suitable for recharging of shallow aquifers, and small houses. For more detail see (Rainwater Harvesting overview -3.4.1.2)

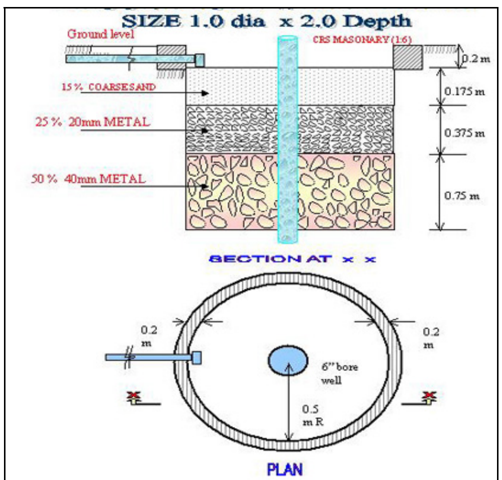


Figure 5.2 Circle recharge Pit

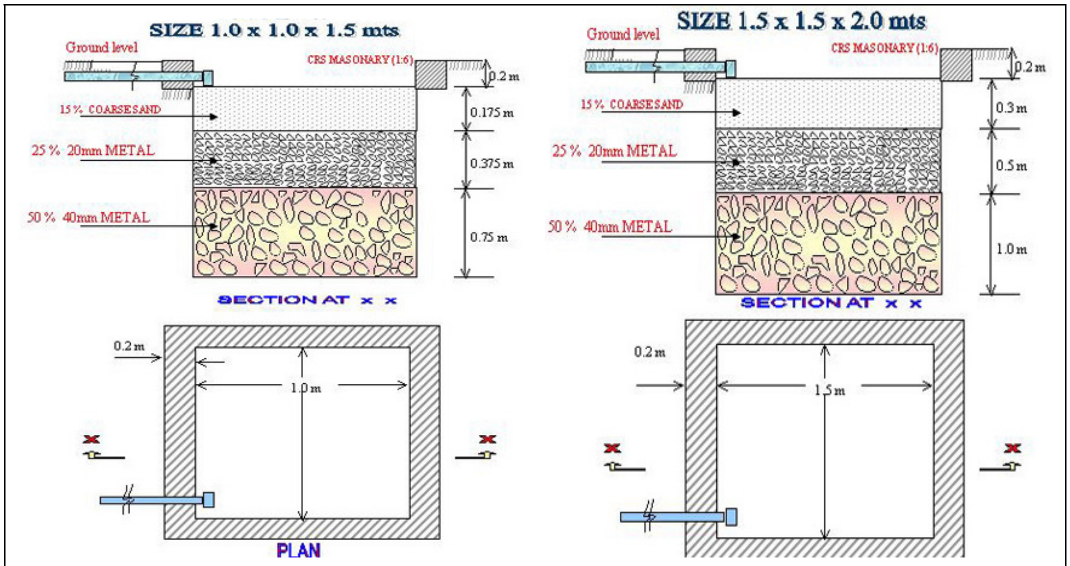


Figure 5.3 Recharge Pit

5.2.1.1.3 Recharge via Groundwater Trench: This technique is suitable for roadside drains and houses having roof area of 200-300 sq m. The recharge trench can be of size 0.50 to 1.0 m wide, 1.0 to 1.5 m deep and 10 to 20 m. long depending upon availability of water to be recharge.

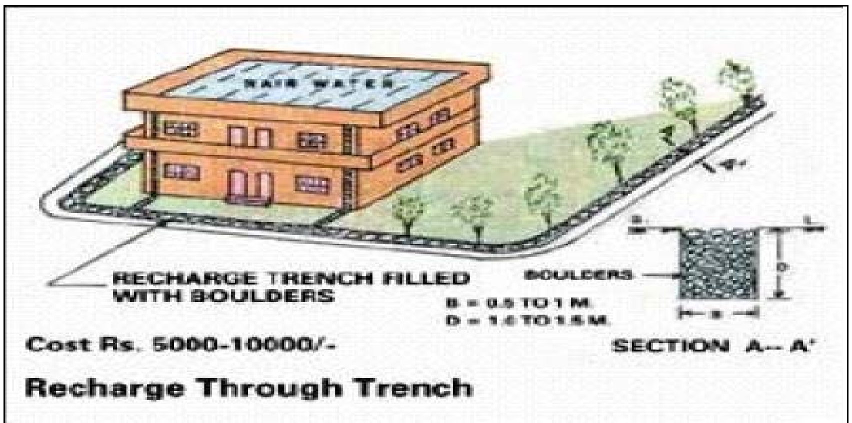


Figure 5.4 Recharge Trench

5.2.1.2 Store Roof Rainwater: In this technique rainwater store in storage for domestic use. Storage size depends on water available and water demand. Collected water needs to be purified before it can be used. This technique is suitable in following condition 1) Lack of other water sources 2) Rainwater supply should be equal or more than water demand 3) Owner should have required budget to install RWHS to there home. 4) Roof size should be large than 100 Sq m. There are few building found in Ahmadpur where all conditions are fulfilled. Only large size roof condition is found in large scale.

About 2500 roofs are present where roof size is larger than 100 Sq m. All conditions will match then this technique will be applicable. For more detail about storage rainwater harvesting technique see (Rainwater Harvesting-3.4.1.1) Suitable roof for recharge and store rainwater has been shown in map 5.3.

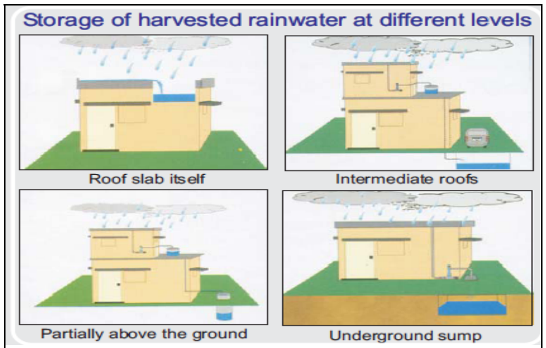
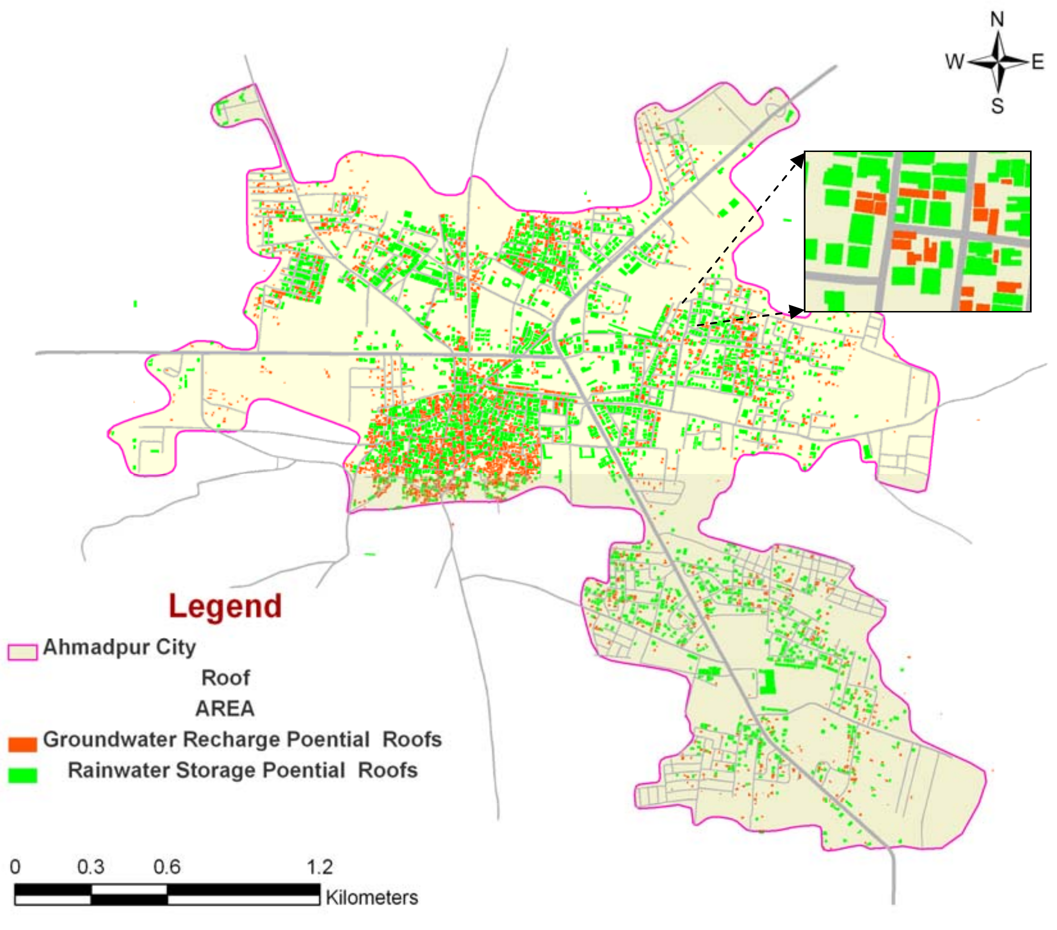


Figure 5.5 RRWH Storage

Suitable roofs for recharge and store RRWH



Map 5.3 Suitable roofs for recharge and store RRWH

5.2.2 Harvest Road Surface Rainwater: In Ahmadpur 25 percentage area is covered by road. In Ahmadpur RSRWH having good scope because 435008 sq m area is covered by road and these are in good condition. Road surface rainwater can be harvested using following techniques.

5.2.2.1 Recharge pit along the road: This technique is applicable for city road because narrow road does not have space for trench beside it then recharge pit is good option for that. Recharge pit gap and it size depend on intensity of rainfall. Recharge pit roof should be strongly constructed because vehicle should pass over it.

Figure 5.6 Recharge Pit along Road

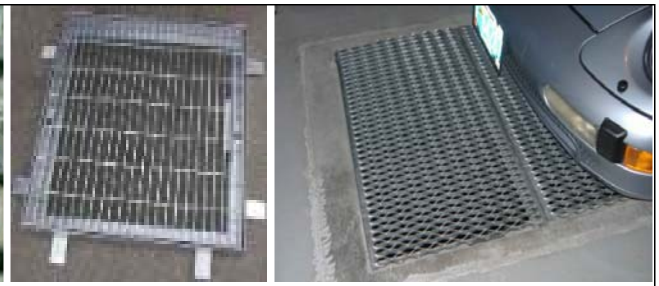


Photo 5.1 Recharge Pit along Road

5.2.2.2 Recharge trench beside the road: As the roads are built sloped towards the sides, rainwater falling on the road is guided to the side drains. When it rains, water flows from the apex to the sides and collects in the sidewalk area and subsequently flows to the storm water drains. This technique is suitable for wide road. In Ahmadpur about 30-35 per cent roads are wide. In this technique rainwater from the road flows into the infiltration trench, water percolates into the ground. In this technique 1 m width and 1 m depth trench covers by gravel and crush stone.

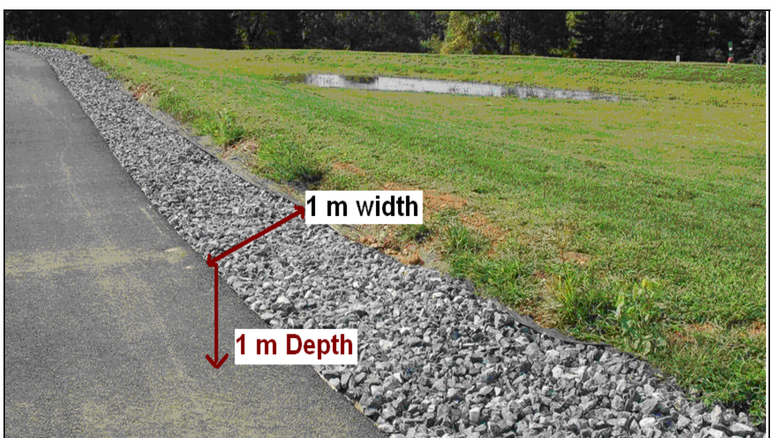


Figure 5.7 Recharge Trench beside the Road

5.2.2.3 Pavers blocks street road & footpath: Very narrow street road & footpath should be constructed using pavers block because it is eco-friendly and help to recharge groundwater.

Photo 5.2 Pavers blocks street road & footpath

5.2.3 Harvest Open Surface Rainwater

5.2.3.1 Recharge Open Surface Rainwater: Yet Ahmadpur is not full developed city so it is having lot of open spaces like open plot, park, play ground and barren land. These open spaces can be use as rainwater catchment. About 645002 sq m area is covered by open space. There are various techniques to harvest rainwater from open space

5.2.3.1.1 Contour bund: Contour bund is applicable where large open space is available with moderate slope. There are 13 place covered 0.500 sq km area in Ahmadpur where contour bund rainwater harvesting technique can be applied. Contour Bund Height and width is depending on rainfall intensity and surface slope. Generally temporary unused or barren land selects for contour bund. For more detail see (Rainwater Harvesting-3.4.2.2).

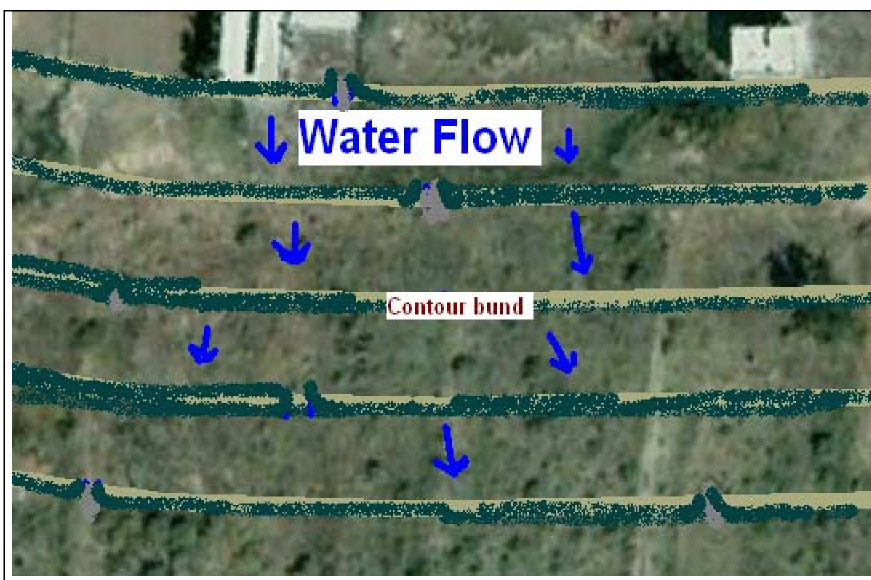
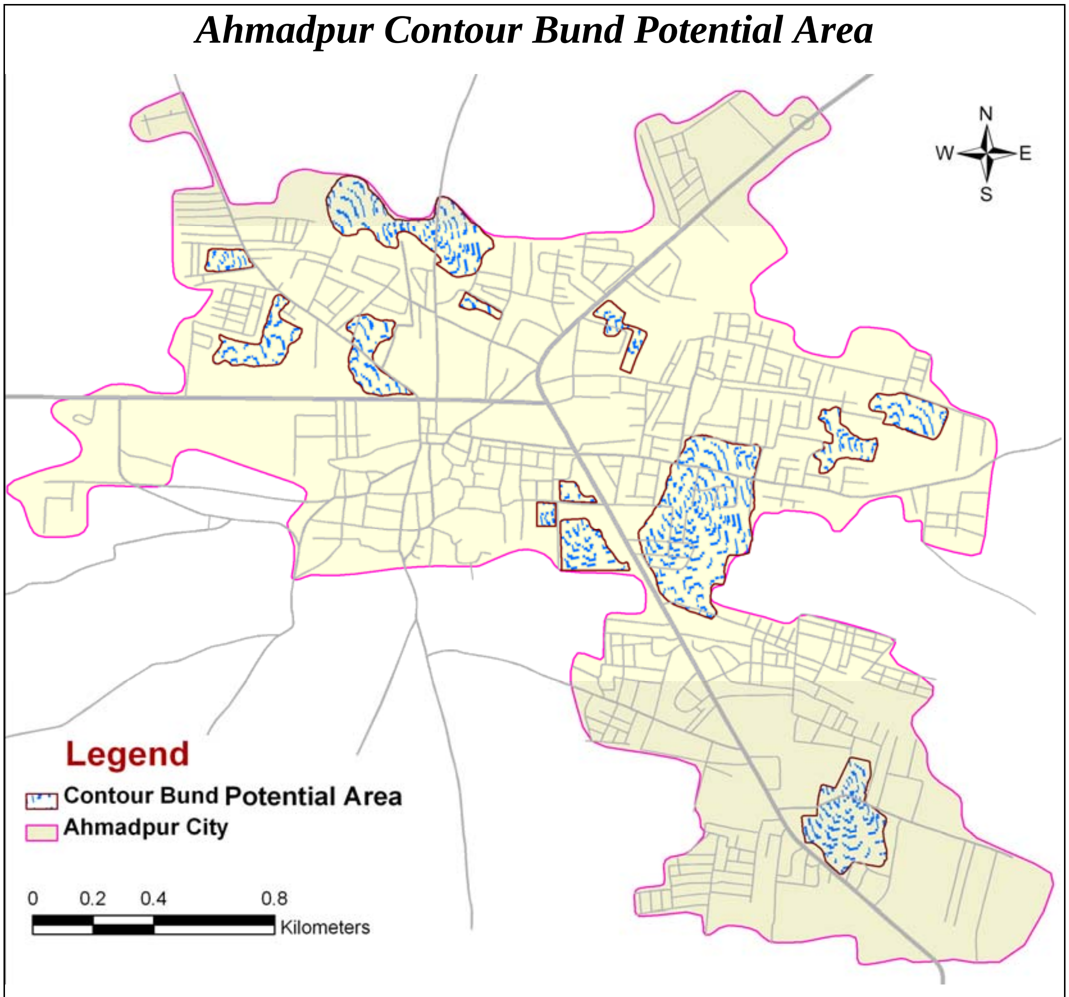


Figure 5.8 Contour Bund



Map 5.4 Ahmadpur Contour Bund Potential Area

5.2.3.1.2 Diagonal trench along the slope: This technique is applicable to large area. Which we use regularly i.e. play grounds, park, parking area etc. Trench should be proper covered which can not be trouble while utilizing open space.

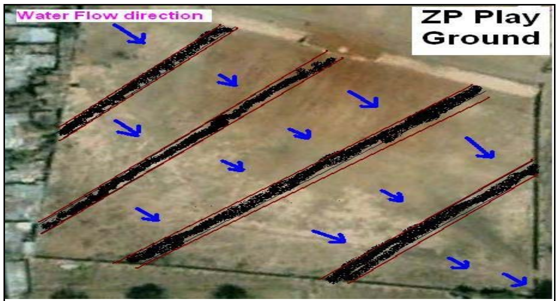


Figure 5.9 Diagonal trench along the slope

5.2.3.1.3 Recharge through Percolation Pits & Trench: This technique is applicable for small and moderate open space i.e. office, school, and Building surrounding area. If the open space surrounding, the surface run off may be recharged into ground through percolation pits or trenches or combination of pits and trenches. Depending on the geomorphologic, topographical and soil condition, the pits may be of the size of 1.20 m width x 1.20 m length x 2.00 m to 2.50 meter depth. The trench shall be of 0.60 m. width x 2.00 to 6.00 meter length x 1.50 to 2.00 meter depth. The surface run off shall be channeled to pits or trenches. There 25 areas are found in Ahmadpur city which are applicable for rainwater harvesting.

Figure 5.10 'L' Shape Recharge trench

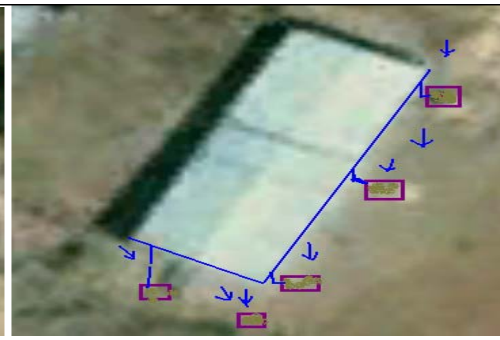
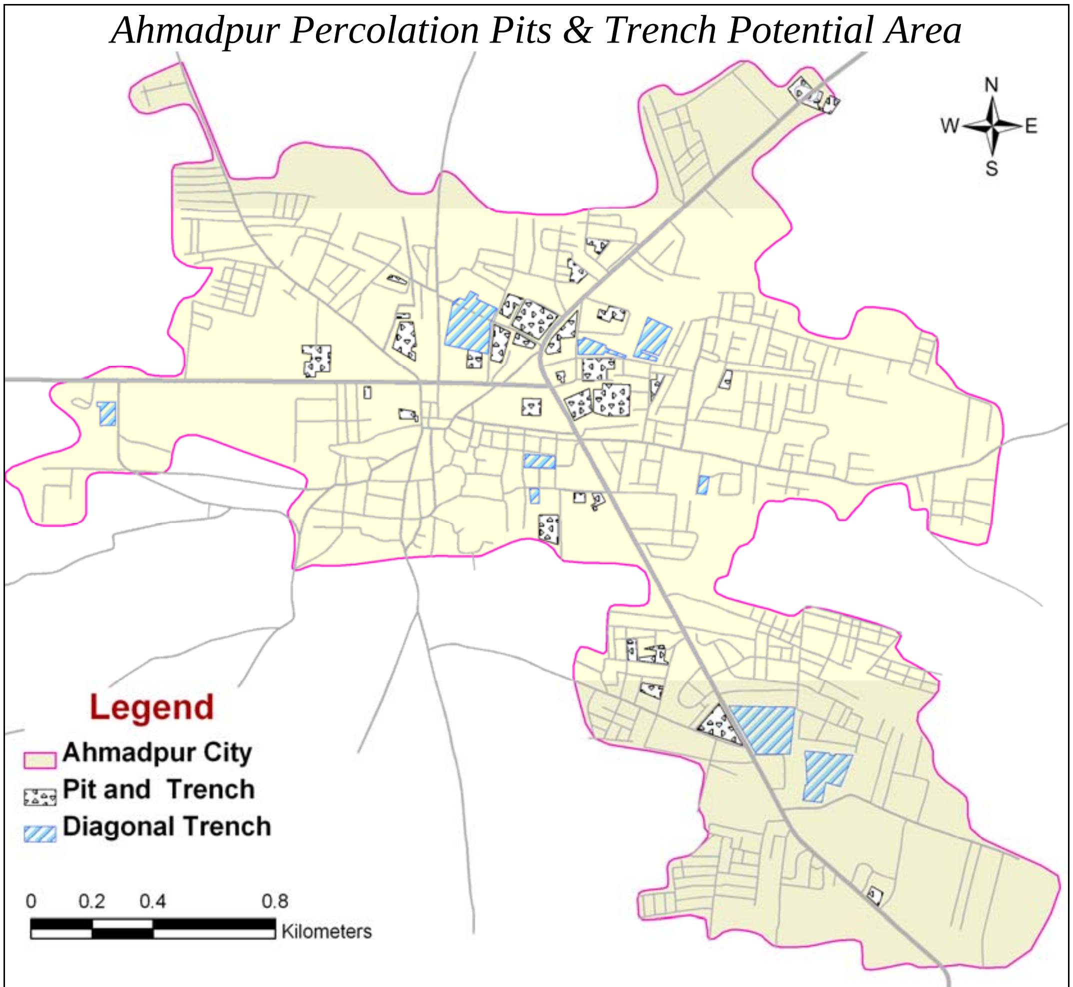


Figure 5.11 Recharge Pit



Map 5.5 Ahmadpur Percolation Pits & Trench Potential Area

5.2.3.2 Store Open Surface Rainwater in small stream / Nala: Using nala bund and check dam we can collect open surface rainwater in stream and nala for future use. In this technique bund are constructed on small stream (1st or 2nd order) after particular distance reference to surface slope. Ahmadpur city is having good scope for this technique because of the three major streams in gentle slope zone witch cover large open space of City.

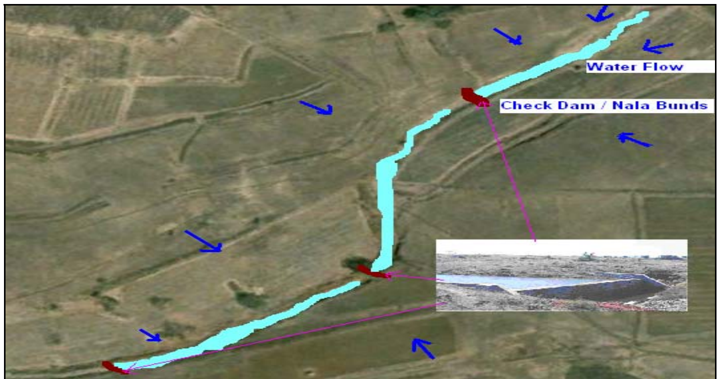


Figure 5.12 Check Dam along the Small Stream / Nala

5.2.4 Harvest Rainwater from Other surface: Other surface category includes agriculture land and barren land which is covered 2298079 sq m area of Ahmadpur. In this area rainwater can be harvested by using following techniques.

5.2.4.1 Farm Bund: Farm bund is a soil wall built across a slope to retain water or to hold waste in a sloping landfill site. Bunds have many benefits, including marking the boundaries of farm-holdings, slowing the movement of soil and water, and providing a place for integrating trees into agricultural systems. Internal bunds can be spaced every 20 to 30 meters apart to promote soil and water conservation. These bunds should follow the contours of the landscape.

Photo 5.3 Farm Bund

5.2.4.2 Farm ponds: Generally farm pond is constructed to full fill short term water demand of agriculture. As far as possible the pond should be located in the lower patches of the field to facilitate better storage and less seepage losses. The size of the farm pond should be worked out considering annual rainfall probable runoff and the catchments area. Generally, 10 to 20 per cent of the seasonal rainfall is considered as runoff in medium and deep black soils. The farm ponds may be circular squared or rectangular. However eared or rectangular ponds are more convenient for harvesting of runoff water.

Photo 5.4 Farm Pond

5.2.4.3 Rainwater water holding farming techniques: There are number of techniques which can be applied for rainwater harvesting in Ahmadpur surroundings. The methods like regular soil ploughing, terrace farming, Crop pattern, water percolation and collection farming pattern etc. needs to be practiced.

Photo 5.5 RWH Orient soil ploughing

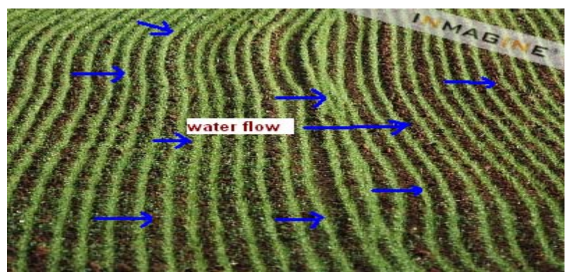


Figure 5.13 RWH Orient sowing pattern

Photo 5.6 RWH Orient Terrace farming

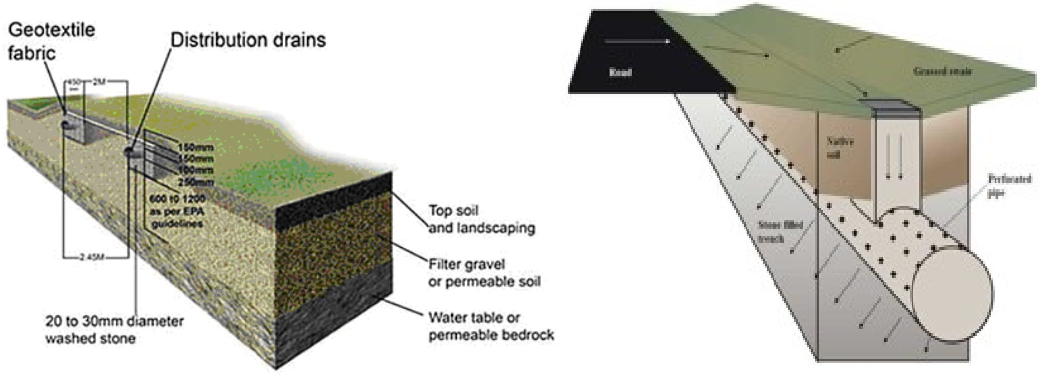


Figure 5.14 water percolation and collection farming pattern

5.3 RWH Benefits for Ahmadpur:

There are so many benefits of RWH for Ahmadpur. Firstly Rainwater harvesting provides the long-term answers for water scarcity. Also it would help to increases secondary water storage. It is the perfect solution to meet water requirements especially where do not have sufficient water resources. It helps in improving the quality of the ground water and increasing the level of the ground level. Also it helps in improving the overall ecosystem.

If Ahmadpur people collect rainwater through RWH then no need to depend on the other water sources. In addition RWH reduces the flooding on roads and further prevents it from contamination. Some additional estimated RWH benefits for Ahmadpur are described bellow.

5.3.1 Best Solution for Water scarcity: Ahmadpur people are facing water shortage problem and this problem will become more serious if they will not take precaution at the earliest. The results of this study show that today with the help of Rainwater harvesting Ahmadpur people will get 85-90 per cent of required water.

5.3.2 Save Money: We know that rainwater is available free of cost, it is gift given by God. We only charge for our storage / infiltration and this cost is very low cost than today Ahmadpur people pay for little water. Following table is showing Ahmadpur city's various sources water cost.

Water category	1000 Liter Water Cost in Rupees
Government Water	10.000
Commercial Water	50.000
Commercial Purify Drinking Water	12000
RRWHS Water	03.000 ✓

Table 5.4 Ahmadpur Various source Water Cost

5.3.3 Reduce pressure on municipal water supply: There Municipal having pressure of regular water supply due to population growth and limitation of water. If Ahmadpur people will start using RRWHS to their house then Municipal water supply 50 per cent pressure will be reduce.

5.3.4 Increase in Groundwater Level: RWH is the ideal solution to Increase groundwater level in Ahmadpur. If implemented RWH properly then 1-2 m ground water level will increase.

5.3.5 Help to control flood & Soil erosion: RWH is solution not only for a water sacristy but also helpful to control the flood & Soil erosion.

5.3.6 RWH is Easy & Environment Friendly Technique: There is no bad effect of RWH on environment because it eco-friendly Technique.

5.4 Conclusion: The population growth noticed in Ahmadpur city is exponential, so the per capita water demand has put stress on fresh water resources. In other side groundwater recharge and surface storage process is not happening satisfactory because most of the rainwater is flushed off and very few amount of water is useful for the charge of groundwater. As a result, most parts of Ahmadpur people are experiencing scarcity of water. The Surface sources are failed to meet the domestic needs and day by day the demands of water supply is rising in Ahmadpur.

This precarious situation can be rectified by immediately recharging the depleted aquifers. Hence, the need for implementation of measures to ensure that rain falling over a region is tapped as fully as possible through rainwater harvesting, either by recharging it into the groundwater aquifers or storing it for direct use. Also water management and reuse of water is important and essential for sustainable development. Each drop of fresh water saves and use properly will go a long way in quenching the thirst and desire of human civilization. Ahmadpur is having ideal situation for RWH because of occurring rainfall and land surface phenomena, surface structure along with RWH potentiality. There are several benefits of RWH especially for Ahmadpur such as best solution for water scarcity, save the money, reduces pressure from Municipal Water Supply, rise in groundwater level, etc. The analysis carried out in this study show that the people in Ahmadpur are facing water crisis and this problem will become more serious if timely precaution is not taken it is going to be a serious issue. The study revels that for Ahmadpur city the Rain Rainwater harvesting techniques produce about 85-90 per cent of required water.

Ahmadpur city is fall in basalt area. The artificial recharge structures is suitable such as recharge pit, recharge trench, recharge bore-well check dams, gully plugs percolation tanks, nalla bunds. The harvested rainwater should be properly filtered before its use.

5.5 Recommendation: Any work will not come in to success without sincere efforts, proper management, economic support and public awareness.Following things need to consider while applying RWH in Ahmadpur.

5.5.1 RWH Public awareness: Rainwater harvesting public awareness is important because people aware about water crisis but they don’t know how RWH can help them. The public awareness work should be developed by the Government as well as all associated peoples. In this concern number of seminars / workshops and exhibitions should organize by various Government agencies, NGOs and private individuals. As a result of this intensive campaign the rainwater harvesting will become popular in Ahmadpur city and automatically the residents will adopt it.

5.5.2 Need to change Government Policy: Government should involve in Ahmadpur RWH to make it success. Some level government is trying for RWH but there is getting less success. Government should make short and long term plane of RWH like Delhi, Chennai, and Bangalore etc. Government should provide subsidy for RWH project so all people will involve in it. Also Government should fix bound for water use.

5.5.3 Public responsibility: In RWH public role is very important because without support of people government can’t do any thing towards implementation of RWH. There are so many examples of policy which are implemented only on paper. So public should involve in RWH and they should know its importance and need. Also People should stop unnecessary use of water. .

5.6 Before RWHS installation: Before RWHS installation to your home checks out following thing, because it should be applicable for you otherwise it will only show item of your home.

5.6.1 Roofs rainwater harvesting potential: Before RWHS installation checks out rainwater harvesting potential of your roofs. If you known your roofs area, run-off coefficient and city average rainfall then use following tool to estimate rainwater harvesting potential.

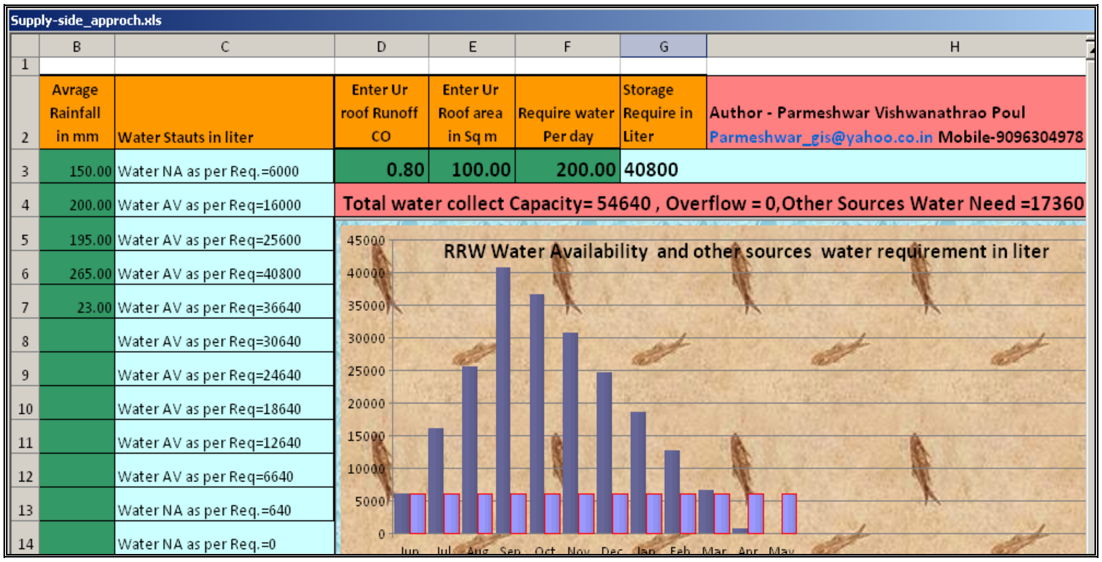


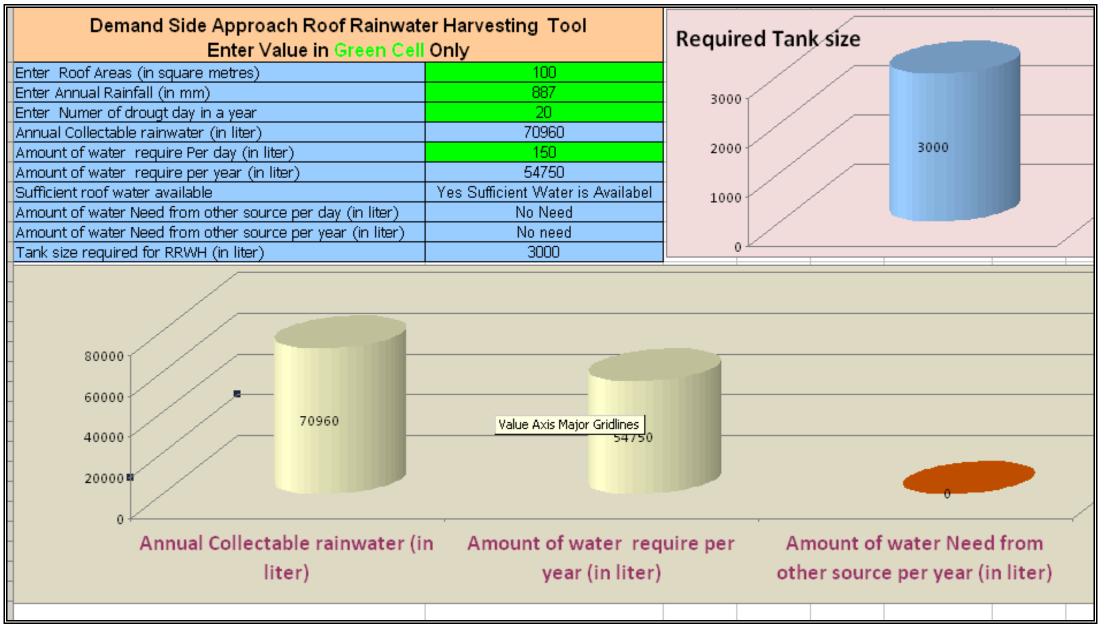
Figure 5.15 Supplied side RWH Tool

Otherwise use following web application tool.

Figure 5.16 RWH calculators (Source- http://www.save-the-rain.com/world-bank)

5.6.2 Rainwater harvesting installation Cost: It is vary important to check because if particular RWHS method is not in your budge then use alternative rainwater harvesting method which is in your budge generally rooftop rain water harvesting system construction require about ₹ 20000. If you want to add a sump, they are an additional ₹ 6-7 per liter of storage. This cost will change place to place. In RRWH tank construction cost is vary high that why tank size & it cost estimation is require. Following tools will help to examine RRWHS cost. If your house in monsoon climate zone then use *Figure*

5.15 Supplied side RWH Tool otherwise use following Demand side approach RRWH tool to estimate suitable tank size.



Demand Side Approach Roof Rainwater Harvesting Tool Enter Value in Green Cell Only	
Enter Roof Areas (in square metres)	100
Enter Annual Rainfall (in mm)	887
Enter Numer of drougt day in a year	20
Annual Collectable rainwater (in liter)	70960
Amount of water require Per day (in liter)	150
Amount of water require per year (in liter)	54750
Sufficient roof water available	Yes Sufficient Water is Availabel
Amount of water Need from other source per day (in liter)	No Need
Amount of water Need from other source per year (in liter)	No need
Tank size required for RRWH (in liter)	3000

Figure 5.17 Demand side approach RWH Tool

5.6.3 Surface Structure: Where you have to recharge groundwater there surface structure should be known. Respect to surface structure rainwater harvesting technique should be applied.

5.6.4 Take RWH experts, RWHS installer & previous user advice before install RWHS.

5.7 Things to implement:

5.7.1 Ahmadpur is underline by Deccan trap basalt where only dug-wells are most feasible structure for groundwater development. After proper scientific investigation the site for bore-well need to be selected.

5.7.1 Generally the bore-wells are deeper, which may not be sustainable. Therefore the Bore-well should be used for drinking water supply not for surrounding irrigation.

5.7.1 All over installation of RWHS should be compulsory. Education institutes, Social community, NGO & Government should apply RWH where it is applicable

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Appendix-A

Rainwater Harvesting System in Ahmadpur City

Questionnaire …./…../2010

Building Owner Name-		
Building Id-		Building category -Gov./industrial./Pvt. inst./Residential
Number of Person-		Type of Building -Kacha/Paka/Tin
Family Income-		Type of Building Roof-Concrete /Soil /Tin
Water problem days in year -		Public Opinion About RWH-
Purchase Water in year		…………………………………………………………………………
Water cost		…………………………………………………………………………
Water Quality	Yes or No	…………………………………………………………………………
Water Satisfaction-	Yes or No	………………………………………………………………………… …………………………………………………………………………

Appendix-B

Rainwater Harvesting Solution on Water Shortage

Monday, June 27, 2011

Rainwater Harvesting Solution on Water Shortage Problem

What is Rainwater Harvesting ?

a) The term "rainwater harvesting" is usually taken to mean the immediate collection of rainwater running off surfaces upon which it has fallen directly. It is also a method for inducing, collecting, storing and conserving local surface run-off for domestic, agriculture and industrial use (Boers and Ben-Asher, 1982)

b) Rainwater harvesting (RWH) is the practice of collecting rainwater and storing it for future use.

c) The Rainwater harvesting is the simple collection and storing of rainwater through scientific techniques from the areas where the rain falls. In RWH three things are important1) Catchment 2) delivery system 3) Storage / Reservoir

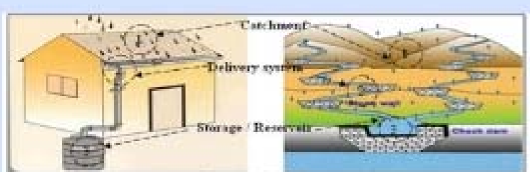

Figure 3.1 RWH Component

Rainwater Harvesting Type

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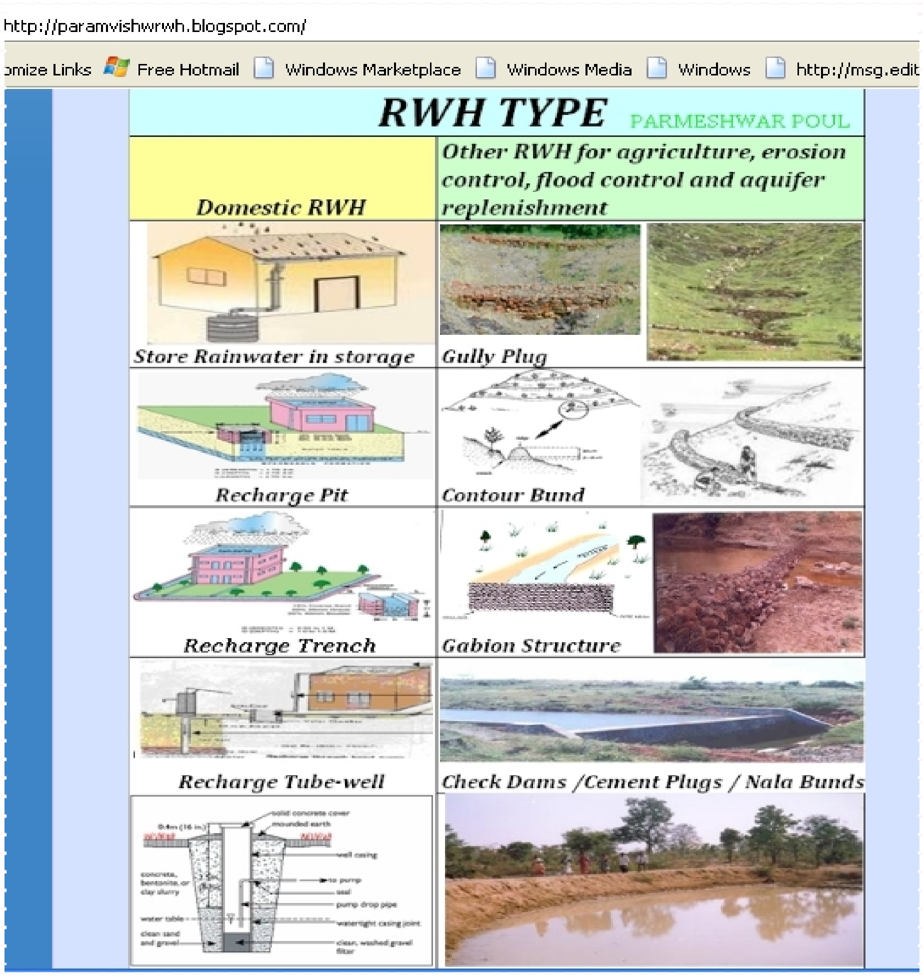
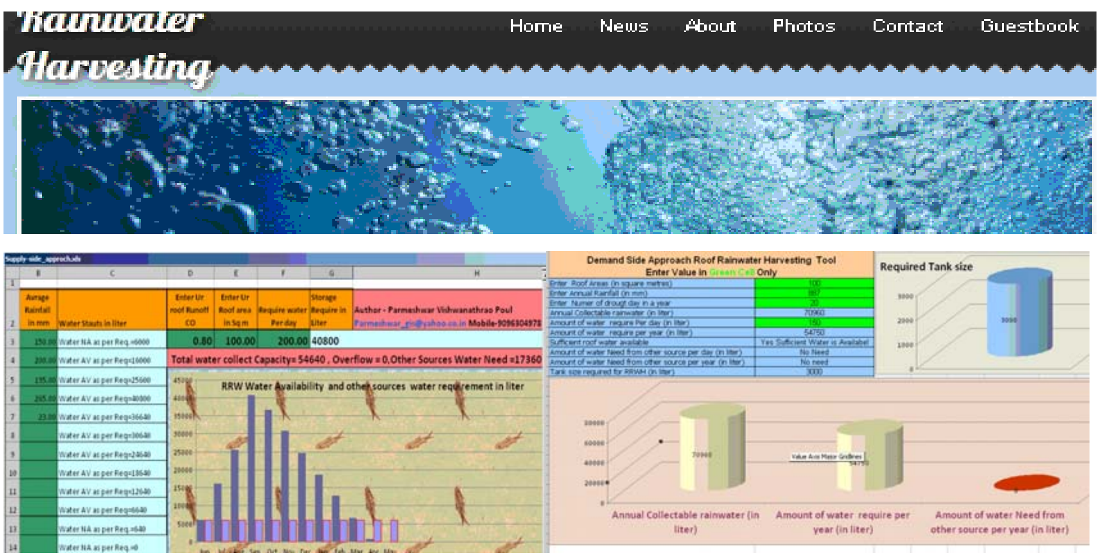


RWH Type Available at http://paramvishwrwh.blogspot.com

Appendix-C



RWH Tool Available at http://paramvishwrwh.webs.com/

Appendix-D

Overview on Water Shortage Problem

पुरेशा पाण्याविना निम्म्या महाराष्ट्राचे 'कुपोषण'

कोल्हापूर | दि. २८ (प्रतिनिधी)

जनतेला शुद्ध व मुबलक पाणीपुरवठा करणे ही प्रशासनाची मुख्य जबाबदारी आहे; पण राज्यातील ४३ टक्क्यांहून अधिक जनतेला आपण शुद्ध पाणी पितो याबाबत खात्री नाही; तर ५० टक्क्यांहून अधिक लोकांच्या वाट्याला कुटुंबाच्या रोजच्या गरजा भागविल्या जातील इतके पाणीसुद्धा मिळत नाही, हे धक्कादायक वास्तव 'लोकमत'ने पिण्याच्या पाण्यासंदर्भात केलेल्या सर्वेक्षणात पुढे आले आहे. संपूर्ण राज्यातून विविध स्तरांतील सुमारे १०,१०० लोकांची मते यासाठी अजमावण्यात आली.

[पाणी... पाणी...]

भौगोलिक विविधतेप्रमाणे राज्यात पाण्याची उपलब्धता विभागवार वेगवेगळी आहे. मात्र, पाणीपुरवठ्याबाबत असलेल्या त्रुटींबाबत तसेच पाण्याच्या अव्वाच्या सव्वा दराबाबत सर्वच विभागांत एकवाक्यता आहे. त्यामुळेच पाणीपुरवठ्याबाबत शासकीय यंत्रणा गतिमान होणे आवश्यक असल्याचे ७८ टक्के लोकांनी ठामपणे सांगितले. तसेच स्थानिक पातळीवर पाणीवाटपाबाबत दुजाभाव होत असल्याचे ४८ टक्के लोकांचे म्हणणे आहे. कारण पाणीवाटपात राजकीय हेवेदावे प्रभावी ठरत असल्याचे त्यांनी सांगितले. राज्यातील सर्वच भागांत पिण्याच्या पाण्यासाठी आकारले जाणारे दर अव्वाच्या सव्वा आहेत. प्रत्येक विभागाच्या सर्वेक्षणात ५० टक्क्यांपेक्षाही अधिक लोकांनी याबाबत नाराजी दर्शविली. असे असले तरी दैनंदिन वापरात पाण्याचा अपव्यय मोठ्या प्रमाणात होतो, असे ६४ टक्के लोकांनी निःसंकोचपणे मान्य केले. यासाठी ७५ टक्के लोकांनी योग्य प्रशिक्षणाची गरज बोलून दाखविली.

शुद्ध पाण्याबाबत आपण जागरूक असल्याचे ४५ टक्के लोकांनी सांगितले. यासाठी पारंपरिक व अत्याधुनिक साधनांचा वापर करीत असल्याचेही त्यांनी सांगितले. प्रवासादरम्यान एसटी स्थानक किंवा रेल्वे स्टेशन, आदी ठिकाणी असलेल्या पिण्याच्या पाण्याचा वापर करीत नसल्याचे ४५ टक्के लोकांनी सांगितले. कारण या पाण्याच्या शुद्धतेबाबत त्यांना खात्री नाही.

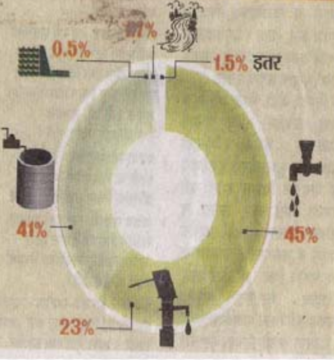
पाणी... पाणी
राज्याचे चित्र /१०

जल - सर्वेक्षण

"महाराष्ट्रात पडणाऱ्या पावसापासून ते सिंचन प्रकल्पांमध्ये अडविण्यापर्यंतच्या पाण्याचा कुठलाही हिशेब नाही. तिसरं महायुद्ध पाण्यासाठी होईल असं म्हणतात, या पार्श्वभूमीवर हक्काच्या पाण्याबाबतची राज्याची उदासीनता खटकणारी आहे. पाऊस मोजण्यासाठी तालुक्याच्या ठिकाणी पर्जन्यमापक यंत्रे आहेत. प्रत्यक्षात ती पाणलोट क्षेत्रामध्ये आवश्यक आहेत.

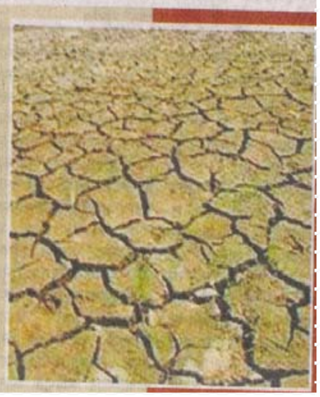
- डॉ. माधवराव चितळे
प्रख्यात सिंचनतज्ज्ञ

ग्रामीण भागाला उपलब्ध पाण्याचा स्रोत



पाणी कमतरतेचे ठळक मुद्दे

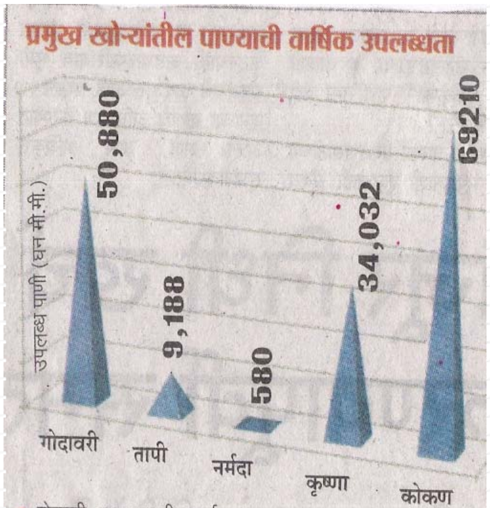
- महाराष्ट्राचा ९० टक्के भाग हा बेसाल्ट या कठीण खडकाचा आहे. त्यामुळे पाणी मुरण्याचे प्रमाण कमी
- राज्यातील १/३भाग अवर्षणग्रस्त आहे. विशेष म्हणजे मराठवाडा, उत्तर महाराष्ट्रातच सिंचनासाठी पाण्याची जादा मागणी
- राज्यात सर्वाधिक पाऊस पडणाऱ्या कोकणात जांभा खडक असल्याने या ठिकाणी पाणी साठून राहू शकत नाही
- भूजल साठ्यात क्षार, फ्लोराईड, नायट्रेट यांचे प्रमाण अधिक
- राज्यातील ९० हजार विहिरी, ३ लाखाहून अधिक कूपनलिका उन्हाळ्यात कोरड्या पडतात



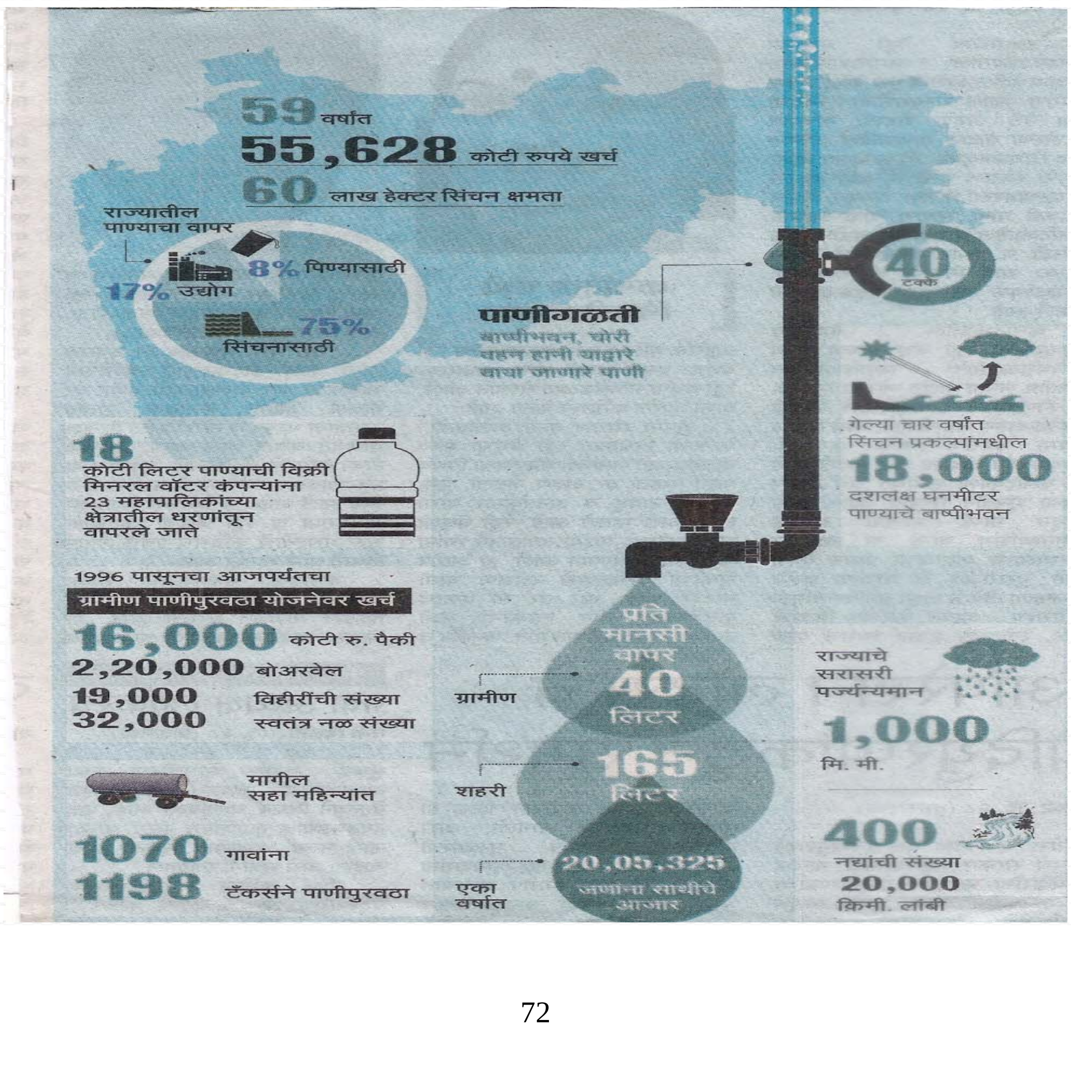
प्रतिमाणसी अपुरा पाणीपुरवठा

मराठवाडा हा तसा अवर्षणग्रस्त भाग. अगोदरच पाण्याची कमतरता त्यात सिंचनासाठी पाण्याची मोठी मागणी. त्यामुळे येथे कुटुंबाच्या दैनंदिन गरजा भागविण्यासाठी योग्य प्रमाणात पाणी मिळत नसल्याचे ४३ टक्के नागरिकांनी सांगितले, तर ३९ टक्के नागरिक मात्र पुरेसे पाणी उपलब्ध होत असल्याचे सांगतात. ४२ टक्के नागरिकांना आपण जे पाणी पितो ते शुद्ध असल्याची खात्री आहे. तसेच पाणी शुद्धिकरणाच्या साधनांचा वापर करण्यातही आपण पुढे असल्याचे ४७ टक्के लोकांनी आवर्जून सांगितले. पाण्याची कमतरता असली तरी पाण्याचा मोठ्या प्रमाणात अपव्यय होत असल्याने पाणीटंचाईत वाढ होत असल्याचे ५७ टक्के नागरिकांनी मान्य केले.

तसेच पाणी वाटपाबाबत राजकीय हस्तक्षेप होतो, पाण्याचे दर अव्वाच्या सव्वा आहेत अशी कडवड प्रतिक्रिया ५० टक्यांहून अधिक नागरिकांनी व्यक्त केली. प्रवासादरम्यान मिनरल वॉटरचा तसेच स्थानकावर असलेल्या पिण्याच्या पाण्याचा वापर करीत असल्याचेही ५० टक्क्यांहून अधिक लोकांनी सांगितले. विशेष म्हणजे मिनरल वॉटरचा वापर करणाऱ्यांची संख्या ५७ टक्यांपेक्षाही अधिक आहे.



- गोदावरी, कृष्णा, तापी व नर्मदा अशा चार मोठ्या नद्यांच्या खोऱ्यांमध्ये राज्याचे एकूण भौगोलिक क्षेत्र
- पाणीपुरवठा व स्वच्छता या सेवांना प्राधान्य देण्यासाठी पाणी व स्वच्छता विभागाची स्थापना १९९६ साली
- यावर्षी मार्च महिन्याच्या शेवटच्या आठवड्यात १०८ गांवे आणि १६७ वाड्यांना ८९ टँकर्सने पाणीपुरवठा
- पिण्यासाठी वापरण्यात येणाऱ्या पाण्याचे टी.सी.एल.द्वारे निर्जंतुकीकरण, पाण्यातील क्लोरिनचे प्रमाण तपासण्यासाठी दररोज ओ.टी.टेस्ट
- देशात बाटलीबंद पाण्याचे एकूण ३०० ब्रँड्स आहेत. यांपैकी सुमारे ११५ ब्रँड महाराष्ट्रात उपलब्ध



Why Water Management?