Chapter - One

INTRODUCTION

1.1 Background

War is the ultimate outcome of tension between the people, the causes of which are many and varied, and water is one of them. Importantly, the water issue has scaled up from the local to the global level. The rapid expansion of urbanization, population, industrialization and global warming has lessened the limited sources of water leading to acute problems and shortages. The Yajurveda presents following expression on the significance of water:

Whole world depends on this indispensable water.

All animate and inanimate objects around us

Require water for their existence.

Water is required by all animals.

Water is full of vital energy.

Water is full of supremacy.

Water is in cosmic state.

Water is knowledge.

Water is truth.

Water is liberty and symbol of purity.

Water is the source for any form of life.

Water is the source for any form of energy.

Finally, anything we try to identify requires

Water and depends parasitically on water.

To this unique indispensable part of our life

We pray.

\- Yajurveda

Only a small fraction of the earth's abundant water is available to us as fresh water. About 97 percent is found in the ocean that is too salty for drinking, irrigation and industry. Out of the remaining 3 percent, that is fresh water, 2.997 percent is locked up in the ice caps. So, only about 0.003 percent is available to us in the form of soil moisture, exploitable ground water, water vapor, lakes and streams (IUCN, 2000).

The source of available fresh water is rainfall, which falls unevenly over the earth. This has at first hand effect on the living of people; especially on drinking water, irrigation and other uses. So, to scale down the pressure on water resources to meet the increased demand of water, tapping of rain water as it falls on an inperable surface and utilize later to meet the diverse requirement of people, can be one of the best alternative to minimize the resource gap. Careful management of water resources must, therefore, become a global priority in a world moving towards a water crisis in the next century.

Rainwater collection catches rain as it falls. The idea of rainwater collection, however, is not new. It is the art of catching the water drops where they fall before they drain away or escape. There is an evidence of water harvesting structures since pre-historic times. During those times, rainwater was harvested to meet the irrigation water needs rather than for drinking. Ponds, lakes, and other storage structures also had been built to capture falling rain and use it later. Greece and Palestine collect rain water in cisterns, made of rocks, from rooftops and paved spaces during the early periods (Agrawal and Narain, 1997).

Nepal has a monsoon type of climate with an annual average rainfall of 1700 mm, out of which 60-80 per unit falls in the four months from June-September. Largely, the farmers depend on rainwater for their agricultural production. Only 26 percent of the agricultural land has irrigation facility while the rest entirely depends on the rainfall. So, the rain water collection system can, to a greater extent, minimize the water crisis which the country is facing. People have much importantly realized the rain water harvesting through simple and appropriate technology, and this has been expanding either too.

1.2 Statement of the Problem

Globally, fresh water is abundant. Contextually water crisis has increased. However, the water is not available when and where it is needed. There is an urgent need to avert such crises by introducing water harvesting and storage system at the households and community level.

In Nepal, the hill region covers 68 percent of the land, and 44.3 percent people are living in this region. Often, the settlements of these people lie at high altitude. They are far away from the water resources (river, stream, stone spouts, well, springs). It takes long time to fetch water. Piped water supply system may not be easily manageable because of landslide, dispersed settlement and less resource potentiality in the hill region. Because of such causes, rural people are facing water crisis. The only alternative way to resolve the problem is to manage rain water harvesting. The following questions state the problems of the study:

- What are the types of rainwater harvesting system in the VDC?
- What is the condition of rain water harvesting system in the hilly region?
- What are the applications of rainwater harvesting in rural development?
- What are the strengths and weaknesses of the rain water harvesting system?

1.3 Objectives of the Study

The general objective of the study is to examine the use of rainwater at the community level for drinking, irrigation, livestock management as well as sanitation in water scare areas. The specific objectives include the following:

1. To find out the total number of *Pani Ghainto* in the area under the study.
2. To study the overall availability situation of water in the area.

3. To assess the function of Rainwater Harvesting System (RWHs)
4. To measure the impact of socio-economic benefits brought about by the system.
5. To identify the issues and problems relating to the RWHs.
6. To find ways to further improve the system.

1.4 Rationale for the Study

Life without water has no meaning. Life began in water. Water forms the lifeline of any society. The importance of water has wide ranging impact on human health, quality of life, environment and productivity. The global scenario still remains grim as all the inhabitants of the world do not have access to safe water and adequate sanitation.

With respect to the topography of the hilly region, limited amount of water resources are available in a more efficient way.

Among the various technologies to augment fresh water resources rainwater harvesting and utilization is a decentralized, environmentally sound solution, which can avoid many environmental problems. Often, caused by conventional large scale projects using centralized approaches.

In Nepal, there are numerous ponds which serve as water storage tanks. The stored water is especially used during the dry season. With the ongoing scarcity, the value of rainwater harvesting whether in pond or Pani Ghainto has significantly increased in the rural areas.

Water scarcity affects the rural household economy and environment in multifarious ways, resulting in hardships such as the necessity of carrying heavy pots of water several kilometers every day to meet household needs. With the increasing demand of water managing rainwater for various purposes brings affinity in rural development.

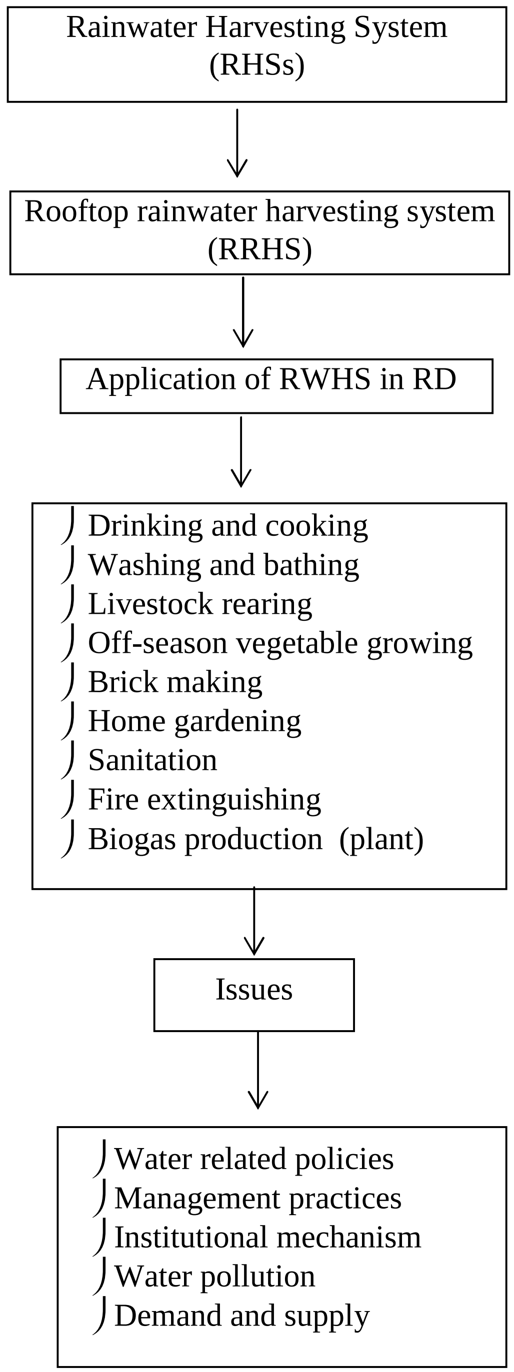
1.5 Limitation of the Study

Although such studies need to be done nationwide, due to constraints such as time, money and lack of past researches, the study will not be examined in general. The study has the following specific limitations:

- The study covered only the Chhatraganj area of Arghakhanchi district.
- The study focused only rain water harvesting jar (Ghainto) in study area.
- It is a study on the impact of rain water harvesting for drinking, livestock rearing, sanitation, and off-season vegetable farming uses.
- The field survey for the study has relatively short to be completed within the period March-May, 2006.

1.6 Conceptual Framework

The operationalization concept plays important role in conceptual framework. The following relation among variables has been tactfully and logically presented meeting the objective of the study.



Chapter - Two

LITERATURE REVIEW

2.1 Overview

Water is one of the most important ecological factors, which forms the lifeline of any society. It affects the vital processes of all the living beings. Primitive life undoubtedly originated in water, which forms about 75 per cent of the earth's surface.

Water of the atmosphere reaches the earth's surface through precipitation and from the earth's surface it reaches the atmosphere through evaporation and transpiration. Thus a continuous circulation of water from earth to atmosphere and vice-versa keeps going on the earth. This is called 'water cycle' or 'hydrological cycle'. It has been estimated that about 80,000 cubic miles of water from the ocean and 1,500 cubic miles of water from the lakes and land surface evaporates annually. The total evaporation is equaled by total precipitation (Mukherjee, 2000).

All the known civilizations have flourished with water resource as the base and it is true in the present context too. Availability of drinking water and provision of sanitation facilities are the basic minimum requirements for healthy living with respect is the physical alternatives to fulfill sustainable management of freshwater, there are two solutions: finding alternate or additional water resources using conventional centralized approaches or utilizing the limited amount of water resources available in a more efficient way. To date, much attention has been given to the first option and only limited attention has been given to optimizing water management systems. Among the various technologies to augment fresh water resources, rainwater harvesting and utilization is a decentralized, environmentally sound solution, which can avoid many environmental problems often caused by conventional large scale projects using centralized approaches (UN-HABITAT, 2005).

2.2 Concept and Definition

Rainwater harvesting, in its broadest sense, is a technology used for collecting and storing rainwater for human use from rooftops, land surface or rock catchments using simple techniques such as jars and pots as well as engineered techniques. It is also a good option in areas where good quality fresh surface water or ground water is lacking. The application of appropriate rainwater harvesting technology is important for the utilization of rainwater as a water sources (UN-HABITAT, 2005).

The quantum of rainwater available for harvesting depends upon frequency; duration and intensity of rainfall, nature of catchments are and run off characteristics. By and large rainwater is biologically pure, soft in nature, low in minerals and free from organic matter but it contents pesticides residues. The airborne pesticides concentration is highest at the beginning of the rainfall and decreases gradually considering the ever-increasing demand for water, rainwater harvesting is not only beneficial but also necessary for many reasons, as follows:-

1. Rainwater harvesting increases the availability of ground water and raises the water levels in wells and tube-wells which causes reduction of cost in the use of energy for pumping water. It has been calculated that one metre high water level saves 0.40 kwh. Of electricity and at this rate 10 hours pumping of water per day saves 1460 kwh. of energy annually.

2. Rainwater harvesting works wonders in areas that lacks well distributed rainfall and affected by the problem of excess arsenic, fluorides, chlorides, salt and iron contamination in groundwater. It thud, provides relatively better quality of water with low content of hazardous minerals.

3. It controls flood and reduces the impact of drought famines and supplement the requirement of water for domestic purposes during the long dry spell of summer.

4. It reduces soil erosion, silting and contamination of water ways from polluted surface runoff. It also reduces flow of storm water and minimizes chances of overloading drainage system.

5. It indirectly curbs the reliance on dams, canals and reservoirs and thus reducing the need to build more such structures with high cost.

6. In addition, rainwater harvesting revives traditional water harvesting structures viz, Ponds, wells, and tube-wells can be used as recharged structures. (Chatterjee, 2004).

Roof water harvesting has also become necessary now in hilly areas having high rainfall. The traditional perennial sources of water in such areas are springs. However, the yield of these springs has either dwindled over the years due to deforestation or the total amount supplied by them has become inadequate because of increase in population.

Whenever the rainwater is stored in a sump, the sump is covered with a lid to avoid penetration of sunlight. The sump is cleaned before the onset of the next rainy season. It is recommended that the first runoff from the terrace be allowed to flow out as it washes away the dirt, bird excreta. This is achieved by installing a bypass value on the pipe taking the rainwater from the terrace to the sump. A filter is also provided at the entry point. If roof water harvesting is practiced on a large scale in an urban area, then it also helps in reducing the severity of floods, which follow a heavy down pour. Similarly if it is used for spot recharging by a large number of households, then it helps in restoring the water table and also in improving the quality of water. Another benefit accuring from roof water harvesting in an urban area is that it reduces the demand on the municipal water supply system that in general is inadequate to meet the needs of each and every household (Athavale, 2003).

2.3 Development of Rainwater Harvesting

Rainwater harvesting system has been used since ancient times and evidence of catchments system date back to early Roman times. Roman villas and even whole cities were designed to take advantage of rainwater as he principal water source for drinking and domestic purposes since at least 2000 B.C.

The earliest known evidence of the use of technology in Africa comes from northern Egypt, where tanks ranging from 2000-20000m^3 have been used for at least 2000 years-many are still operational today. The technology also has a long history in Asia, where rainwater collection practices have been traced back almost 2000 years in Thailand. In many remote rural areas, this is still the method used today. The world's largest rainwater tank is probably the Yerebatan Sarayi in Istanabul, Turkey. This was constructed during the rule of Caesar Justinian (A.D. 527-565). It measures 140m by 70m and has a capacity of 80000 m3. Elsewhere, countries like Germany, Japan, United States, and Singapore are also adopting rainwater harvesting (UN-HABITAT, 2005).

Indians have been the world's greatest water harvesters; proof of this is evident in many age-old structures found in many old forts. Evidence of irrigation with rainwater harvesting system can be found even in Kautilyas' Arthasastra. In Rajesthan traditional rainwater harvesting in Kund help people to tide over the water need of the scorching day of summer.

In Afghanistan, one could final the world's ancient technological marvels to harvest water know as karez or qunals. The karez system evolved in North Western Iran some 3000 years ago. By 714 B.C, the system spread to Egypt, Afghanistan and for away south India (Chatterjee, 2004).

Mexico as a whole is rich in ancient and traditional rainwater harvesting technology (dating back to the Azfecs and Mayas). In the 10th century AD an integrated agriculture bared on rainwater harvesting existed. People lived their sufficed drinking water provided by 20 to 45 thousands litres cistern called "chultuns" (UN-HABITAT, 2005).

2.4 Global Scenario on Water Issues

Rapid population growth, combined with industrialization, urbanization, agricultural intensification and water-intensive lifestyles is resulting in a global water crisis. In 2000, at least 1.1 billion of the world's people-about one in five did not have access to safe water. Asia contains 65 percent of the population without safe water and Africa 28 percent of the population without safe water (UN-HABITAT, 2005).

The greatest development failure of the 20th century is the failure to provide clean drinking water and sanitation to every person on the planet. It is difficult to believe that in a world of rapid telecommunication, computing speed and many other advances more than a billion people do not have access to clean safe drinking water. This fact is one of modern society's greatest embarrassments. Who is to blame for this? All are responsible. Ascribing blame, however, does not take us forward, and it is high time we get going forward (Gleick, 2004).

There is wide spread recognition that the world is facing a growing water crisis, affecting the well-being of millions of the poorest people. Rapidly growing population, urbanizations, agricultural intensify and climate changed (such as global warning) all contribute to greater competition and scarcity of water resources. Despite massively increased provision of water facilities over the past few decades and the development of low cost, sustainable technical solution to many aspects of water provision, millions still suffer from water-related diseases and the physical, social and economic burdens associated with scarcity (UN, 2005)

The United Nations reports 1.1 billion people (one in six of the world's population) lack access to improved drinking water, and 2.4 billion lack sanitation. As result, the burden of death and disease related to inadequate water is high, with an estimated mortality of 3 million people a year, and millions more suffering water related diseases (UN-HABITAT, 2005).

Apart from being a part of life, water is older than life. Through the ages human kind has demonstrated an awareness of the significance of water. At the sometime water has become the focal point of international relations in a world that is increasingly preoccupied with traditional security concerns. The ending of the Cold War has led to emergence of the so-called water discourse as a distinct and highly topical field of practical and scholarly concern (SAROCH, 2003).

The world is facing a water crisis of the 21st century. The problem is multi-faceted as it involves not only the issue of water but also those relating to wastage, pollution and flood and drought.

What is the magnitude of water crisis? How grim is the picture? Water use worldwide has more than doubled since 1950. Two billion people in the world are without clean water and sanitation. In the worst water-famished countries, people live on just two gallon of water a day, far below the 13.2 gallon stipulated by the UN as the absolute minimum for water needs. In about 20 years time, average water supply per person around the globe is likely to be one third smaller than it is now (Lekhak and Lekhak, 2005).

Water dispute or water scarcity is burning issues for water short countries. Among 150 of the world's 214 major river systems are shared by 2 countries, and 50 by 3 to 10. Thus, 40% of the world's population already clashes over water. The next war in the Middle East will probably be fought over water not oil. Most water in this arid region comes from three shared river basis: the Jordan, the Tigris-Euphrates and the Nile. There is also fierce competition for water among Jordan, Syria and Israel, which get most of their water from Jordan River basis. In 1967 Arab Israel war was fought over access to this water. Turkey, by contrast has abundant water. It plan to build 22 dams along the upper Tigris Euphrates to generate huge quantities of electricity, irrigate a large area of land and provide more that 3 million jobs. These dams will reduce drastically the flow of water to Syria and Iraq, which lie down stream (Lekhak and Lekhak, 2005).

Contradiction also prevails regarding the upstream/down stream privilege of several rivers among the neighboring countries of SAARC region such as Pakistan, India, Nepal and Bangladesh (Ibid).

There is clear indication that a crisis is building up. According to Chalise, following are contributing to this crisis.

1. The rapidity with which the population is growing.
2. The rapidly changing consumption with increasing demands for water and other natural resources.
3. The breaking down or growing irrelevance of traditional social, economic, and technological systems and indigenous knowledge.
4. The rapid depletion of the natural resource base through internal and external pressures.
5. The inadequacy of knowledge about the natural processes that govern the natural environment.
6. The uncertain but possible impacts of global warming and climate change.

Thus scarcity of water adds to the already miserable economic circumstances and mass poverty that cause the constant out migration of able bodied men from mountain areas. Here is an urgent need to avert such crises by introducing water harvesting, collection, and storage systems at the household and local community levels with people's participation (Chalise, 2000).

2.5 Water as an Economic Commodity

A key shift in the global perspective on water is to cease considering it as a free gift of nature but rather to consider it as an economic good or commodity. The Rio Conference on Environment and Development in 1992 clearly enunciated this.

However the perception of the average mountain dweller in the HKH is still traditional in this respect and water is still seen as a free gift of nature. With the gradual incursion of the market economy, even in remote mountain areas, changes in this traditional perspective are becoming visible. Similarly, the possibilities of using water for/to produce high value, off season vegetables or cash crops have increased awareness about the economic value of water among local mountain communities (Chalise, 2000).

2.6 Rainwater Harvesting System and Technology

There are different types of rainwater harvesting systems depending on topography, slopes and rock types. The systems can be both household and community level depending on the nature of collecting system and volume of water collected. The then HMG/N (1998) has identified the following systems; which can be used to store water and use later or can be used to recharge underground aquifer. Among the listed system, the most popular and widely practiced systems are the surface and rooftop harvesting systems.

1. Rooftop Harvesting Systems

2. Surface Harvesting Systems

3. Rock catchments

4. Excavated Reservoirs

5. Earthen dams

6. Under ground and sub-surface dams and

7. Sand dams

Typically, a rainwater harvesting system consists of three basic elements: the collection system, the conveyance, and the storage system. The collection system can vary from simple types within a household to bigger systems where a large catchments area contributes to an impounding reservoir from which water is either gravited or pumped to water treatment plants. The categorization of rainwater harvesting systems depends on factors like size and nature of the catchments areas and whether the systems are in urban or rural settings. Broadly, rainwater can be harvested for two purposes.

- Storing rainwater for ready use in containers above or below ground.
- Charged into the soil for withdrawal later (ground water recharging)

(UN-HABITAT, 2005)

Scientifically, water harvesting refers to collection and storage of rainwater and other activities aimed at harvesting surface and ground water. In general, water harvesting is the activity of direct collection of rainwater. Rain is the first form of water and Rivers, Lakes and ground water are all secondary sources of water. In present times, we depend entirely on such secondary sources of water. In the process, generally, it is forgotten that rain is the ultimate source that feeds all these secondary sources. Water harvesting means making optimum use of water at the place where it falls so as to attain self sufficiency in water supply, without being dependent on remote water sources (website: www. wotr. org).

Two types of rainwater harvesting are described.

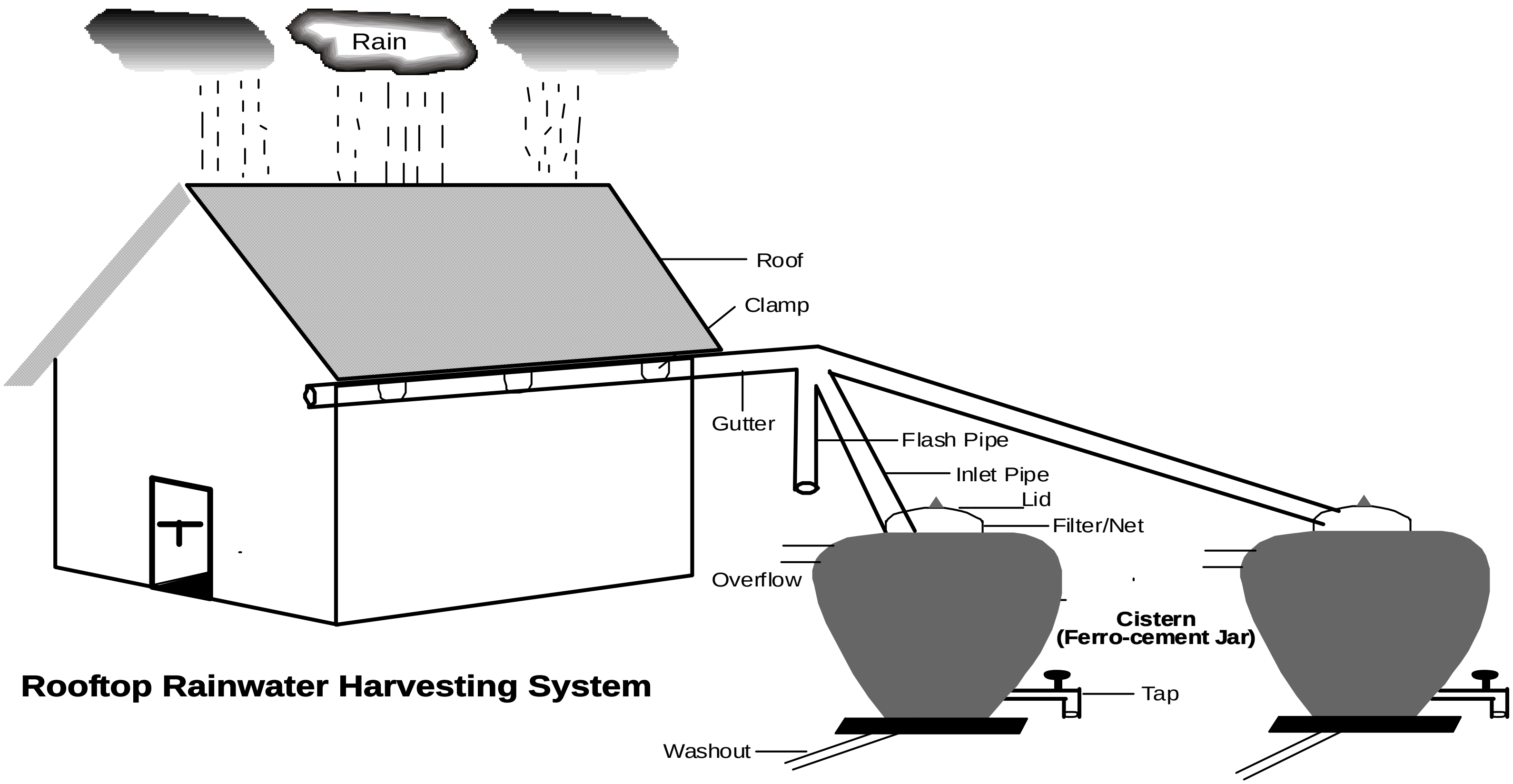
Rooftop Harvesting System: Rooftop harvesting system is highly practiced in most of urban and suburban areas where there is storage of municipal supply. In Nepal this system has been installed in both urban and rural areas.

Usually, house roof made of cement and Corrugated Galvanized Iron (CGI) sheet is used for the collection of rainwater. Tile, slate and thatch roofs are also used. The quality of water collected depends on the surface where it is collected. Water from cement roof and CGI is comparatively clean than collected from other types. However, the surface of the roof must be cleaned and maintained regularly as there would be lots of dust particles and food; and debris brought by birds. First rainwater of monsoon should not be allowed to flow in the collection chamber or tank (UN-HABITAT, 2005).

In a normal RHS system, a gutter, pipe, tap, and a tank are needed. People use different kinds of storage tanks to store rainwater. Some of which are polythene, Ferro-cement or local bitumen drum. The tank is often covered to prohibit entry of pollutants. Rainwater from the roofs is diverted by means of gutter and pipes to bring into a tank. The amount of water collected depends on the roofing area, size of tank and the amount of rainfall (UN-HABITAT, 2005).

Roof water harvesting was practiced, as a matter of necessity, mostly in the low rainfall areas of the country. It was also practiced in some coastal areas where the ground water was brackish. Modern construction during the last fifty year has no provision for the collection and storage of roof water. The utility of roof water harvesting is now being realized and the movement of roof water harvesting is slowly gathering momentum (Athavale, 2003). In the following figure, the different parts and material require in the system has been shown (Figure 2.1).

Figure 2.1: Rooftop Rainwater Harvesting System



Source: Paudel, L. 2006

Surface Harvesting System: It catches rapid run-off from natural or man-made surface, then concentrates and stores it. Water collected by this method is comparatively non-drinkable, however it can be used for purposes other than drinking liked, cleaning, washing, watering cattle, and irrigation. There are examples in other parts of world where such water is treated and used for drinking. Singapore collects rainwater from the airport and is supplied to the main system of drinking water after treatment (Dixit, 2005).

RHSs has been practiced very widely in the southern peninsular region, where some of the ponds or tanks, constructed a few hundreds of years ago are still is use. Mohenjodaro, the largest among cities belonging to Harappan culture, had over seven hundred open wells (Kuwas). Every third house had a well.

2.7 Technology Use in Water Harvesting

Rainwater harvesting is simple, economic, and affordable process by which rainwater that collects or falls on roofs, terraces, courtyards and pavements etc is directed to a storage tank or well which recharges the ground water. The recharging techniques include collection of rainwater and pass it through pipes and other means to underground water table which is normally lie below the ground (Chatterjee, 2004).

In the past, the technology used by local people to collect drinking water consisted of split bamboo pieces laid end to end.

In southwestern China, by1996, rainwater collection cisterns numbered 5,25,600 units, bringing about a tremendous impact on the lives of the people, farming, and livestock productivity. The rainwater harvesting technology also included the pond construction, storage tanks, and sub-surface and surface water harvesting. Roof catchments collection in two cisterns or tanks known as the (1-2-1) rainwater harvesting project was quit popular (Pradhan, 2000).

In India, rainwater tanks are used for collecting water in Himalayan villages. They also practice roof-top water harvesting technology. Small water ponds are constructed in the villages to capture rainwater.

In Pakistan, the water harvesting method developed is the diversion and dam systems for agricultural purposes. In Northern Balochistan, two of the main water harvesting techniques used include building embankments and bunds to divert the stream and flood water during the rainy season (Pradhan, 2000).

Different methods of water harvesting have been designed and taken advantage of traditionally through out the centuries. Some of the very earliest agriculture, in the Middle East, was based on techniques such as diversion of "wadi" flow (spate flow from normally due to water courses) onto agricultural fields. In the Negev Desert of Israel, water harvesting systems dating back 4000 years or more have been discovered (Evanari et al. 1971). There schemes involved the clearing of hill sides from vegetation to increase runoff, which was the directed to fields on the plains. The importance of traditional, small scale systems of rainwater harvesting in sub-Saharan Africa is just beginning to be recognized. Simple stone lines are used for example, in some West African countries, notably Burkim Faso, and Earth bunding systems are found in Eastern Sudan and the central Rangelands of Somalia. Flood water farming has been practiced in the desert areas of Arizona and North West New Mexico for at least the last 1000 years (Gurung, 2004).

2.8 Components of a Rainwater Harvesting System

All rainwater harvesting systems comprise six basic components irrespective of the size of the system.

1. Catchments Area/roof:

   The surface upon which the rainfalls the roof has to be appropriately sloped preferably towards the direction of storage and recharge.

2. Gutters and Downspouts:

The transport channels from catchments surface to storage; Gutters and/or down pipes have to be designed depending on site, rainfall characteristics and roof characteristics.

3. Leaf screens and roof washers:

The systems that remove contaminants and debris; a first rain separator has to be put in place to divert and manage the first 2.5 mm of rain.

4. Cisterns or storage tanks:

Sumps, tanks, etc. where collected rain-water is safely stored or recharging the ground water through open wells, bore wells or percolation pits etc.

5. Conveying:

The delivery system for the treated rainwater is either by gravity or pump.

6. Water treatment:

Filters to remove solids and organic material and equipment, and additives to settle, filter, and disinfect.

Briefly the system involves collecting water that falls on roof of a house made of zinc, asbestors or other material during rain storms, and conveying it by an aluminum, PVC, wood, plastic or any local material including bamboo drain or collects to a nearby covered storage unit or cistern. Rain water yield varies with the size and texture of the catchments area. A smoother, cleaner and more impervious roofing material contribute to better water quality and grater quantity (UN-HABITAT, 2005).

2.9 Nepal and Rainwater Harvesting System

Nepal is a country of diversity. There are great geo-physical, climatic and biological diversities that have resulted diverse socio-economic and cultural pattern in the country. It is the country that lies in the youngest fold mountain, Himalaya, of the world. It ranges from about 60 metre elevation to the 8848 m, the highest point of the world. From the climatic point of view, it ranges from tropical to the tundra from south to north. The southern belt is almost plain and the northern belt is rocky and mountainous where there are thousands of snow peaks. The Mahabharat range that lies in between these two belts is the gently sloping land having river valleys and tars. This belt is gently sloping in the eastern part and move steep in the western part.

Nepal is known as the second largest country after Brazil for water resources potential. There are thousands of rivers in the country. Most of there rivers originate in the Mountain, Middle Hill (Mahabharat Lekh) and in the Churia Hill. The country is mainly drained by the three major river systems namely Koshi, Gandaki and Karnali from east to west respectively. The rivers originating from the mountains are the snow fed rivers. The flow of water in the river originating from the middle hills decreases during the winter. The rivers originating from the Churia are non-perennial. Most of these rivers dry up in the inter season (Ekta, 2005).

Ecologically, Nepal is divided into three regions, the high mountains, the hills, and the flat land (Terai). The Terai is the bread basket of the nation. With the variation in altitude from the high Himalayas in the north to the flat plains of the Terai in the south, the climatic change across the country is dramatic. The Terai region close to the Indian border receives about 1500 mm of rainfall per annum. In the hills, the average rainfall is around 1800 mm a year, but varies from place to place. There is a significant temporal variation in the amount of rainfall. About four fifths of the annual rainfall occurs during the monsoon season which last from mid June to September. The high mountain ecological belt receives quite light rainfall, and some of the districts are rain shadow districts. The eastern region receives heavy rainfall compared to the far Western region. The meeting point between the Churia hills and the flat lands of Terai is called the Bhabar zone and the soil is porous and the water table quite deep. The water scarcity areas in Nepal are the mountain/hill tops, rain shadow hill districts, and the Bhabar zone (due to the deep water table). In the hills and mountains, there is usually excess water in the monsoon season, creating havoc with landslides and soil erosion, and no water in dry seasons (Sainju, et al, 2000).

2.10 Climate of Nepal

Climate of Nepal can not be assigned to any particular type because of the prevailing variation in altitude, topography, orography and resulting temperature and precipitation. It varies for the scratching heat in Terai to freezing cold in Himalayas (Lekhak and Lekhak, 2003). Due to the great variation in altitude within the country, Nepal has wide range of climate, ranging from hot tropical in the Terai to tundra in the high mountains. The variation leads to five more or less clearly defined climatic zones; tropical, sub tropical, temperate, alpine and tundra. There is a great variation in the amount of rainfall in different parts of Terai and Hills. During summer, the southwest monsoon brings heavy precipitation (about 80 percent of the total); the remaining eight months being more or less dry. The country's average annual rainfall is estimated to be 1600 mm but the mean annual precipitation ranges from 250 mm or less in the inner Himalayan valleys for e.g. in Mustang to more than 5,000 mm along the south east slopes of the Annapurna range in the western development region (Panday, 1992).

Nepal has four seasons: a) spring from March to May; b) summer, from June to August c) autumn, from September to November d) winter, from December to February. Because of varying altitudes and topography temperature in Nepal range from extreme cold in the north to very warm in the south. In the Terai temperatures range from more than 40^{o}c in the summer and late spring to 23^{o}c to 27^{o}c in the winter while the central valleys experience 12^{o}c with frequent frost. The Himalayan range has an alpine climate and the temperature drops below zero in winter and in summer goes up to 10^{o}c. Temperature is closely related to altitude, but there exists no such relation between rainfall and altitude. There are diverse pockets in the country in terms of rainfall and temperature. Because of extremely steep surfaces and fragile hill land, problems like landslides and erosion occurs frequently resulting in the decline of productivity. Irrigation plays key role in the development of the agricultural sector, which has remained the backbone of the country's economy. The agricultural sector still has to rely heavily on rainfall (Panday, 1992).

2.11 Rainfall

The water available to all sorts of life on lands comes as a result of rainfall. This happens because of an interchange of water between the earth's surface and the atmosphere, forming the 'water cycle' or 'hydrologic cycle'. Rain water has been regarded as a symbol of purity. However, now as a result of increasing atmospheric pollution rains water also becomes impure and falls down as acid rain.

Nepal falls under the monsoon system of the Indian sub-continent. Eighty percent of the precipitation occurs in the form of summer monsoon rain from June to September. Winter rains are common in the western hills. The average annual rainfall in Nepal is about 1600 mm, but the actual amount differs in different eco climatic zones. The eastern part of the country is wetter than the western part due to higher rainfall. For example Taplejung (altitude 1768 m) in the far Western region gets only 1,037 mm. The southern slopes of the Himalaya e.g. Pokhara, receives higher amount of rainfall (3,345 mm) while the rain shadow areas such as Dolpa, Jomsom and Mustang receive considerably low amount (295 mm) of rainfall. Rainfall generally increases with altitude up to 2000 m and after that it decreases. Precipitation decreases in the north by roughly 50% every 12 km. In the higher altitudes of the greater Himalayas precipitation occurs in the form of snow. Normally, the eastern part of the country gets first hit of monsoon rain by the advancing monsoon generating in the delta of Ganges. In the western part of the country monsoon arrives a few days late (Lekhak and Lekhak, 2005).

Sometimes, Nepal gets heavy and continuous rain for several days at a stretch which causes landslides in the hills and floods in the Terai. Nepal is completely cut of from the monsoon system after the summer rains are over. However, the influence of the so called Western atmospheric disturbance originating in the Mediterranean move into Nepal by the end of December or the start of January. This brings certain amount of rains popularly called as 'maghejhari' in Nepal. This rainfall is useful for winter crops such as wheat and barley.

Since, the rural population depends on rainwater both for agriculture and drinking water, a timely and good amount of rainfall greatly influence their life (Lekhak and Lekhak, 2005).

2.12 Rainwater Harvesting Practices in Nepal

The traditional water-harvesting system is based on conservation of rainwater where it falls and its utilization to meet the diverse requirements of the local people. There is evidence of such systems all over the country. These systems met the basic domestic and irrigation water requirements of the local population. There systems use low-cost, ser-friendly techniques and were kept in good operational condition by local communities. These facilities not only served the minimum requirements of individual households but also fostered social cohesion and self-reliance (Sainju, et al, 2000).

In the hills and mountains of Nepal, Ponds were dug in the past to collect rainwater mainly for livestock use. Recently, different technologies were tried out to evaluate their use. They are being tried out by both government projects as well as by NGOs.

- Plastic-lined tends for small irrigation activities (SAPPROS) and (INSAN) are being promoted.
- At household level, Ferro-cement jars with a capacity of two cubic metres are used to collect water harvested from corrugated, galvanized iron sheet (CGI)

roofs in Gulmi and Palpa districts (Pradhan, 2000), and recently practices in Arghakhanchi, district.

- Ferro-cement tanks for use in rural water harvesting are being promoted by Peace Crop Volunteers.

Rainwater harvesting and utilization is not a new technology; it is an ancient legacy. Historically, the communities in Nepal have used local water resources successfully for centuries. The ancient people had a good knowledge of the hydrological cycle, and they constructed ponds to collect water for dry season and also to recharge the springs and increase moisture. To capture rainfall run off from the slopping hills, the farmers of Nepal construct terrace land with bunded fields to accumulate rainwater for irrigated agriculture. The modern development process gradually undermined this innovative system. Ancient RWHU systems are dying out and are gradually losing their importance. Currently, there are some efforts to revive this dying wisdom. Rapid population increase, urbanization, and improved quality of life have increased the demand for water. This means that RWHU systems need to be revived. Slowly, efforts are being made to revive and promote RWHU. The modern approaches to RWHU are collection, storage, and use of rainwater from the roofs of house (Sainju et al, 2000).

In the early 1960s, the mission Hospital in Tansen, Palpa, constructed a rainwater Harvesting System and it is still functioning well. The major ongoing work of RWHU at household level is undertaken by Rural Water Supply and Sanitation Project, FINNIDA (RWSSP/F) in the two districts of Palpa and Gulmi in Nepal. This project involves user participation. It is considered to be a successful programme. The Department of Water Supply ad Sewerage (DWSS) has also undertaken some RWHU at community level in Syangja and Tanahu districts through its district offices with little or no cost sharing. Peace Corps, Nepal, constructed some RWHUs with Ferro-cement tanks. Some NGOs, with support from INGOs, have built small RWHUs mostly with plastic-lined tanks for small irrigation for marginalized farmers. Some agencies have constructed RWHUs for their own use. ICIMOD has constructed small, plastic-lined tanks in Kabhre and Godavari. Most of the houses in the hills and mountains have thatched roofs, and they are not suitable for collecting rain water for domestic use. It is a great constraint (Sainju et al, 2000).

In 2000 PARDYP supported the construction of 8 Ferro-cement waters jars in Yarsha Khola and 13 in Jhikhu Khola. The jars, each of 2000 lt capacity, are filled by collecting rainfall from a house roof. Where jars are installed, the households can use water for domestic needs harvested from their house roofs for the duration of the monsoon with a carry over of approximately two months. Other trials are underway to construct underground cisterns to collect run off to be used for irrigation in the dry season. When linked to locally manufactured drip irrigation systems, water use efficiency can be significantly improved (ICIMOD, 1997).

RWSSP/F constructed 478 jars of Ferro-cement by March 1998, at the household level Ferro-cement jars of two cubic metres in capacity are used to collect water harvested from CGI roofs. Peace Corps Volunteers have constructed Ferro-cement tanks for RWHU.

2.13 Case Studies

RWHU constructed by the DWSO, Suyangja RWHU systems were constructed three years ago in Kharikot village, Kichans, ward No. 6, Syangja by the DWSO. Four Ferro-cement tanks of ten cubic metres in capacity were constructed. Each tank cost about Rs. 0.1 million (Rs. 0.125 million at present prices) which is expensive, and hence this system was not continued in subsequent years. The users are satisfied with the system according to DWSS officials. In Tanahun, Manungkot Vyas Municipality (ward no. 7), scheme consists of rainwater collection from the roof of a school building and storage in a tank with a capacity of 350 cubic metres to be used by 30-35 households. Initially, the tank was built with black soil with lining of plastic sheets at the bottom and sides of stone. The cost was Rs. .055j million. This tank leaked and was subsequently rebuilt by the users with 20 centimeter (cm) stone soling (cm), topped with 10 cm of concrete in bed and cement plaster and punning in the existing stone walls. A slow sand filter has been installed and the users are advised to boil water for drinking. Occasionally, the users demand and take bleaching powder from the DWSO. The scheme is successful and there is sufficient water all round. As this scheme was constructed as a sample case; users did not contribute anything towards the cost. However, they have taken full responsibility for O & M. Further, RWHU schemes are planned in two more places in Jamuni VDC, Tanahu, and Rs. 0.5 million has been allocated in the 1998/99 budget (Sainju et al, 2000).

Chapter - Three

RESEARCH METHODOLOGY

Precisely, the research methodology of the study has been prepared to fulfill the objectives of the research problem accordingly. Both the qualitative and quantitative types of data have been collected. In accordance with the methodology, the following methods/procedure has been followed.

3.1 The Study Area

Chhatraganj, a VDC of Arghakhanchi is facing acute drinking water scarcity due to lack of ground water and its sources such as rivers and streams.

Arghakhanchi district is situated in western part of Nepal. The majority area of the district lies in the hill, which elevation from 305 to 2515 above from sea level. The district has 42 VDCs. It has 208391 populations in 40,861 households. The population density is 175 per sq. km., while literacy rate is only 56.1 percent (CBS 2001). Here only few people get drinking water from the improved sources. It is of no exception about the scarcity of water. Very little expansion of piped water could not solve the water demand. This VDC consists of few number of secondary sources of water such as, river, ponds, springs and well.

FINNIDA is encouraging villagers to build and renovate cemented water jar/cisterns. It is using technology to increase runoff from areas in tanks and ponds. Previously rural areas used to have large number of ponds. At present, this number has declined dramatically.

3.2 Research Design

The research study has carried out on the basis of descriptive and exploratory research. This is a process of learning in order to act more effectively and it is a broad methodology for designing activities to understand and improve the situation where the researcher has given keen interest in making the participants aware, co-learning and new approaches.

3.3 Sources and Nature of Data

The research has based on primary and secondary data. Primary information is collected from face to face interaction through questionnaire, field visit, key informants, focused group discussion, observation and case study. Secondary information/data has been collected from the different published and unpublished sources and website. Data were aggregated of facts and numerical.

3.4 Universe and Sample

The study has carried out in selected a VDC of Arghakhanchi district. All the cisterns (Ferro-cement jar) of the study area was the universe of the study. The VDC consist four hundred cisterns, among these, forty, i.e. 10 percent was taken as sample size. For the selected sample size households of ward no. 1 and 2 were selected purposively. Almost 105 households have jars out of 165 HHs forty households 20 from each ward was taken by simple random method.

3.5 Data Collection Techniques and Tools

Technique is the method of a researcher that determines what sort of information has been appropriate and prove or substantiate the hypothesis and objectives of the undertaking.

3.5.1 Household Survey

The household survey was conducted in order to gather qualitative and quantitative facts about socio-economic aspects of community toward water harvesting system. The questionnaire has focused on the objective of the study and the primary data has collected from the VDC. The respondent has requested to fill up the questionnaire or have filled up by the researcher when the respondent is unable to fill up the questionnaire him/herself.

3.5.2 Key Informant Interview

The information was collected from key informants using the semi or unstructured interview method. The local leader, teacher and aged people have the key informants. Three school children, two school teacher, one local leader, two age old people, altogether eight people were the key informants for the interview.

3.5.3 Field Visit and Observation

To find out the real number of the cisterns, the researcher visited the VDC. The qualitative and quantitative information was recorded during the direct observation of the selected area.

3.5.4 Focused Group Discussion (FGDs)

Focused group of this study constitutes beneficiaries of the study area who are active and knowledgeable about cisterns and their impacts. Qualitative information such as decision-making, implementation and management skills has obtained from FGDs.

Tools: Primary data has collected applying the above techniques. Moreover, to fulfill the necessary information for the purpose the map, scale, structured-questionnaire/scheduled interview and checklist has applied as tools.

3.6 Data Processing

The collected information/data were edited, coded, classified and tabulated to get effective use of raw data. The data output has taken and presented in diagram, central tendency and pie-chart. For the calculation of central tendency the following formula has been employed.

$$\text{Median} = \left(\frac{N}{2}\right)^{th} \text{item} = \left(\frac{50}{2}\right)^{th} \text{item} = 25^{th} \text{ item}$$

$$\text{Median} = L + \frac{N/2 - c.f}{f} \times i$$

(Where, L = Lower Limit, N = Number, f = Frequency, c.f. = Cumulative Frequency, i = Interval)

3.7 Data Analysis and Interpretation

All the data/information have been presented and analyzed to fulfill the objectives. And, collected information has presented in numerical textual paragraph for qualitative information and only textual paragraphs have been written for qualitative information.

Chapter - Four

THE STUDY AREA AND ITS RWHS SITUATION

4.1 Topography and Climate

Physical structure and condition of land surface is called topography and is directly related with climate. Climate of different topography is different due to the variation in invasion of sun rays and other physical factors like pressure, temperature etc. Topography and climate of particular area is directly related with development process of that area. Mountain topography and the rain shadow effect further complicate the precipitation pattern and even adjacent watersheds can be differ widely in terms of climate and hydrological reigns.

4.1.1 Topography of Arghakhanchi District

Arghakhanchi district mainly located in Mid hill region of Nepal and many of the part of district remains in Mahabharata ranges and some in Siwalik hills topographically. Arghakhachi is steep and irregular land so, there is very difficult to establish basic infrastructure of development. Different land use type of Arghakanchi district is agricultural land, pasture land, forest and other. All the details of different land use types are presented on the following tables.

Table 4.1: **Topographic Distribution of land of Arghakhanchi District**

Physical Condition	Agriculture		Pasture	Forest	Others	Total
	Cultivated	Non-cultivated				
Mid-Mountain	20696	13642	9433	40239	22	84032 (68.16%)
Siwalik	3548	2060	309	32895	428	39240 (31.83%)
Total	24244	15702	9742	73134	450	123272 (100.00%)

Source: CBS, 2004.

According to the above tables land use type present in Arghakhanchi district on 19.66% of cultivated land and 12.39 % and 7.90% pasture land and 59.32% forest and 0.36% others.

4.1.2 Climate

The average weather condition/temperature precipitation and humidity of certain places at certain period of time is called the climate of that place. Climate affects the development activities of any region.

Table 4.2: **Distribution of Climatical Record of Arghakhanchi District**

(Location = Khanchikot, Elevation = 1760 m)

Year	Air temperature					Relative humidity (% observed at)		Precipitation (mm)	
	Mean			Absolute		08:45 NST	17:45 NST	Total	Max (in 24 hrs. and month)
	Max	Min	daily	Max. and month	Min. and month				
1996	20.5	12.9	16.7	28.8/5	0/11	78	85	2418	127/10
2000	-	-	-	-	-	-	-	1920	831/June

Source: CBS, 2004.

The above table shows the climatic condition of Arghakhanchi district. The average annual precipitation is 2169 in 2000 A.D. The highest rainfall occurs at the month of June 83 day and other months receive less rainfall.

4.2 Demographic Information on Households

Demography study shows the characteristic such as caste/ethnicity, population household size age structures family size and structures and other relevant characteristic to the population.

4.2.1 Households and Caste/Ethnicity Composition

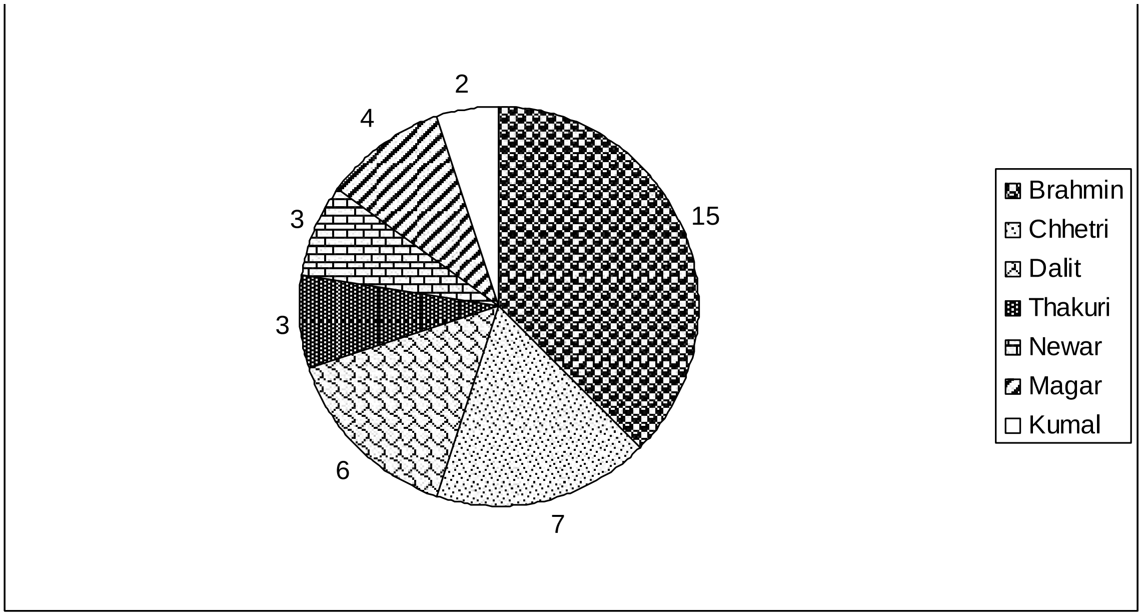
Nepal is a agricultural country with land of ethnic diversity. It is a fertile land for multi-lingual society. According to the CBS (2001, census), there are 102 identified caste and ethnic groups in Nepal. National integrity of this different caste/ethnicity into a single thread has made Nepal unique. The demographic features are also important for the study in the efficient use of water. Water to a greater extent has a relation with the population and household size. Larger the household size, greater will be the use of water. In the following table distribution by caste/ethnicity and household size in the study area is shown below.

Table 4.3: **Distribution of Population by Household and Caste/Ethnicity**

Ethnicity	No. of households	Size	Population
Brahmin	15	5.26	79
Chhetri	7	6.1	43
Dalit	6	6.66	40
Thakuri	3	5.66	17
Newar	3	4.33	13
Magar	4	6.25	25
Kumal	2	5.5	11
Total	40	5.7	228

Source: Field Survey, 2006.

.Figure 4.1: **Distribution of Population by Household and Caste/Ethnicity**



Based on: Table 4.3

The above table and figure is the proof of diversity Nepal. The total population of the study is 228 comprising average household size of 5.7, which is very close to the national figure. The study consists of different caste such as Brahmin, Chhetri, Dalit, Magar, Thakuri,Newar, and Kumal with their households size of 5.26, 6.1, 6.66, 6.25, 5.66, 4.33 and 5.5 respectively. The greatest household size in the study is of Dalit which is 6.66, higher than national figure.

4.2.2 Age Structure

Age is the prime factors which exhibit the use of resource (land, water, forest, mineral etc.) by the individual. Rural Nepal is rich in water resource which ultimately helps to flourish the rural development of Nepal. But the irony is that due to the declining of the resources, different ages of people go for the search of water. School children, housewives, even age-old people are seen scorching with water. Economically active population is between the ages of 15 to 59 years. Age below 14 years population is child and age above 60 years population is passive one in the context of developing country. The table below shows the age structure of the population.

Table 4.4: **Distribution of Population by Age Structure**

Age groups	Population	
	Number	Percent
< 14 years	92	40.35
15 to 59 years	119	52.19
> 60 years	17	7.45
Total	253	100.00

Source: Field Survey, 2006.

The above table depicts that most of population remain in the age groups 15 to 59 years is 119 (52.19%). It is seen that population above age 60 is 17 (7.45%) and below 14 is a century (40.35%). Economically active population as mentioned above is 52.19 percent.

4.2.3 Educational Attainment

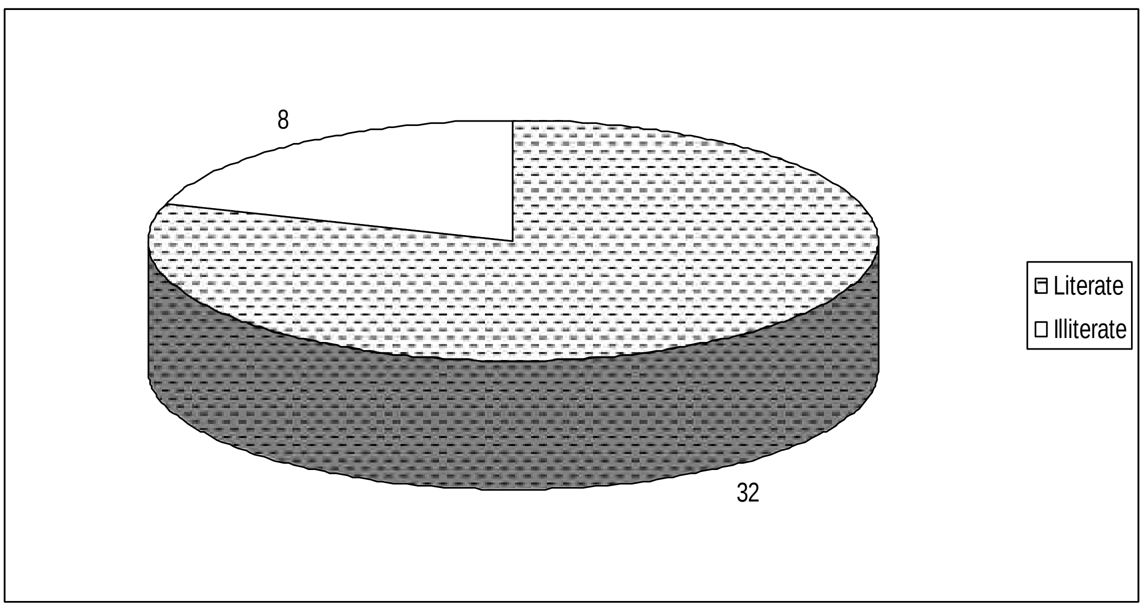
Education condition is proxy of socio-economic status. Level of education is also the prime factor which determines proper use of water by knowing the value of water. It is also the measurement of socio-economic development of any community and nation. Literacy level also determines the life standard of the people in the study area. Education is the major weapon to uplift the poor condition of the weakest people of any society. The following table shows the educational attainment by the respondents.

Table 4.5: **Educational Status of Respondent by Caste**

Literacy		Caste							Total
		Brahamin	Chhetri	Thakuri	Dalit	Newar	Magar	Kumal	
Illiterate	No.	1	1	-	2	1	2	1	8
	%	6.66	14.28	0.00	33.33	33.33	50.00	50.00	20.00
Literate	No.	14	6	3	4	2	2	1	32
	%	93.33	85.71	100.00	66.66	66.66	50.00	50.00	80.00
Sub total		15	7	3	6	3	4	2	40

Source: Field Survey, 2006.

.Figure 4.2: **Educational Status of Respondent by Caste**



Based on: Table 4.5

Table 4.5 shows that out of total 40 respondents only 8 (20.00%) are found illiterate rest are literate. Thakuri caste has cent percent literacy followed by 9.33 and 85.71 percent literacy of Brahmin and Chhetri. Magar are 50 percent literate and same with the Kumal. Dalit has literacy double of illiterate 33.33 percent and same is the case with Newar.

4.2.4 Occupation

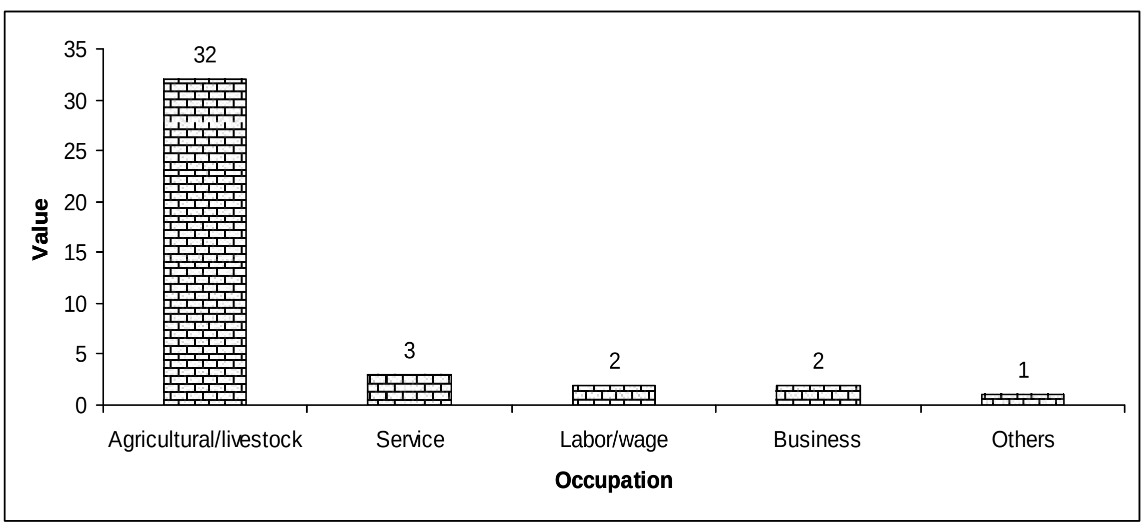
Occupation reflects the status of rural people. It is also the determinant factors for socio-economic as well as rural development of the people. It is well known that primary occupation of the rural people is agriculture. Beside agriculture people do business, services, labour etc as their secondary or tertiary occupation. The following table shows the occupation of the respondents.

Table 4.6: **Distribution of Households by Occupation**

Occupation	Households	
	Number	Percent
Agricultural/livestock	32	80.00
Service	3	7.50
Labor/wage	2	5.00
Business	2	5.00
Others	1	2.50
Total	40	100.00

Source: Field Survey, 2006.

.Figure 4.3: **Distribution of Households by Occupation**



Based on: Table 4.6

From the above table and figure, it is clear that agriculture is the prime occupation of the household in the study area. A service includes 7.50 percent. For the wage/labour it is 5 percent equally. If the water is available in sufficient amount, the peasant people could produce more grain which ultimately helps in rural development. Proper use of water is very necessary for the sustainable development too.

4.2.5 Priority of Water Sources

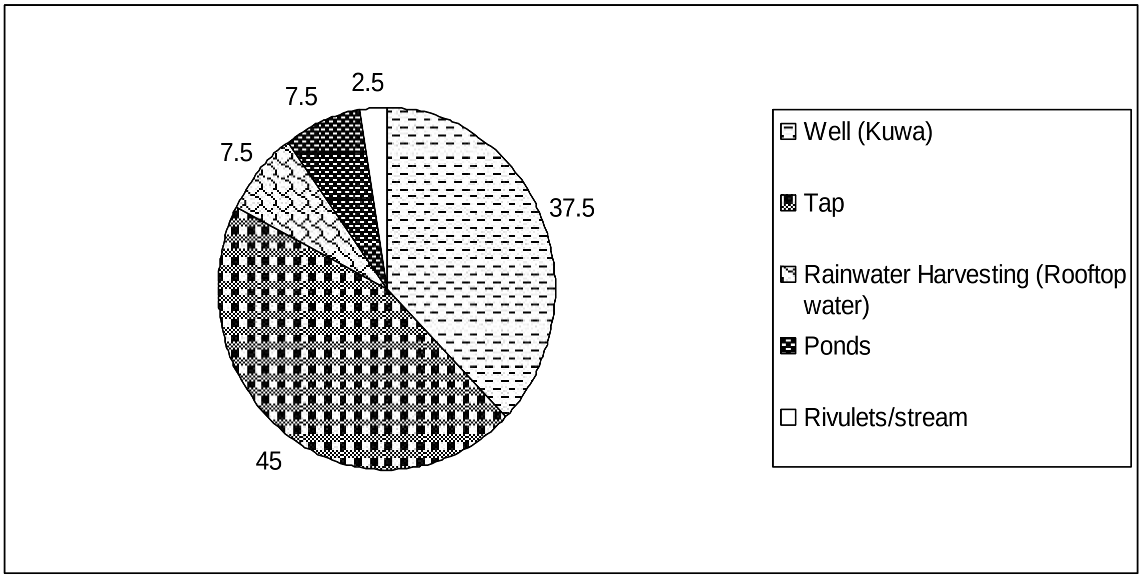
Water has dynamic and multiple uses. Nepal is rich in water resources. The different resources of water available in Nepal are rivers, lakes, glaciers, ponds, rivulets/streams, wells, pouts, roof top water harvesting etc. Due to the topographic variation priority of water sources by the respondent differs. Fundamental for the priority level is sufficiency/availability of water. Water is the life which every living being in this planet requires. Without water no development is possible. Water is the basic needs for the rural development of Nepal. Priority of water resources is changing with the charge in culture, migration, agricultural practices, deforestation and other human activities. The following table shows the priority level of water sources by the respondents.

Table 4.7: **Priorities of Availability of Water Source by Respondent**

Sources	Households	
	Number	Percent
Well (Kuwa)	15	37.50
Tap	18	45.00
Rainwater Harvesting (Rooftop water)	3	7.50
Ponds	3	7.50
Rivulets/stream	1	2.50
Total	40	100.00

Source: Field Survey, 2006.

Figure 4.4: **Priorities of Availability of Water Source by Respondent**



Based on: Table 4.7

In the above table and figure, the best attempt has been made to find the water resources available in the study area. The water resources found are well (Kuwa), tap, Rainwater (Rooftop water), ponds and rivulets/streams. Here 37.50 percent households prefer well as a prime source because they are the perennial source which never dies. Due to the nearness of tap water large number of households 18 (45%) prefer to say prime source of water. Pond water harvesting technology is the oldest of all but they are dying out. Rooftop water and pond water have been given equal emphasis by 7.50 percent households. According to the above figure, consumption of water from tap and well is maximum. Rooftop water harvesting and ponds have been seen alternative source next to tap water.

4.2.6 Sufficiency of Sources of Water

No any living being can survive without water. Water is fundamental to life. The Earth has very limited amount of fresh water. Fresh water is require for human use. Sufficiency of sources of water must be properly used for socio-economic as well as human development. Insufficiency of outer leads to miserable condition, ultimately low human development. Here sufficiency denotes to the use pattern of water. How the people (respondent) say about the sufficiency of water resources around them. This has been shown in the following table.

Table 4.8: **Sufficiency of Water source by Households**

Sources	Households				Total	
	Yes		Number		Number	Percent
Well (Kuwa)	34	85.00	6	15.00	40	100.00
Tap (Piped water)	12	30.	28	70.00	40	100.00
Rooftop Harvested water	2	5.00	38	95.00	40	100.00
Ponds	7	17.5	33	82.5	40	100.00
Rivulets/stream	37	92.5	3	7.5	40	100.00

Source: Field Survey, 2006.

The sources of water may be different but the availability of plenty of water in the sources is important than the former. From the above table it is evident that sufficiency of water in the well is maximum. When asked 85 percent reported having plenty of water in the well (Kuwa). The sufficiency of water in the rivulets is higher than all other sources. Sufficiency of tap (piped) water has been found very little. 30 percent households said that that can get sufficient water from the tap. The rainwater harvested has been found sufficient only for 5 percent households. 95 percent households do not find rain water sufficient for the use.

4.2.7 Time Spent for Fetching Water

Almost eighty-five percent of the population live in rural areas and are engaged in agriculture, which is the basis for subsistence. In the hills and mountains, there is usually excess water in the monsoon season, creating havoc in dry season. During dry season people spend much time in fetching water. They even push off a day in fetching water for a single trip. The following description mention the time spend on fetching water for a single trip.

Table 4.9: **Time Spend for Fetching Water at a Time**

Time spend (minute)	Households (frequency)	Percent
< 15	4	10.00
15 to 30	24	60.00
30 to 45	7	17.50
45 to 60	3	7.50
> 60	2	5.00
Total	40	100.00

Source: Field Survey, 2006.

In the above, the respondents were asked to answer the question how much time does it take to fetch water for a single trip. 5 percent household requires more than an hour for single trip to fetch water. Greater number of household i.e. 60 percent households have to spend 15 to 30 minutes. This shows that these people are close to the source since they require less than 30 minutes. 7.50 percent household requires time in between 45 to 60 minutes to go round a single trip.

4.2.8 Time Repeated for Fetching Water (per day)

In the hills and mountain people spend many hours or even a day in fetching a bucket of water in a dry season. People in these areas do not have alternative sources then go to remote sources and fetch water or wait even many hours in the sources close to them in fetching water in a day. During a day how many hours do they spent or times repeated in fetching water has been attempted to portrait in the following table.

Table 4.10: **Repetitions of Time for Fetching Water (Per day)**

Repetition time	Households (f)	Cumulative frequency
3-5	7	7
5-7	25	32
7-9	7	39
9-11	1	40

Source: Field Survey, 2006.

We know,

Median = $\left(\frac{N}{2}\right)^{th}$ item = $\left(\frac{40}{2}\right)^{th}$ item

Median = 20^{th} item

Median lies in the interval 5-7

Again, we know,

Median = $L+\frac{N/2-c.f}{F}\times i = 6+\frac{25-24}{21}\times 2$

N/2 = 20, i = 2, L = 5, c.f = 7, F = 25

$= 5+\frac{20-7}{25}\times 2$

$= 5+\frac{26}{25}$

= 5 + 1.04

Median = 6.04

Mathematically, median value for the average repetition times is 6.04.

4.2.9 Water Requirement

Water is fundamental to life. It is require for drinking, cooking, bathing and washing, agricultural use, industrial use, etc. But people have to manage water more than this because peasant rear animal/livestock. Water require by animal is higher. In hills and mountains people tamed the livestock and for these livestock too they fetch water. Quantity of water require by household in the study area is given below.

Table 4.11: **Quantity of Required Water by Households**

Water required (in litre)	Households frequency (f)	Cumulative frequency
50-75	4	4
75-100	8	12
100-125	10	22
125-150	11	33
150-175	3	36
175-200	3	39
200-225	1	40

Source: Field Survey, 2006.

Median = $\left(\frac{N}{2}\right)^{th}$ item = $\left(\frac{40}{2}\right)^{th}$ item = 20^{th} item

Median lies in the interval 100-125

We know, Median = $L + \frac{N/2 - c.f}{F} \times i$

$$N/2 = 20,\ i = 25,\ F = 10,\ C.F = 12,\ L = 100$$

$$= 100 + \frac{20 - 12}{10} \times 25$$

$$= 100 + \frac{8}{10} x25$$

$$= 100 + 20$$

Median = 120

The average quantity of required water by household is 120 liters per day.

From the above table, only one household requires 200-225 of water daily while 4 households need less than 75 litres of water daily. The large household i.e. 21 requires 125-150 litres of water daily for both human and livestock purposes.

It is calculated that the average requirement by household studied consumed 120 litres of water daily.

4.2.10 Decisions making on Installations of the Ferro-cement Jar

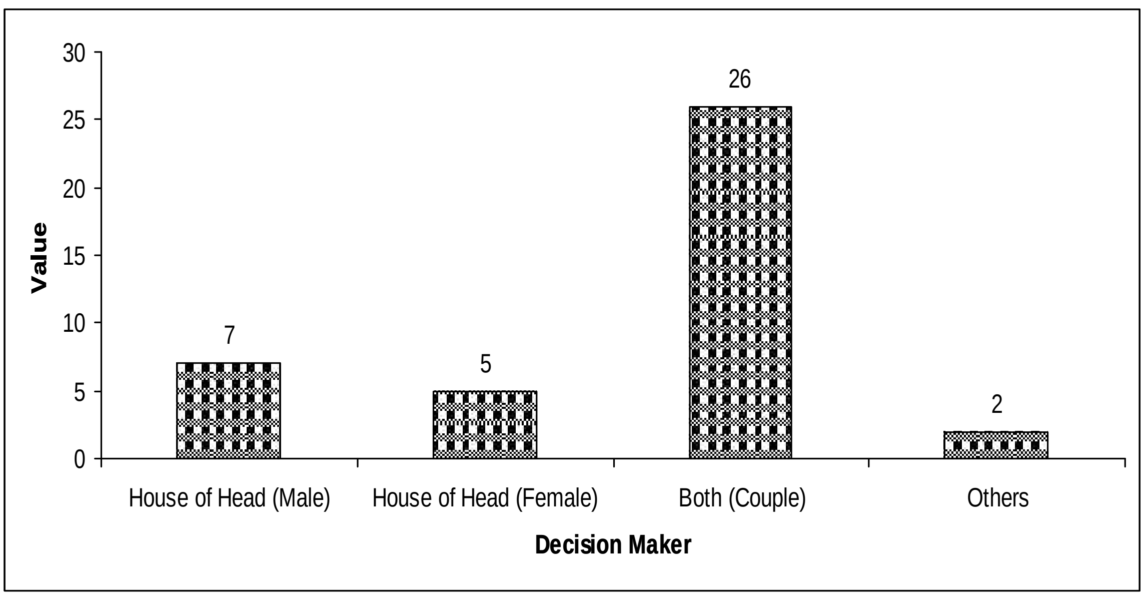
In the hills and mountain where people have to spend much of the time in collection of water and have to travel long distances in search of water. The alternative source for these places and people is rain water collection to preserve the rainwater in large quantity and for a longer period, a system has to be built up. Ferro-cement Jar (cisterns) has become the best option due to which people feel much relief by the installation of jars. Generally burden is upon women and children because pressure falls upon them for the collection of water. Even the school children have to drop out the school because of the only reason water. Installation of jars has to be made after making the discussion in the family or use groups. In the following table decision made on institution of Ferro-cement jar either by male or female or by other has been shown.

Table 4.12 **Distribution of Decisions Made on Installation of the System by Respondents**

Decision maker	Households	
	Number	Percent
Head of House (Male)	7	17.50
Head of House (Female)	5	12.50
Both (couple)	26	65.00
Others	2	5.00
Total	40	100.00

Source: Field Survey, 2006.

Figure 4.5: **Decision Making on Installation of the System by the Respondents**



Based on: Table 4.12

Though water management in the house has to be made by women, their role in decision making of Ferro-cement jar installment is dominated by male. Together with the husband and wife have higher share of decision which is 65 percent.

Separately, 17.50 and 12.50 percent male and female respectively have had decided to install the jar.

4.2.11 Adequacy of Harvested Water in Sampled Population

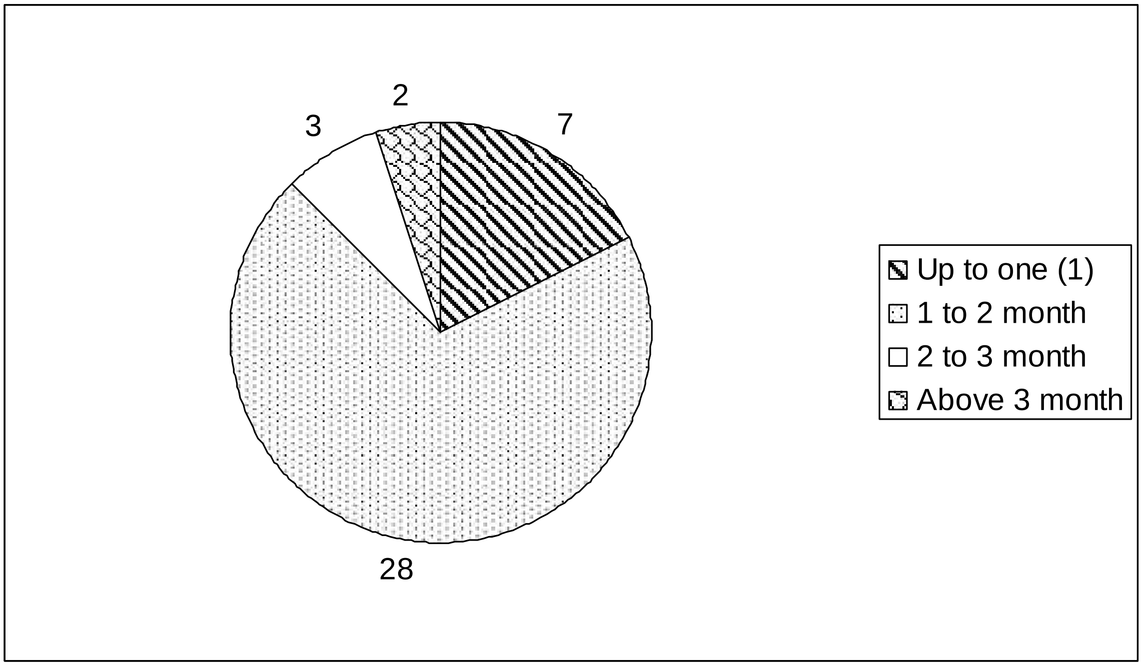
Adequacy of water depends upon many factors. First is the using pattern. Generally monsoon starts from June to September (4 months only). During the four months 80 percent rainfall takes place and other eight months can be described as water crisis period. Option of cement jars could be the solution for other months. Secondly adequacy depends upon numbers of jars installed and family size. Larger the family more will be the water use. The numbers and size of jars also determines the sufficiency and adequacy of harvested water. Third is the roofing pattern. People stock harvested water for longer period and use it in the crisis and havoc period. Longer adequacy of water certainly will help to engage women children and men in farm and off-farm activities which will ultimately enhance in rural development. In the following table it is calculated for how long the store (harvested rainwater) water is adequate.

Table 4.13: **Distribution of Household in Adequacy of Harvested Water**

Adequacy/Sufficiency	Households	
	Number	Percent
Up to one (1)	7	17.50
1 to 2 month	28	70.00
2 to 3 month	3	7.50
Above 3 month	2	5.00
Total	40	100.00

Source: Field Survey, 2006.

Figure 4.6: **Distribution of Household in Adequacy of Harvested Water**



Based on: Table 4.13

From the above table and figure, the harvested water runs for more than 3 months for 5 percent households. 17.50 percent households make use of harvested water for less or equal to one month. Large households (28), 70 percent make it use for one to two months. The use of water is for various purposes such as drinking, sanitation, livestock, gardening etc.

4.2.12 Uses of Harvested Water

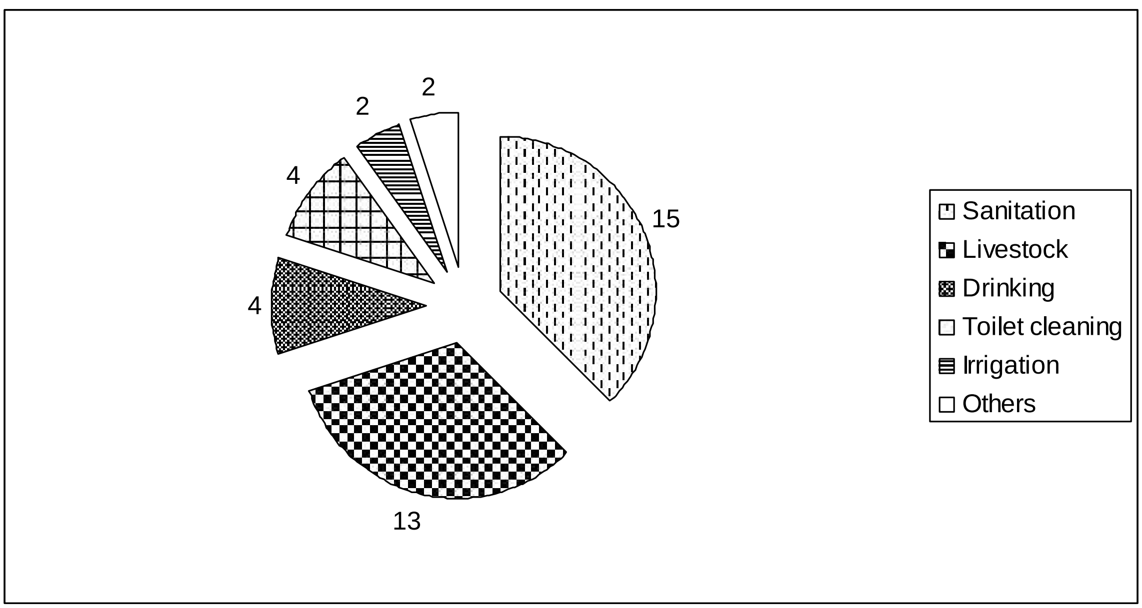
People use water for various purposes. Without water no life can sustain. Many uses of water in the rural areas of Nepal are irrigation, drinking, sanitation, livestock and industrial uses. In country side various sources of water are use for multiple purposes. But the alternative source of water/rainwater is basically use for the following purpose (column 1st).

Table 4.14: **Distribution of Harvested Water by Use**

Purpose of Water use	Households	
	Number	Percent
Sanitation	15	37.50
Livestock	13	32.50
Drinking	4	10.00
Toilet cleaning	4	10.00
Irrigation	2	5.00
Others	2	5.00
Total	40	100.00

Source: Field Survey, 2006.

Figure 4.7: **Distribution of Harvested Water by Use**



Based on: Table 4.14

In the above table, the RHs are in use for sanitation, livestock, drinking toilet cleaning, irrigation and other purposes. 37.50 and 32.50 percent households collected rainwater for sanitation and livestock purposes respectively, where as only 4 households, 10 percent, use for drinking purpose, which was the sole objective of the program. Since much of the water is use for above mention purposes but less is spent on small land irrigation.

4.2.13 Advantages of RHS

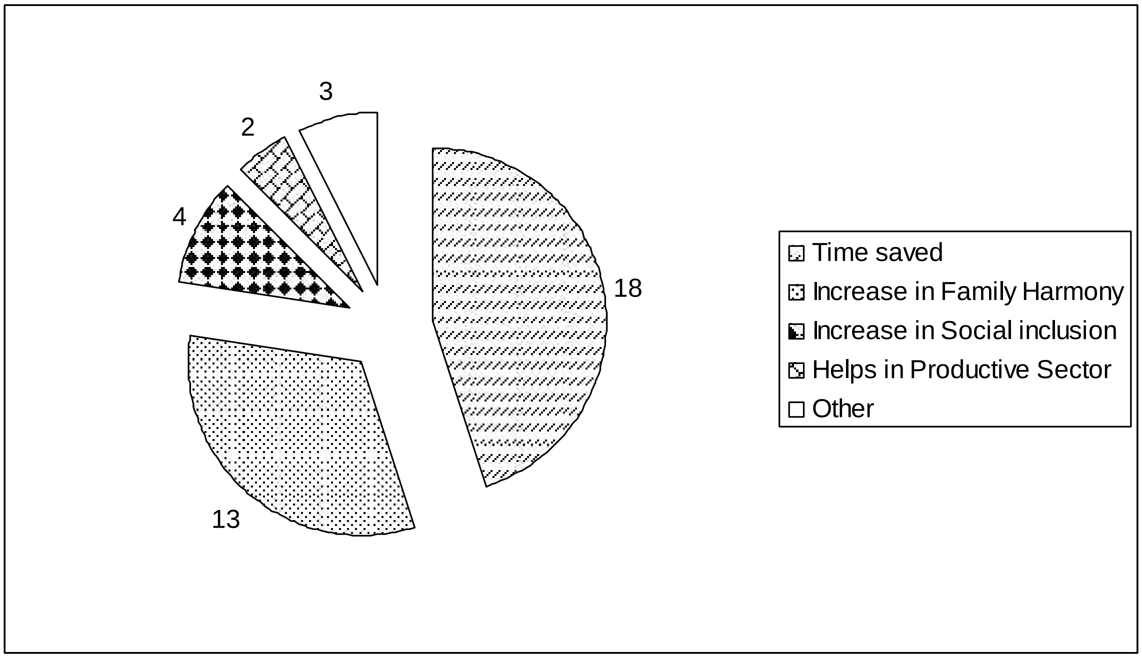
Rainwater has multiple uses and benefits. It is pure and fresh regardless of secondary pollutants. Rainwater collection is meaningful and advantageous where the secondary sources of water such as tap water, groundwater, stone spouts, and well (kuwa) contain in sufficient water and are less in number. The households who made the cisterns (Ferro-cement water jars) have benefited in number of ways. This benefit by them will bring progress in the rural development of Nepal.

Table 4.15: **Benefits of RW Harvesting System by Household**

Benefits/Advantages	Households	
	Number	Percent
Time saved	18	45.00
Increase in Family Harmony	13	32.50
Increase in Social inclusion	4	12.5
Helps in Productive Sector	2	5.00
Other	3	7.50
Total	40	100.00

Source: Field Survey, 2006.

Figure 4.8: **Benefits of RW Harvesting System by Household**



Based on: Table 4.15

Mentioned in the above table and figure, the benefits of Rain water collection/Ferro-cement jar/container are namely time saving, increase in family harmony, increase social inclusion and ultimately help in production aspect. Ferro-cement jar full of rainwater has saved time; the proportion of household for this benefit is 45 percent. 32.5 percent household has found benefit increase in the family harmony. Social exclusion is one of the disharmony factor in our society. But due to the installation of cemented jar 12.5 households benefited social inclusion/harmony.

4.2.14 Utilizations of the Time Saved

Having called spade a spade, the program has reduced a day in day out problem of water in rural areas and has saved the time. The other objective of the program was that people must utilize their time saved in productive works so that they can economically benefit. In what ways the beneficiaries group utilize the time saved have been shown in the following table.

Table 4.16: **Utilization of Timed Saved by Households**

Utilization of time	Households	
	Number	Percent
To collection of fodder/firewood	18	45.00
To Educational Attainment	7	17.50
To increases in participate in development activities	8	20.00
Others	7	17.50
Total	40	100.00

Source: Field Survey, 2006.

In the rural areas source of energy for cooking is fodder and firewood. Due to the availability of water at home they (households) can freely go in search of firewood. 45 percent households' use the time saved in fodder and firewood collection. Not only the school children but also the illiterate female has gained educational attainment through informal education system (adult literacy program). For the educational attainment 17.50 percent households have utilized the time saved. Due to the leisure available, 20 percent households increase participation in development activities. Others such as, skill development by tailoring activities, improve health etc. by 17.50 percent households have been found.

4.2.15 Beneficiaries

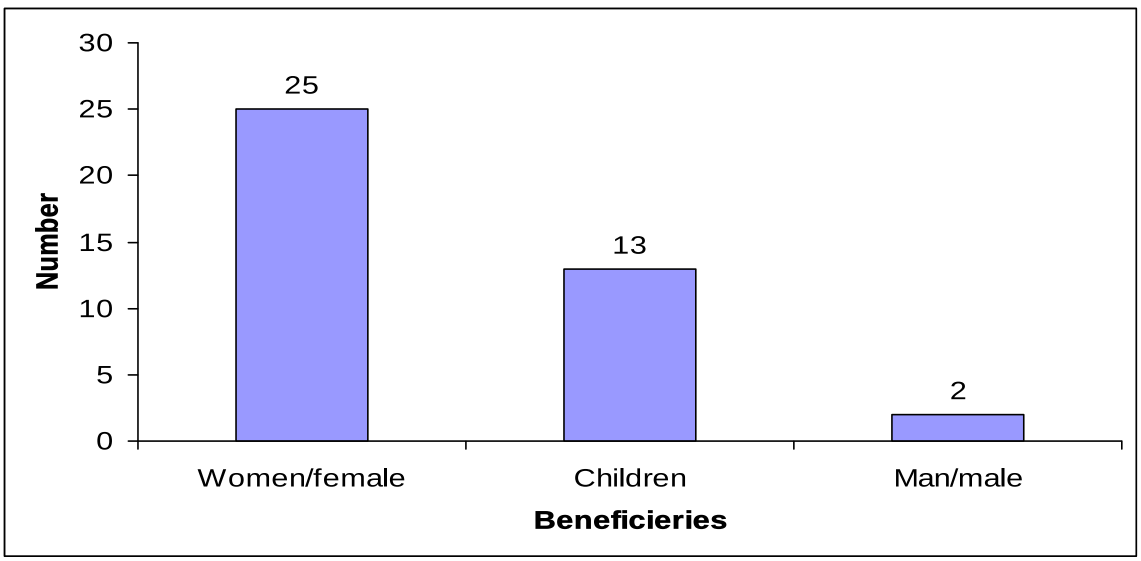
Along with the benefits and multiple uses rainwater harvesting into Ferro-cement jar provides many more advantages and benefits to the users. In the home it is the female (either unmarried, married or girl child) who has to solve water problem day in day out. By the use of the system mostly female as well as children have felt relief and burden down. In the following table the beneficiaries group have been demonstrated.

Table 4.17: **Beneficiaries of RWHs in Household**

Beneficiaries	Households	
	Number	Percent
Women/female	25	62.50
Children	13	32.50
Man/male	2	5.00
Total	40	100.00

Source: Field Survey, 2006.

Figure 4.9: **Beneficiaries of RWHs in Household**



Based on: Table 4.17

In the above table and figure, beneficiaries shown are women/female, male/man and school children. It is the proof that 62.50 percent households female are the beneficiaries brought about by the installation of the collection jar. It is also the women first who have to hover over the management of water but not the men. 32.50 percent children have been benefited by the system in use. Even these children either have had to drop out school or reach school lately. To some extent this has solved the problem of school children and maximizes relief. Men are the least beneficiaries who do not have to take burden of water management at home.

4.2.16 Economic Activities Supported by the System

Other objective of the program was to support for economic activities and reduced poverty which in turn bring rural development. One of the normative ideas of program was also to see people engage in productive activities. By and by this is gaining momentum. The prove is shown in the following table.

Table 4.18: **Economic Support by RHs in Households**

Supporting Activities	Households	
	Number	Percent
Livestock rearing	18	45.00
Non-seasonal vegetable production	14	35.00
Others (not state)	8	20.00
Total	40	100.00

Source: Field Survey, 2006.

In the above table, it is clear that the RHs have helped in livestock rearing ultimately leading to economic support. Economically 45 percent households have benefited by livestock rearing. Off-season vegetables on small farm land (no more land can be irrigated) have also supported economically to 35 percent household.

4.2.17 Attitude towards the Quality of Stored Rainwater

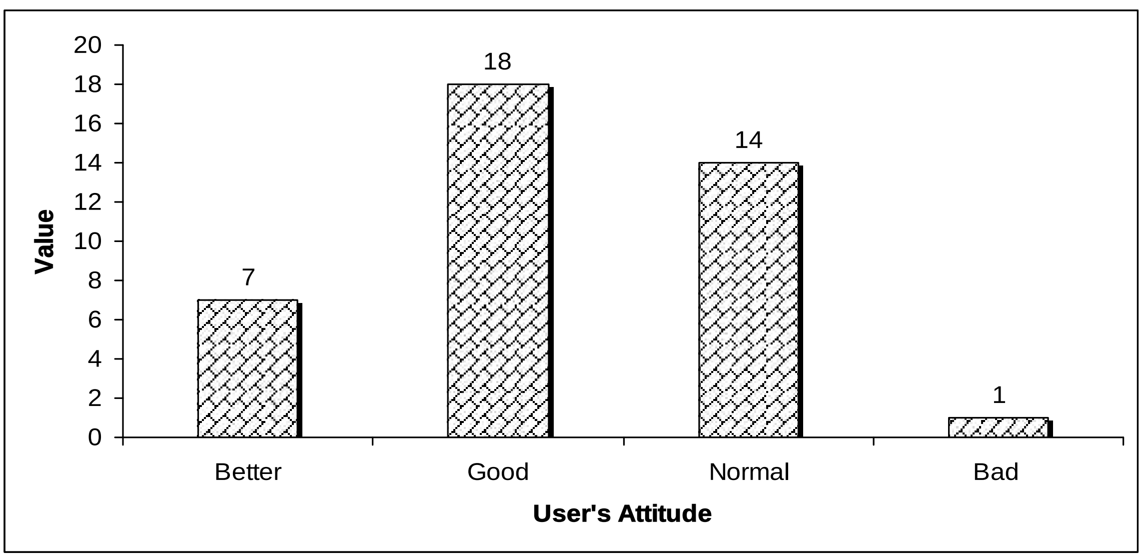
The capital idea of the program was to provide maximum advantage and benefit to the people through the installation of rainwater harvesting system. The system has more advantage than drawbacks. So it is hardly difficult to find any one who could dare to voice against the benefit of the system. Truly the system provides good service to those who use it. Rainwater harvesting in Ferro-cement jar has multiple advantages. In the following table attempt has been made to disclose the attitude of people towards rainwater harvesting system.

Table 4.19: **Percentage Distribution of Attitude toward Rainwater**

Attitude	Households	
	Number	Percent
Better	7	17.50
Good	18	45.0
Normal	14	35.00
Bad	1	2.50
Total	40	100.00

Source: Field Survey, 2006.

Figure 4.10: **Percentage Distribution of Attitude toward Rainwater**



Based on: Table 4.19

The table and figure, show that attitudes of households towards the functioning of system have been found positive. 17.50 percent household said it better while 45 percent termed it good. 35 percent households take it as a normal (neither bad nor good). But only 2 percent households disapproach.

4.2.18 Pollution of Harvested Water

The basic important thing one should aware about the use of rainwater collected is knowledge based on pollutants of water bodies and other related to water. Water is polluted by different agents such as leaves and dust particles, mixing other sources of water, absence of filter (net) and stagnation for longer period. Further, pollutants causing adverse effects must be known so that the sole objective of the program is fulfilled. But often people (households) in the study area do not use water more for the above mentioned causes and less for unknown reasons. The knowledge/understanding about the pollutants of RHs by respondent is given below.

Table 4.20: **Information of Respondents' on Pollution of Harvested Water**

Causes/reasons	Households	
	Number	Percent
Leaves and dust particulars	12	30
Mixing of water from other sources	3	7.50
Absence of Net & filter	5	12.50
Stagnant for longer time	2	5.00
All above	34	85.00

Source: Field Survey, 2006.

The study was also concerned on whether the respondents know about the causes which make the water pollution in the jar. General cause mentioned by the households are; leaves and dust particles, mixing water from other sources, absence of Net/filter, stagnation of water for longer period. 85 percent households have know/informed about all above causes. Only 7.50 percent know mixing causes pollution of water then it is east to sit that other unknown may directly mix water from other sources making water more pollution. 30 percent households know about leaves and dust particles which cause water pollution. 5 percent household said that longer stagnation make water pollution.

Understanding about the causes of pollution of RHs and using water for no drinking purpose is different. The reason behind this has been tried to portrait in the next table.

4.2.19 Causes of Not Using for Drinking Purpose

The sole objectives of program (facilitators) were to provide pure and fresh water for drinking purpose at the places where people face havoc and crisis all round the year. Besides the drinking use, the system has secondary purposes such as, gardening, off-season vegetable crops, livestock use, sanitation etc. But the first and the primary objective have been paced in second while the secondary purposes have been given first preference. The causes behind this have been attempted to draw in the following table.

Table 4.21: **Causes of Misuse of Harvested Water (not used for drinking)**

Causes/reasons	Households	
	Number	Percent
Pollutant	13	32.50
Nearby well/other sources	12	30.00
Nobody use	8	20.00
Other	7	17.50
Total	40	100.00

Source: Field Survey, 2006.

By the study, it was found that the causes/reason behind using rainwater for other purposes but for no drinking purpose have been flashed out. The reason for not using harvested water are: Water is polluted (by birds excreta, dust/debris in the roof, roof types, mixing of water from other sources, containing no filter), concept that rainwater is already contaminated, stagnation for longer period, presence of well (Kuwa) or pipe water nearby, homogeneous concept that everyone use for no drinking purpose etc. 30 percent household don't use for drinking because they have other ground sources nearby them. 20 percent don't use for drinking purpose because they know that nobody use for drinking purpose.

4.2.20 Maintenance Barriers of the System

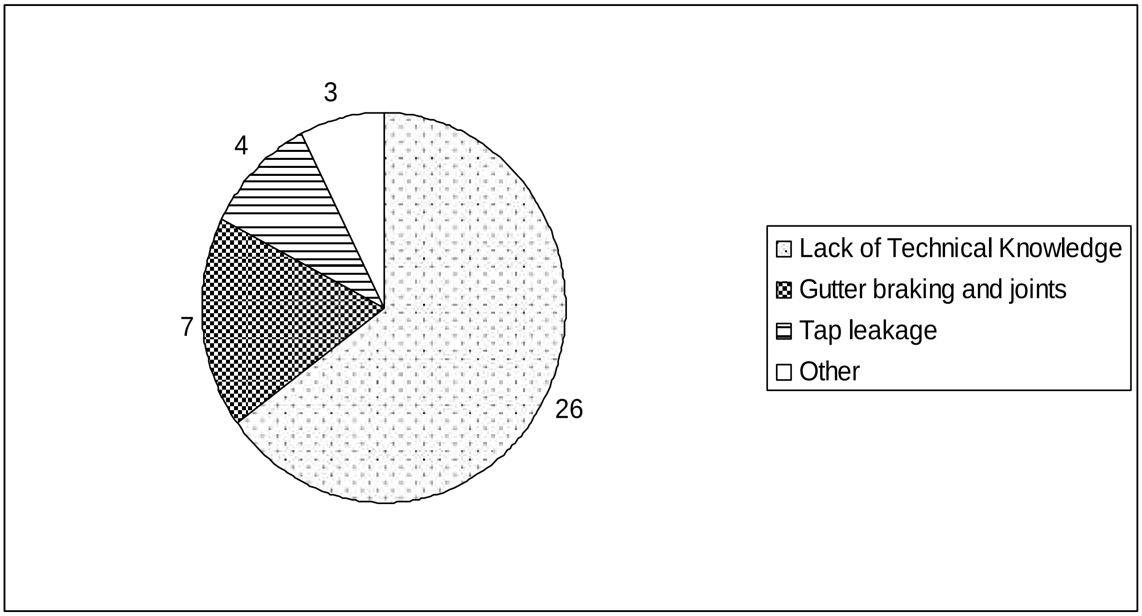
Maintenance with the cisterns/Ferro-cement jar is not so complicated. Because of the lack of technical aspect of the jar it makes little difficult in the maintenance. Only jars were made to fulfill the particular objective but they (facilitators) did not provide the spell for the maintenance and proper use of water. This is the main drawbacks that these facilitators install the cisterns and return back with no recommendations. The following table shows the obstacles and barriers in the maintenance of Ferro-cement jar.

Table 4.22: **Barriers in Maintenance of RHs System**

Barriers	Households	
	Number	Percent
Lack of Technical Knowledge	26	65.00
Gutter braking and joints	7	17.50
Tap leakage	4	10.00
Other	3	7.50
Total	40	100.00

Source: Field Survey, 2006.

Figure 4.11: **Barriers in Maintenance of RHs System**



Based on: Table 4.22

The bottlenecks and hurdles in the maintenance of water harvesting systems (Rainwater collection in Ferro-cement jar and its maintenance) are lack of technical know how in household level, problem with pipe gutter pipe, down ward pipe, joints, water leakage, wash back etc. Other barriers such as short length of pipe, no lid at the water container jar, absence of net, frequently tap damaging etc, have been found. 65 percent households do not know technical know-how. 17.50 percent household face problem with gutter breaking and joints.

Some household have sort length of gutter pipe, some have thatched roof while others have water leakage at joints.

Chapter - Five

FINDINGS FROM FGDS, KEY INFORMANTS AND OTHER RESPONDENTS

Focus group discussions, Key informant and interviews the visit has generated detailed information about RHs. The main summary of discussions and interviews has given below.

a) Installation Provision

The RWSSP/F has not provided sufficient jars for year round use. They have provided two jar and one jar where thatched roofs have been converted in CGI roofs against a requirement of jars. Each household is required to provide Rs. 300/- in cash plus collect and transport local materials, provide unskilled labour, provide water for construction, and supply transport for construction materials from the nearest road ahead.

To construct a Ferro-cement jar of capacity 2400 litre costs NR 8000-10000 provided by the project. The government bears 50 percent of the total cost other by FINNIDA.

b) Normative Aspects of System

These aspects are as a result of discussion made among groups and beneficiaries. The advantages of RHSs are:

Time saved from rainwater collection;

Irrigation on small scale land which increase seasonal and non-seasonal agriculture production;

Reduce long distance walk so provided less hardship and drudgery;

Rainwater is sign of purity and is fresh than others source which improve health;

Increase family harmony as well as neighborhood understanding;

It is very convenient in trouble-shoot such as in fire-fighting;

Improvements in the sanitation of the people due to potable and easily available water;

Decrease soil erosion by stopping down power of roof/terrace water;

Decorated structure of Ferro-cement jar increase rural beautification;

Supported in livestock rearing;

Help in the supply of water in the rural activities such as marriage festivals, paying homage to God, and help in community schools, hospital and in public places.

c) From the discussions following drawbacks have been drawn,

Difficulty in the selection of place and location;

Size and capacity of the cistern is not adequate to meet the require demand;

Difficulty in collecting construction materials such as mould, cement and concrete directly affecting transportation;

Leakage of water from gutter, downward pipe, different joints, flash out, tap, and washout pipe;

Pollutions such as dust, leaves, birds excreta make water non-drinkable; not provided technical know-how to the user groups make difficulty in maintenance;

Add pollution due to the absence of net, filter and lid;

No regular water in the cistern makes the structures crack and split;

d) Demand and Supply of Water

Demand Side: With increasing population water from natural sources in the hills would have fallen wall short of the demand. This exigency that threatened the survival of the entire community gave birth to various water harvesting practices. The dictum of natural selection fevered communities with developed sense of water management.

The demand for water is rapidly increasing. The most common uses are for drinking irrigation and livestock consumption with many socio-economic changes, demand is increasing and diversifying. It is a big challenges for local system that have not altered significantly over decades to meet this rapidly growing demand for water (Banskota, 2000). The demand for water has varied by both elevation and ethnicity. This is a sensitive issue, as it is a potential source of conflict will need attention in future.

Supply Side: Supply of various water sources are used by the community for fresh water supplies. The sources include rainfalls, ponds, wells, Rivulets, and others are springs, stream, rivers, marshes, groundwater, snowmelt, oozing, and in one case, even moisture, community is using most of the available sources of water for different requirements. Although, there are continuing problems, water supplies are insufficient. Given the likely scenario that demand for water will grow rapidly, supply constraints are going to be a major problem in the future (Banskota, 2000).

Falling waters tables are widespread and cause serious problems both because they lead to water shortages and, in coastal areas, to salt intrusion. Both contamination of drinking water and nitrate and heavy metal pollution of rivers, lake and reservoirs are common problems throughout the world. The world supply of freshwater cannot be increased.

Only 40% of households in Nepal have access to drinking water piped to the house and 30% have their drinking water piped but outside the house. The remaining 56% of household depend on covered well (37%) open well (15%) and others 14%.

Terai has the least access to pipe water (15%) where about (75%) of Households fetch drinking water from covered wells. Urban as expected, have better excess to safe water relative to rural areas (68% versus 39%). Arghakhanchi districts ranks 54th, Rupandehi 1st and Dolpa last (75th) position in access to improved source of grinding water (CBS, 2004).

e) Institutional Provision

The major ongoing work of RWHU at household level is undertaken by the rural water supply and sanitation project, FINNIDA (RWSSP/N) were conducted this project in hilly region of Nepal. This project had been launched in Arghakhanchi at household level. This project involves user participation. It is considered to be a successful programme. The department of water supply and sewerage (DWSS) has also undertaken some RWHU at community level in Syangja and Tanahun districts through its district offices with little or no cost sharing. ICIMOD has constructed small, plastic lined tanks/ponds in Kabhre and Godawari (Sanju et al, 2000).

Some others, institution are involved in the promotion and development of the water harvesting/management system all over the country. National and international organization/agencies are interested to the system in scares area specially in urban. At the central level, the institutions involved or with the potential to be involved in water harvesting are: DWSS, SECS, MLD, DSCWM, DOI BOARD, IDE, ADB, I/NGOS NWSC, etc. and at the local level are: DDC, RWSSP/F, DWSO, BWMP, SAPROS, INSAN, ADB/N, UG, NEWHA, ENPHO, NGO forum of sanitation and water supply for urban area etc. (ibid).

RWHU needs to be promoted in water scares areas considering its potential to free women from the drudgery of fetching water for drinking and other domestic uses.

f) Policy Provision

The country has promulgated various acts and policies in the water resources sector. Some of these acts and policies have indicated the importance of RH in hill and mountains. But until the present time, there have been no separated acts and policies on rainwater harvesting and utilization.

In Nepal the Ministry of Housing and Physical Planning published a National Policy on Drinking Water Supply in 1998. There is no separate policy for rainwater harvesting and use. It is mentioned in the 9th plan of Nepal that, in every remote area of Nepal where alternative viable sources of drinking water are not available, rainwater harvesting and use will be practiced. However, there is no specific policy as such for rainwater harvesting (Pradhan, 2000).

In the absence of specific policy on water harvesting, traditional water harvesting technologies have been neglected in some countries resulting in added hardship in getting sufficient water. It is important to understand both the existing traditional technologies of water harvesting and the involvement of local institutions, people's organizations, and civil society in promoting water harvesting within the broader policy context of addressing the challenges of water stress (Pradhan, 2000).

Chapter - Six

THE MAJOR FINDINGS, CONCLUSION AND RECOMMENDATIONS

6.1 The Major Findings

Topography and climate of particular area is directly related with development process of that area. Arghakhanchi district is steep and irregular land; so here it is very difficulty to establish basic infrastructure of development. The district constitutes 68.16% mid mountain area and 31.83% Siwalik Hills. The large part of the district is covered by forest (59.32%). The average annual precipitation of the district at location of Khanchikot was 1920 mm in 2000 A.D.

The total population of the household under study is 228 comprising average household size of 5.7. Economically active population is between the ages 15 to 59 years. In the study area the economically active population of this age group is 52.17 percent.

Education is the measurement of socio-economic development of any community and nation. Only 6 percent of the total respondent is illiterate. Primary occupation of the rural people is agriculture. 76 percent household is engaged in agriculture sector.

Nepal is rich in water resources. The different resources of water available in Nepal are rivers, lakes, glaciers, ponds, rivulets, streams, wells, stone spouts, roof top water harvesting and etc. Most of the people in the study area depends upon well and tap water for water resources. But tap water/piped water is not sufficient to meet the local needs. Rivulets are of sufficient source (92%) but far from village settlements.

In hills and mountains, there is usually excess water in the monsoon season creating havoc in dry season. The average time people spend to fetch water for a single trip takes 15-30 minutes for a household. People in these areas do not have alternative sources than go to remote sources or wait in queue even many hours in the sources close to their houses in fetching water in a day. The average repetition for the people in the study area is 6.04 times people collect average amount of water equal to 120 litre in a day.

Rainwater collection system existing in the rural areas is small pounds, using polythene drum or kerosene tin and recent practice Ferro-cement jar. 72 percent household collect rainwater using Ferro-cement jar in the study area.

Ferro-cement jar/cistern has become the best option due to which people feel much relief by the installation jars. Installations of jars have to be made after making discussion in the family or user group. Together with the husband and wife (couple) have higher share of decision which is 69.44 percent.

Adequacy of water depends upon use pattern, numbers of jar and family size. 83.33 percent households make harvested water use for 1 to 2 months. People use harvested water for various propose like as sanitation, livestock, small scale irrigation, drinking and toilet use. Mostly use in livestock rearing (31.48%), and sanitation (29.62%).

Rainwater has multiple uses and benefits. The household who made the cisterns have benefited in number of ways. Ferro-cement jar (cistern) full of rainwater has saved time; the proportion for this benefit is 44.44 percent. Along with the benefits and multiple uses rainwater harvesting system provides many more advantages and benefits to the users. It is the proof that 55.55 percent females are the beneficiaries. The people must utilize their time saved in productive works so that they can economically benefit. 27.55 percent household use the time saved in fodder and firewood collection. 25.00 percent households have utilized the time saved in educational attainment. The system has helped in livestock rearing ultimately leading to economic activities and reduces poverty which in turn brings rural development.

Truly, the system (technology) provides good service to those who use it. The attitude of the households towards system has been found positive. 38.88 percent households said it better while 2.77 percent said it inappropriate. Water is polluted by different agents such as leaves and dust particles, mixing other sources of water, absence of filter/net and stagnation for longer period. 52.77 percent of respondents have understanding about the cause of pollutions. The sole objectives of the program were to provide pure and fresh water for drinking purposes. But the sole objective shifted to other position due to pollutions, concept that rainwater is already contaminated, stagnation for longer period, homogeneous concept that every one use for no drinking purposes.

The bottlenecks in the maintenance of the systems are not so complicated but the lack of technical know how about the systems make little difficult. 50 percent households said that they lack technical know-how.

6.2 Conclusion

Rainwater harvesting technology has been used since ancient times, at least as early as 2000 B.C. in the Negev desert in Israel. The use of system has been in practice from Africa, Asia, and Europe.

Day in and day out the population growth is demanding more water leading to crisis. Due to the over-crisis of water rainwater harvesting system is gaining popularity world-wise, which is the only source to get purest form of water.

The starting of Rooftop water harvesting technology in Nepal was from Palpa Mission Hospital, 1960 which is still functioning well.

The technology of rooftop water harvesting system introduced very lately in Arghakhanchi district.

In Chhatraganj VDC, rainwater harvesting technology introduced in the year 2003 provided services to water scarce area and expanding rapidly for solving water demand. Here are four hundred cistern made till date.

The study area consists of heterogeneity in ethnicity and their occupation sustains in Agriculture. The area too has been water scarcity. So the installation of the rainwater cistern has great importance for rural development.

There are different sources of water available in the study area such as well piped water, ponds, stone spouts, streams/rivulet some sufficient water sources are far from settlements and takes almost half an hour to fetching water. Each household of the study population repeat 6 times a day for fetching water and requires above 120 litre of water for a day (both for human and livestock). Most of the houses have made cistern (jar) either one (capacity 2400 l) or two in number. Water of these jars is sufficient for almost 2 months for a family size of almost 5.5. By the installation of he system advantages of time saved, family harmony, and social inclusion have found. Moreover, school children and female are also the beneficiaries. The system has supported in livestock rearing.

Seeing the appropriateness and multiple advantages of the system, many of the non-user groups too are eager to make/install the system. The objective of the program is to fulfill water supply for drinking purpose but due to frequent pollution and rumor about the water quality has made use of the water for no drinking purpose. So, it is most important need to provide knowledge of technical knows how to the users group so that water can be use for attaining the objective.

6.3 Recommendations

The following recommendations have been made for the further development, management and promotion of rainwater harvesting system (especially rooftop rainwater harvesting).

6.3.1 At the National Level

Hydrological and climatologically data base information should be developed for long term planning and policy development.

Conservation and use of surface water sources should be maintained for migration and survival of plants and organisms in considerations of the potential impacts of sustainability of water resources.

The concept of water and importance of RHSs is not understood fully by the local people. In this case, GOs, COs, I/NGOs and local institutions must act as facilitator/provider in making aware and supporting water demand by the local people.

The absence of catalystic institutions to promote local water harvesting and utilization in rural area is pertinent. So government must act as facilitator itself for the inducement of such organizations in the promotion of local water harvesting resources/technology.

Government must formulate Act and Policies for water harvesting systems as an integral part of soil conservation forest management, pasture development and livestock raring for rural development.

The state should develop programme and project with highly participation of local people.

Key stakeholders should be encouraged to team up and draft a national strategic policy on RHSs. So as to give it the importance and priority it deserves.

DWRC, DWSCO, DWSS etc. should be persuaded to take up RHSs in hill and mountain places where other viable alternative are not available.

Traditional water supply systems, such as ponds and stone spouts in urban and rural areas need to rehabilitate to augment the existing water supply.

Regular monitoring and evaluation of RHSs should be undertaken to assess their impact on the community and draw valuable lesson for feedback.

6.3.2 At the Community Level

Community should be encouraged to play a greater role in this system activities and to use time save in income generating activities.

The system should be promoted first at household level with users sharing a small amount of cost since people are keen interested to install the system.

Installation provision should be made so that households that are too poor to contribute to the costs are not denied access to community facilities.

Development agencies should work in the community level for water harvesting on the behalf of supporting untouchable for ending the untouchable's conflict in the society.

The water user group should be strengthened through the development of an appropriate training programme aimed at development use, and dissemination of local skills and indigenous knowledge.

Since traditional ponds and spouts looked after by trust are in state of neglect and are being encroached upon, community participation should be persuaded to act efficiently.

Community people, schools, buildings must be aware to use CGI roofs for using incentive and advantage by RHSs in supply of water.

To maintain the water table community should practice and manage check dams, terracing on gentle slopes, earthen ponds, land use, and pasture and forest management.

This system (RHSs) should be encouraged in view of the heavy rainfall in winter and during monsoon.

People's participation was more effective in the past and partially absent at present particularly in planning and management; so people must make aware for active participation in the use of water resources.

This system (RHSs) should be developed as integral part of the WMP (Water Management Programme), Rainwater harvesting, storage, and recycling of water.

Water harvesting is appropriate for scattered mountain settlements as rainwater can be harvested extensively by individual households independently of each other and with minimum conflicts over ownership being raised.

User or system adopted community should be trained or provided about technical know-how of the different part of the system (gutter, inflow pipe filter net, lid, tap, etc.) because it is technical in form.

The size of the system is unattainable and too narrow for the require need so the planner of the new establishment of this system must pay attention to increase the existing size.

The rainwater is itself pure and drinkable in its form but household are using for sanitation and livestock purpose only this is why the planner, expert and development agents should counsel for meeting the sole objective (drinking purpose) of the program.

At the time of study only some households have had this system but interest in every holds was seen too for the installation of the system that is why the development agencies should expand this system in each households.

6.3.3 Recommendations for the Further Research

The rainwater collection has not been seen in the drinking purpose in the study for the possible cause of pollution (dust, leaves, birds excreta) and homogeneous concept that rainwater is already contaminated that is why further research is suggested upon these issues.

The environmental impact of different water harvesting system has been recommended for further study.

It has also recommended that databases should be developed on different aspects of hydrology, meteorology, geomorphology, geology and biology.

Research and pilot testing should be undertaken, especially in high mountain areas with flat roofs and in areas where thatched roofs are predominate.

References

Agarwal, A. and Narain, S. (1997). *Dying Wisdom: Rise, Fall and Potential of India's Water Harvesting System.* New Delhi: Center for Science and Environment.

Athavale, R.N (2003). *Water Harvesting and Sustainable Supply in India*. Jaipur Rawat: Environment and Development Series.

Banskota, M and Chalise S.R. (2000). *Waters of Life*. Vol.-II. Kathmandu: ICIMOD.

Banskota, M. (2000). Water Harvesting Practices in Mountain Areas. In: M. Banskota, and S.R Chalise, (2000) *Water of Life*. Kathmandu: ICIMOD.

Banskota, M. and Chalise S.R. (2000). *Waters of Life*. Vol.-I. Kathmandu: ICIMOD.

Banskota, M. Chalise, S. R. (2000). *Waters of Life. Perspectives of Water Harvesting in the HKH*. Vol. I and II. Kathmandu, Nepal: ICIMOD.

Baskota, S. (2005). *Research Methodology*. Kathmandu, Kirtipur: New Hira Books.

CBS (2002). Population Census 2001, Kathamdu: CBS.

CBS (2004). *District Profile of Nepal*. Kathmandu: CBS.

CBS (2004). *Nepal Living Standard Survey 2003/04*. Kathmandu: CBS.

CBS (2005). *Statistical Year Book of Nepal*. Kathmandu: CBS.

Chalise, S.R. (2000). *Water Resources Management in the HKH*: *An Overview, Waters of Life*. Kathmandu: ICIMOD.

Changming, L. et al. (2000). Water Harvesting in the south western mountains of China. In: M Banskota,.and S.R. Chalise, *Waters of Life*. Kathmandu: ICIMOD.

Chatterjee, S.N. (2004). Rainwater Harvesting: Principle and Nepal Practice. In: *The Economic Journal of Nepal*. Vol.-27, No. 3, Jul-Sept, Kirtipur: Tribhuvan University.

Critchley, W.R.S. and Reij, C. (1989). *Water Harvesting for Plant Production*. Part 2. Case Studies and Conclusion from Sub Saharan Africa (Draft).

Dixit, K. (2005). Rainwater Harvesting in Kathmandu Valley, In: *Nepalese Journal of Development and Rural studies.* Vol. 2, No. 2. Kirtipur: T.U. CDRD.

Ekta (2005), *School Atlas*, Kathamadu: Ekta Books.

Evanari, M. (1971). *Stone Mounds and The Mechanics of Runoff*. A chapter in the book, *The Negev, the challenge of a desert,* U.K.: Oxford University Press.

Gleick, H.P. (2004). *Emerging Paradigm of water Development and Management*. Vol-II, No. 1. In: Water Nepal, Journal of Water Resource Development.

Gurung, R. (2004). *Rainwater Harvesting in Soil and Its Application in Dry Season Farming*. M. Sc. Thesis, Kirtipur: T.U. Central Department of Environmental Science.

ICIMOD (1997). *Local Water Harvesting and Management.* Kathmandu: Annual report.

IUCN Nepal (2000). *Environmental Education Source Book.* Editors Pande, B.D., Maharjan, S.D., Shakya, V. and Karki, U.B. Kathmandu: IUCN-The World Conservation Union.

Lekhak, H. D. and Lekhak B. (2005). *Natural Resource Conservation and Sustainabel Development in Nepal*. Kirtipur, Kathmandu: Kshitiz Publication.

Mukherji, R. (2000). *Environmental Management and Awareness Issues.* New Delhi: Sterling Publishers.

NGO Forum (2062). *Water*. Vol. 1, No. 1. Kathmandu: NGO Forum for Urban Sanitation and Drinking Water.

NWCF (2000). *Nepal Water Conservation Foundation.* Kathmandu: A Report.

Ojha, E.R. (1999). *Dynamics and Development of Highland Ecosystems.* Kathmandu: Walden Book House.

Parajuli U.N. and Sharma, C. (2000). Study of Local Water Harvesting Systems in a Micro Watershed in the upper Mustang Region of Nepal. In: M. Banskota, and S.R. Chalise, (2000) *Waters of Life*. Kathmandu: ICIMOD.

Paudel, L. (2006). *Rainwater Harvesting System for Rural Development in Hills:* A Case Study of Kerunga VDC in Arghakhanchi, Nepal. M.A Thesis, Kirtipur: T.U. Central Department of Rural Developments.

Pradhan, P. (2000). *Water Policies and Local Water Harvesting in the Hindu Kush-Himalays.* In: M. Banskota, and S.R. Chalise, (eds 2000). Water of Life, Kathmandu: ICIMOD.

Sadan, Arghakhanchi Sampark (2061). *Arghakhanchiko Chinari.* Kathmandu.

Sainju, M.M, et al. (2000). *Policies and Institution for water Harvesting in Nepal*. In: M. Banskota, and S.R. Chalise (2000). Waters of Life. Kathmandu: ICIMOD.

Sharma, C. K. (1997). *A Threatise on Water Resources of Nepal*. Kathmandu: Mass Printing Press.

Sharma, P. (2003). *Social Science Research Methodology*. Kirtipur: Kshitiz Publication.

UN (1998). *Towards Efficient Water use in Urban Areas in Asia and the pacific*. New York: UN.

UN (2005). *Women and Water, Division for the Advancement of Women*. New York: UN.

UN-HABITAT, (2005). *Rainwater Harvesting and Utilization Blue Drop Series*. New York: UN.

WECS (2005). *National Water Plan Nepal.* Kathmandu: Government of Nepal.

www.rainwaterharvesting……

Zaunderer, J. and Hunchinson, C.F. (1988). A *Review of Water Harvesting Techniques of the Arid South Western USA and North Mexico*. Draft, Working Paper for the World Bank's Sub-Sahara Water Harvesting Study.

Appendix -I Questionnaire

An Assessment of The Role of Rainwater System in Rural Development of Hilly Areas

A Case Study of Chhatraganj in Arghakhanchi, Nepal

Questionnaire for household survey

1. Demographic Information:

Name of the Respondent: .... Age: ....

Education: .... Family size: ....

Occupation: .... <14 yrs: ....

>15-59 yrs: ....

above 60yrs: ......

Date: ....

2) What are the main sources of water for your household?

a. Tap water
b. Open well
c. Pond
d. Rainwater collection
e. Stream and river
f. Spring

3) Do the sources of water change according to the seasons?

Yes ☐ No ☐

If yes, what sources are used mostly and during which season?

Seasons	Sources
Summer	
Winter	
Autumn	
Rainy	

4) How often do you face the shortage of water?

Months: ....

5) Which sources are easily available?

a. Tap water b. Open well

c. Pond d. Rainwater collection

e. Stream and river f. Spring

6) Is the available water sufficient?

Yes ☐ ☐

If not, priorities the sources of water by use. (Ranking 1-5)

a. Tap water b. Open well /Spring

c. Pond d. Rainwater collection

e. Stream and rivulets

7) How long does it take to fetch water from sources?

a. 0-15 minute b. 15-30m c. 30-45m

d. 45-60m e. above 60m

8) How much water do your family need per day?

a. 25-50 litre b. 50-75 litre c. 75-100 litre

d. 100-125 litre e. 125-150 litre f. 150-175 litre

g. 175-200 litre h. above 200 litre

9) How many times do you repeat to fetch water per day to fulfill the require water?

....

10) Do you know about rooftop rainwater collection system?

Yes ☐ No ☐

If yes, how do you collect the rain water?

a. Make a small pond b. Cemented water jar

c. Hill-Take Tank d. Small drums

Since when are you using it?

....

11) Do you use the collected water for drinking?

Yes ☐ No ☐

If yes, is this healthy for drinking?

Yes ☐ No ☐

If not, do you use what the RRWH system water for?

a. Cooking and drinking b. Irrigation

c. Livestock d. Washing/bathing

e. Toilet flushing f. Sanitation

12) What is the water storage capacity of the system?

a. 100 ltr.-200 ltr. b. 200 ltr.-500 ltr. c. 500 ltr.-1000 ltr.

d. 1000 ltr.-1500 ltr. e. 1500 ltr.-2000 ltr. f. above 2000 ltr.

13) What is the water storage capacity of the system?

a. 100 ltr.-200 ltr. b. 200 ltr.-500 ltr.

c. 500 ltr.-1000 ltr. d. 1000 ltr.-1500 ltr.

e. 1500 ltr.-2000 ltr. f. above 2000 ltr.

14) For how long, is the collected water sufficient?

a. Less than one month b. 1-2 months

c. 2-3 months d. More than 3 months

15) In your household, who decided to install the system?

a. Couple b. Head of family (female)

c. Head of family (male) d. Others

16) Which aspects of economic activities have been supported by RRWH?

a. Irrigation b. Off-season agricultural production

c. Livestock rearing d. Gardening

17) Through above activities, did you improve your economic level?

a. Increased production b. Employment generation

c. Time Saved d. Bricking

18) Who have been more benefited by this system? (Ranking 1-3)

a. Male ☐

b. Female ☐

c. Schooling children ☐

19) How are they benefited?

a. Time saved b. Family understanding

c. Adult literacy d. Sanitation

20) After the system was adopted, have you noticed that your time has been saved?

Yes ☐ No ☐

If yes, what do you use the time saved for?

a. Weaving and stitching

b. Schooling of children (girls)

c. Participation in women's community organization activities

d. To improve health

21) Do you think that it is appropriate to install the RRWH?

Yes ☐ No ☐

If yes, why is it appropriate?

a. Easily available b. environmentally friendly

c. Generate employment d. financial support

If no, what are the reasons?

a. Financial problem b. Technical problem

c. Stored water is of poor quality d. Insufficient

22) Is the RHSs long lasting?

Yes ☐ No ☐

If not, why?

a. Effective less b. High cost

c. Low water quality d. Financial problem

23) What do you think of the quality of storage water?

a. Better b. Good

c. Normal d. Bad

24) How does water become polluted by?

a. Leaves and dust particles

b. Absence of filter and net

c. Stagnant for long time

d. Mixing of other sources of water

e. Others..............................

25) Do you suggest all us to install the system?

Yes ☐ No ☐

If yes, why?

....

If not, why?

....

26). Is your opinion, what strong and weak points do you see regarding the RRWH system?

Strong	Weak
....	....

27) If not installed, are you planning to install the system?

Yes ☐ No ☐

If yes, approximately when?

a. After................ months/years

28) Why do you plan to install it?

Reasons

a. ....

b. ....

c. ....

29) Why not?

Reasons

a. ....

b. ....

c. ....

30) What are the perceived difficulties/problems in the installation?

....

31) What could be done to encourage/support the installation of the system?

....

Points for Discussion with FGDs and Key Informant Interview

a) Availability of sources of water

b) Fetching time and distances

c) Quality of water

d) Installation provision

e) Supporting Agencies

f) Positive and Negative Aspects of the system

g) Expansion Provision

h) Lasting of program/system

i) Supporting activities by the system

Appendix-II: Photographs

Photo 1: Rainwater harvesting at a community school (inside the classroom)
Jana Jyoti Primary School, Rata Pokhara

Photo 2: Surface water harvesting in a pond, Dhanti

Photo 5: Surface water harvesting in a pond (Rata Pokhara)

Photo 6: Diminishing surface water harvesting (Lakurika Rukha)

Photo 3: Corrugated Galvanized Iron water harvesting

Photo 4: Roof top CGI water harvesting system