Assessing the Changing Patterns of Water Availability and Adaptation to Water Scarcity through Sustainable Water Management in Dir Lower.

A Thesis of Master of Science in Disaster Management

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This is to certify that the thesis entitled

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Declaration

I **Muhammad Idrees**, Registration No. **2017NUSTMSDM00000205647** declare that this research work titled "Assessing the Changing Patterns of Water Availability and Adaptation to Water Scarcity through Sustainable Water Management in Dir Lower" is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred. None of this work has been published before submission of this thesis. This work is not plagiarized under the HEC plagiarism policy.

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Copyright Statement

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List of Acronyms

IWMI	**International water Management Institute**
m	**Meter**
m^3	**Cubic Meter**
Cm^3	**Cubic Centimeter**
CC	**Climate change**
ISWC	**Indigenous soil and water conservation**
WDM	**Water demand management**
LRB	**Limpopo River Basin**
MAH	**Million Acre feet**
MHe	**Million Hectares**
FGD	**Focus group discussion**
SSI	**Semi structure Interview**
SPSS	**Statistical package for Social Sciences**
KPK	**Khyber Pakhtunkhwa**
TMA	**Tehsil Municipal Administration**
PHED	**Public health Engineering department**
WHO	**World Health organization**

Abstract

Water is one of the most essential component of sustaining life and development on the Earth. Earth is also called the blue planet and as seen from the satellite pictures water seems to be in very abundance on the earth but unfortunately maximum of this water is inaccessible to human being for their consumption and in some places there is already a huge water disparity. After the mid-21st century climate change, over population, mismanagement, over exploitation and lake of conservation have intensified the already existing water disparity in some places while at the same time these factors have also increased water stress in other places where water was once in abundance. Dir Lower was also once a water-abundant place now struggling with acute water stress and hence this research was conducted to find out the availability, consumption and patterns of water stress, and sustainable water management practices in Dir lower. Mix-method research was adopted to find out these objectives. Questionnaires, Focus group discussion and semi structured-interviews were conducted in the targeted population. The data was then analyzed and interpreted through SPSS frequency distribution, and qualitative data analysis. The research shows that more than 70% population rely on privately owned bore wells. Government owns very few water supply systems. Currently, there isn't any reservoir built on the rivers to store the surplus flow and floodwaters and there isn't any artificial recharge of the depleting ground water aquifers. Precipitation level has decreased from 2300 mm to 500mm per annum which is very alarming. If the current situation goes on for next few years, the district will be in the lap of absolute water scarcity as majority of the springs has already dried and underground water level has reduced alarmingly.

Chapter 1

INTRODUCTION

1.1 Introduction

Water is the mainstay of life and the planet. Clean water for the purpose of drinking and sanitation while sustainable at reasonable cost is something which cannot be avoided by any human being. In order to meet these necessary needs- chiefly water- we must conserve water in a fair way to avoid water scarcity and drought. Biological stability and sustained life chain in this planet is only possible because of water, it provides habitat to almost one third of the living entities on this planet by repeating its rigid hydrological cycle (Cosgrove & Rijsberman, 2014).

Freshwater reservoir contributes only 3% to the total global body of water while one third of that is beyond human utility (Clarke, 2013)**.** In the similar way, almost 97% of global water resources rest in oceans and seas rich with salt amount making it unable to drink or utilize for production. Following the above calculation, the remained water resources is a depository in the form of glaciers; ice bergs, swamps, permafrost and deep aquifers of about 108,000 below the ground lever annually. It is to be estimated that, almost 60% of the remained reservoir evaporates back directly into the atmosphere i.e. (61,000 km3) which leaves 47,000 km3 streaming towards the sea, which statistically lead us to record an average flow of 9000 m3 per person per year. Seasonal floods waste much of the water stream leading us to estimate that, only 9000 km3 to 14000 km3 can be controlled ultimately, including 34,000 km3 of water for utility purpose (D. W. Seckler, 1998). Rest of the water is distributed unequally leading to a permanent water stress in most parts of the world (Clarke, 2013). Thus leaving poor nations in extreme water crises and almost one third of the global population faces the problem of water scarcity (Kummu *et al.*, 2010). However, there is no universal definition for water scarcity but we can simply generalize, that an area is to be considered as water deficient, if common folk has no access to clean water for drinking and other necessary needs for life. (Rijsberman, 2006).

Scarcity of water is not confined to a single territory and it has been a tradition to cover large territorial areas having rich water resources to exploit more and more water. Nevertheless, it

is a fact that water has a pivotal role in each and every aspect of life including agriculture and food security (Nepomilueva, 2017).

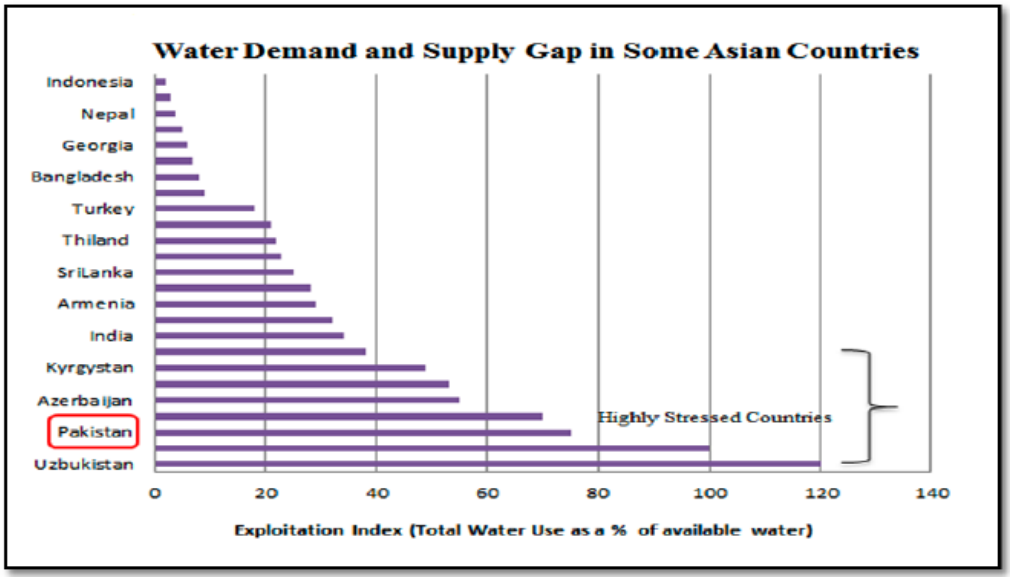

Figure 1.1 Water Demand and Supply Gap in some Asian Countries. Source: After UN ESCAP, 2012.

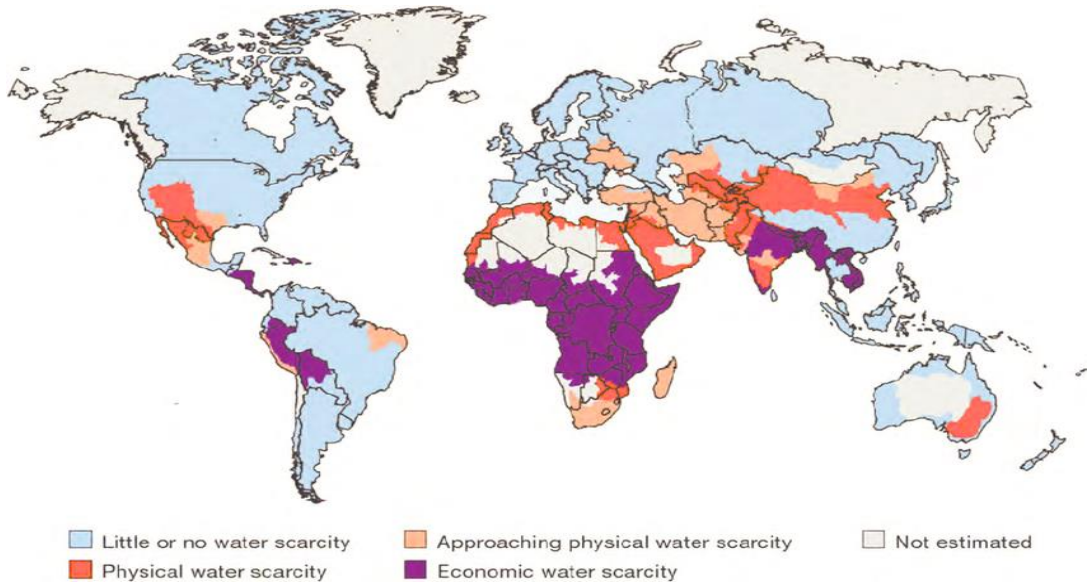

Figure 1.2 Map of global water scarcity. Source: IWMI, 2007a

According to the IWMI (International water Management Institute) announces that, Pakistan is one among those countries which are liable to Absolute Water Scarcity. The country is projected to be at absolute water scarcity by 2025(D. Seckler *et al.*, 1999). Pakistan is amongst the countries that do not have sufficient annual water resources to meet the needs of per capita for its rapidly growing population.

In Pakistan over the past 2 decades, the phenomenon of water scarcity and water exploitation has increasingly become severe, although have been blesses with major rivers, one of the world largest irrigation system, natural glaciers and water basin(Ahmed *et al.*, 2007).

In current scenario of water shortage in Pakistan, some short term and long term policies have been proposed for conservation. These include awareness campaigns, increasing On-farm application efficiencies, improving conveyance efficiencies. Improving surface irrigation methods, changing in cropping patterns and crop varieties, regulation of ground water and identifying new water storage sites (Kahlown & Majeed, 2003).

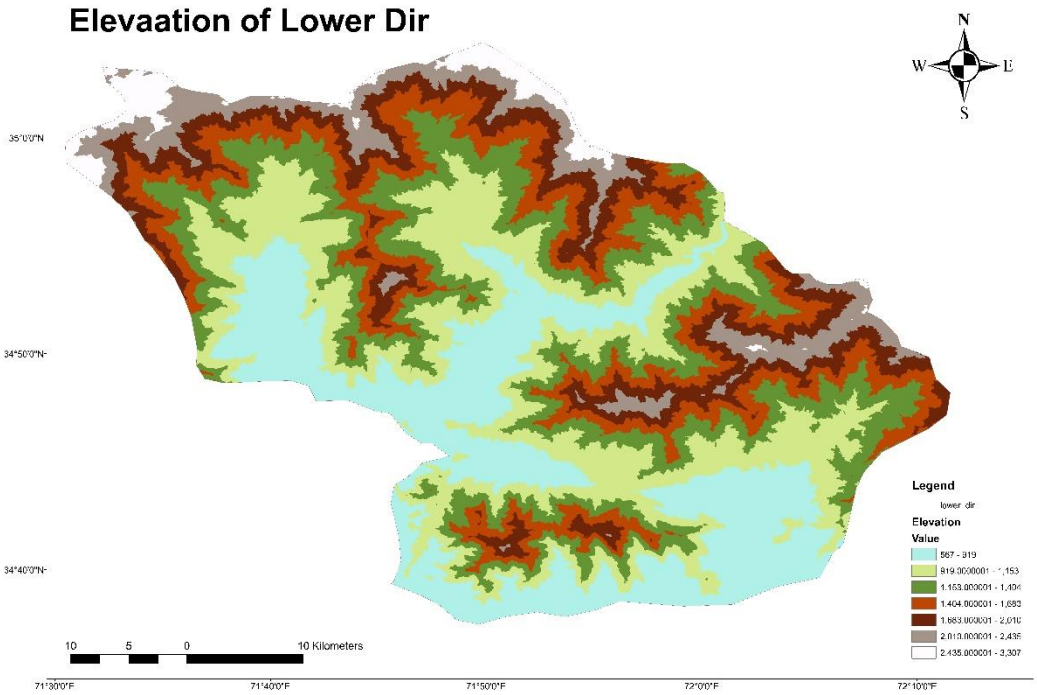

Figure 1.3 Digital Elevation of District Dir Lower.

Dir Lower was one of the water abundant districts of the Province having Rivers, streams, ponds and springs. However, Due to climate change, overconsumption and mismanagement, the district is facing a severe water shortage. The district is mountainous terrain and the scattered population mostly dependent on springs and torrents for their water needs. Moreover, the water table and ground water reservoirs are also facing existential challenges as water pumping out of the ground has been increased manifold in the recent years while on the other hand natural recharge of these resources has been hindered by clearing out the woodlands and vegetative cover in watershed area.

1.2 Problem Statement/ Reason/Justification for the Selection of the Topic:

Lower Dir is a district of Khyber Pakhtunkhwa which is home to rivers, torrential streams and natural springs but due to population increase, rapid urbanization, unsustainable agriculture and irrigation practices, climate change, erratic precipitation, exploitation and mismanagement of water resources, water stress is ascending at a concerning rate. Water scarcity and its management is becoming a chronic issue in the previously water sufficient area of District Dir Lower. Therefore to study the root causes of water scarcity and identify problems of the available water resource management District Dir Lower is selected for the current research.

1.3 Objectives

The main objective of this research was the assessment of changing patterns of water availability in district Dir Lower and sustainable water management opportunities. This was established by the following sub-objectives which helped in understanding and assessing the main objective.

1. To identify existing practices of water demands and supply in the study area.
2. To suggest appropriate conservation and management practices to ensure sustainable utilization of available water resources.

1.4 Relevance to National Needs:

Pakistan is among the countries that are blessed with abundant water resources but due to lack of efficient management strategies and sustainable utilization of existing resources the country is leading to a state of water scarcity. Continuous exploitation and wastage of water, ignoring the construction of new dams, impacts of climate change, prevailing drought situation and reduction in precipitation level are making the situation even worse. With agriculture forming the basis of our economy, huge glaciers and increasing impacts of climate change in the country it is critically important to work out feasible solutions for improving water management practices and ensuring sustainable utilization of the available resources.

1.5 Areas of Application

- Community

- District government
- Irrigation department
- Agriculture department
- Disaster Management Authorities
- Pakistan council of Research in water Resources (PCRWR)
- WAPDA
- Ministry of climate change
- Forest department

Chapter 2

LITERATURE REVIEW

2.1 Rationale of the chapter

This chapter presents the relevant literature and research regarding the availability, scarcity and management of water. In addition it also reviews the sustainable water management practices. The literature review further helps the researcher to design and develop data collection tools i.e. questionnaires, key informant interviews and focus group discussion questions. In this chapter international and national knowledge has been added in order to understand the problem.

2.2 Introduction

Water is a necessity evil for life" this quote by UN secretary General implies that without water there is no life and water as a connecting bridge between all aspects of human life. The availability and usability of water is directly related to common good and people's well-being and their economic development. Inaccessibility and reduction of water leads to scarcity while excess of water leads to flooding situation. While on the other hand contaminated water has his own disaster in the form of health issues in worldwide communities (UNDP, 2016)

2.3 Water Uses

Throughout the centuries man has always tried to manipulate the water sources on either ways. The remote agriculture system depended on the natural precipitation and runoff. The innovation of dams and canals systems has improved the crop production and fertility. With the expansion of urbanization there needs a proper piping system as well as canal system which will brought water to the consumers in a better way and reduce wastage which was practiced from centuries (Crouch, 1993; Landels, 2000). With the advent of modern industrial revolution and population boom in recent times the surface water resources declined dramatically with the excess demand. There has been multiple preservative measurements and engineering projects designed to cope with floods and protect clean water supplies in order to provide water for irrigation and hydro power, the same method has proved beneficial in many ways for the human beings. Almost one third of the world electricity is generated through hydro power plants (Gleick, 2003). Even today, around 30 to 40 billion dollars are invested in construction of dams (Dams, 2000).

One of the major uses of water is its domestic consumption. Both indoor activities and outdoor activities consumes uneven amount of water. Washing, cooking, drinking and bathing are indoor activities while consumption in ponds, lawns, gardening and landscape are included in outdoor consumption. Household water is supplied from some outer source like suppliers, tube wells, springs or inner source like wells and rain water harvesting (Dieter, 2018). Those water which are provided by suppliers and i.e. government or private vendors denotes public water supplies. These water are supplied with some limited connections to households up to 15 connections. These water are provided for different uses i.e. household, industries, irrigation and commercial purposes. Which also serves at the time of system loss (Dieter, 2018).

2.4 Water Supply and Demand

Pakistan receives rainfall over the periods of time i.e. summer from June to September (Monsoon season) and winter from December to March. Summer receives more rainfall than winter annually. Indus River receives about 140 MAF. The flow during summer season is almost 84% while winter is that of 16% which makes it 118 and 22 MAF consecutively. Indus is the sole contributor to the water system having 65% along with Jhelum giving 17% and Chenab 19% respectively. Following the verdicts of Indus basin water treaty Pakistan has initiated a series of canal linking systems in order to divert water from the western rivers to cope with the water necessities of Southern Punjab. To combat the scarcity period of winter season, Pakistan has built a storing capacity of 18MAF water for irrigation purposes in which around 4MAF capacity has been reduced by the sedimentation load. The plain fertile land of Pakistan has aquifer of 50MAF. 40MAF has been consumed though 600,000 tube wells chiefly in private sector. The availability of water in Rabi is 56MAF while that of khareef is 77MAF making 133 MAF of the total supplies. Out of total of 120,000 water courses, 45000 water courses have been improved under the supervision of on-farm water management program. To improve water courses and water use efficiency at farmer field a second program was also carried out in this regard. Farmers are facilitated with modern technologies i.e. laser leveling, zero tillage, sowing of crops on beds and furrows and balance supply of fertilizers. This improved the productivity of crops extensively and improved the standards of farming. For higher value crops I.e. orchards and vegetables a new system was introduced that replaced the pressurized irrigation system. This system proves efficient particularly for areas of uneven topology and rain fed areas. In poor farming communities especially drought hit areas of Balochistan and other places cannot afford such expensive, therefore the initial

investment was very high and prohibited. Moreover, in pressurize irrigation system most of the products are imported and highly expensive. But recently indigenous steps have been initiated which are not enough. There is a dire need for private sector to work in these areas in order to assure competitive and cost effective supplies to replace the pressurize irrigation system and facilitate the farmers (Kahlown & Majeed, 2003)

2.5 Water Scarcity

An increasing demand on drinkable water resources resulting from population boom, droughts and nasty changing weather patterns owing to climate change is much ordinary in most parts of the globe (Bates *et al.*, 2008). So far, water has been counted among non-limited natural resources, because of its cyclic renewal with altering seasons annually. Excessive usage of water with less care caused many future problems regarding the water crisis. Management of underground water and surface water resources which has been using by population is not being cared about, these resources hasn't been sustainably utilized while keeping the quality reserved. Therefore, in the meantime there is a threat of water scarcity in both the drought prone and arid zones, but the same problem is attributed to those regions where precipitation occurs in abundance. Water scarcity is now measured in the context of the water quantities available for social and economic uses, as well as in association with water requirements for natural and man-made or artificial ecosystems. The very notion of water scarcity also encapsulates the quality of water, because degraded water resources are almost near to its end or somehow marginally available for use in human and natural systems.(Pereira *et al.*, 2009)

After the half century, the China's population has increased by 700 million which as a whole is almost equal to the world's population since industrial revolution. Majority to their population has lived in the nearer areas to Rivers Yangtze, Yellow and others. Water of these rivers were utilized to grow crops for the majority of China's People, also for the newly growing cities and emerging industries. With the continuous utilization and exploitation of these surface and ground water, they induced an extensive pressure on their resources because china was not able to expand its population to its suburbs like America did in California and Great Plains. Few decades earlier, when these water from rivers extracted with enormous rate exceeding to their needs, then in 1972 China has faced with the dried Yellow River for first time and continued in the next years. With years passing the river dried for more and more days and reached up to the level that in 1997 it parched before reaching to the

Shandong province which was the highest corn and wheat productive province of the country (L. R. Brown & Halweil, 1998).

Since the last few decades most probably after 1980, China is in continuous strife and struggling with water shortages of increasing magnitude and frequency for irrigated agriculture, domestic consumption and urban industry. (WB, 2002). In the basin of River Hai, 40% dab out 4000 km of watercourses dried up and 194 natural lakes and depressions with a total area of 6.67 km 2 disappeared (Wang *et al.*, 2000). The water flow from the river to the ocean dropped out from an annual average of 24 billion m3 in the 1950s to 1 billion m3 in 2001(Xia *et al.*, 2007). Insufficient local water resources and reduction of water quality due to the increasing population has increasingly severe the situation. Three major factors associated with the scarcity issue are Urbanization, rapid economic development and uneven spatial division of water resources (Jiang, 2009). Overconsumption of water resources has endangered life on the planet and led to dire and unpleasant consequences, such as salinity intrusion, ground subsidence, and ecosystem deterioration (Changming *et al.*, 2001). Meanwhile, poor water quality contaminated because of overpopulation further aggravates the lack of water availability in water-scarce areas (Liu & Diamond, 2005; Z. Zhu *et al.*, 2002)

Insufficient treatment and wastewater discharge is the basic cause of water quality degradation in China. Quality-related water meagerness is triggered by poor water quality that does not care monetary utilization instead having less amount of water available (Wu *et al.*, 1999). Degraded water is the root cause that leads to quantitative insufficiency of the naturally available freshwater which is much more alarming for China's socio-economic development.

Arid and semi-arid areas are more prone to the impacts of climate change especially fresh water resources. These areas were having huge irrigation systems like United States on western sides, China, Pakistan and India. These areas cannot be only rely on natural rainfall especially in the current climate change phenomenon which has reduced the precipitation to dreadful level and increased the drought periods. While in those arid and semi-arid areas where the irrigation system is minimal, agriculture practices are highly risky and causes extensive losses (C. Brown & Lall, 2006). In climate change affected areas proactive measures are necessary to cope with long term sustainable initiatives to enhance the well-being of the communities especially farmers (T. Zhu & Ringler, 2012).

Analysis by (Jenkins *et al.*, 2009) in United Kingdom shows that the climate change has enormous impacts on precipitation and water availability. That implies a major challenge for their regulatory bodies. These analysis has shown a major reduction in rainfall over the years of 1961 and 2006. While the amount of precipitation has increased in winter seasons. Another model projection of rainfall by (Giorgi *et al.*, 2008) and the UKCP09 regional projections (Murphy *et al.*, 2009)) shows the trends will linger in future. The models also shows the unpredictability of weather patterns in which there would be possibility of wet summer in upcoming years. In addition the runoff will also having the same trends for surface water and ground water (Sanderson *et al.*, 2012).

By 2025, South Africa will be a country physical water scarcity as it has remained fresh water sources below 1000m3 per person. With continuous exploitation and wastage, the pressure would be increased on the available resources and stress would lead to conflicts and scarcity in the region. Like the majority of the world, South Africa did not expanded its water resources. Study carried out by (Enright, 2000) suggested possible solutions. Initially the improving and management of demand system was carried out which will enhance the efficiency of water for accessible to more population. Next is the identification and developing of substitute system for water supply which will increase the quantity in the water system. Third is the improvement of water quality to the standards. Fourth is the distribution of water on the basis of equity. Fifth is the transmission of excessive water to scarce areas.

Most of the Khyber Pakhtunkhwa people rely on the agriculture and associated activities as their livelihood resource. Livelihood of these people have been hardly affected by the recent changes in weather patterns and unpredicted precipitation (Ahmad *et al.*, 2017). Keeping in view the climate change phenomena, there is a dire need for the adaptation of climate change to sustain the livelihood of the region (Israr *et al.*, 2020).

2.6 Water Management and Conservation

In modern times, water management and creating long-lasting sources of water is not only a thought in water-scarce regions or specific agricultural areas, but it's been an international issue for all sectors and regions. The fact cannot be denied that, Imbalances between availability and demand; degradation of surface and groundwater quality, inter-sectorial competition, inter-regional and international conflicts, are the major issues that need our dire attention to be coped with. (Pereira *et al.*, 2009). The water scarcity would be increased by 2025 and 35 countries of the world will be at absolute water scarcity (Engelman & LeRoy,

1993). There are a wide number of causes that are contributing to water scarcity and water stress. Population growth, climate change contribution, industrialization, and exploitation of natural reservoirs are the main contributors to water stress. Population boom; excessive consumption of water in agriculture and industry caused water-demand-graph to cross its elevation. Similarly soon, severe abrupt climate changes may act as an added factor by altering water supplies (Mirza & Ahmad, 2005).

In order to cope with this problem, a range of technological and management practices are adopted to enhance the supply system for urban areas. A range of WDM practices are carried out for sustainable consumption to divert communities' behavior (Savenije & Van Der Zaag, 2002). The main characteristic of this system is to sustainably use and consume water resources efficiently (Brooks, 2002; Deverill, 2001; Tate, 1993). These measures are accepted as the reliable solutions for different social, economic and environmental factors for the security of water systems (White *et al.*, 2007). These measures emphasis on the reduction of supplementary water supplies and waste water management. These tools focuses on the reduction of consumer consumption of water through different mechanisms, supply tools and knowledge. It also directs the individuals to reduce the water usage in their day to day activities and utilize water sustainably (Willis *et al.*, 2011).

To minify the issue of water scarcity India and Turkey have constructed 24 and 64 dams during the last 70 years(Ahmed *et al.*, 2007).). In the quasi-arid and arid zones of eastern and southern Africa small household farms, the usage of rainwater harvesting system is introduced which saves the rainwater in sub-catchment areas and improved productivity (Rockström, 2000). Small farmers in arid and quasi-arid regions of Kenya uses indigenous soil and water conservation (ISWC) strategies to decrease the runoff of water and soil losses. In this method they use trash lines and stone lines spaced about 15 m apart across the slopes which results in control of surface water runoff in rainy seasons. This helps in the recharge of the aquifer and better crops production (Wakindiki & Ben-Hur, 2002)

In Southeastern Tunisia a commonly applied practice of water harvesting technique uses the Jessr, in which runoff water from the micro catchments is collected on a terrace to increase the availability of water and recharge of the aquifer during the dry seasons (Schiettecatte *et al.*, 2005)

(Coombes, 2012) carried out a study for South East Queensland to examine the integrated system approach by studying the performance of water cycle management. Aim of the study was to develop understanding of different strategies for rain water harvesting indigenously. The system was matching the analysis approaches of Victorian government's Living Melbourne Living Victoria policy and for the Board of Sydney Water Corporation. The study was carried out to analyze the demographics, water systems, sewage and environmental factors. Lot scale input was used as the basic element which works on system behavior and spatial performance. 3 working mechanisms were used for the system which includes;

- "Sources - Regional and local water sources, catchments and waterways''
- "Flux – transport and treatment of water, sewage and storm water throughout the region''
- "Sinks – Storm water runoff and wastewater disposal to waterways"

The system was secured by framework of infrastructure, demand nodes, discharge points and system model.

In Australia, water planners have recognized a simple three-part sequence to characterize the developmental phases of water resources. The initial phase applies to pre-industrial societies where water is considered as a free gift and availability is very easily. The next phase is distinguished by the active water exploitation of the construction of dams for hydropower and irrigation and inter-basin transfer from better-endowed regions to nearby dry region. The final mature phase has close to the maximum attainable level of stream flow regulation n major river basin the costs of further water resource development and management increase rapidly and attention turns to non-conventional techniques to enhance supply (smith) for Australia. Owing to our small population base and a relatively short history of settlement, the arrival, and recognition of the mature phase has been much more recent than for most countries. But the 1980s heralded a sea-change in water resources planning so that changes in water policy over the last two decades have, arguably, eclipsed that of the preceding 90 years(Hussey & Dovers, 2007). As a consequence, the sustainable management of urban water has become imperative, in particular for countries which are more liable to extreme droughts such as Australia. Unfortunately Australia receives the lowest possible annual rainfall of all continents- where life is possible- and is experiencing strong population growth in urban areas (Birrell *et al.*, 2005).

The current situation of Pakistan water resources indicated that it is about to be in an absolute water scarcity. There is a hap hazard situation amongst the institutions and government. The continuous reduction in water supplies, reduction in rainfall, least management of water resources, and reservoirs have highlighted the chronic nature and importance of the subject. The development and adaptation of conservation practices is the dire need of the day (Kahlown & Majeed, 2003).

Numerous other techniques are also used in urban areas for water conservation and utilization. These include restrictions on use, installation of water-saving devices, metering, horticultural changes, pressure reduction, reuse, and public education.

Current modern gadgets like computers and mobiles are tending to make it easier for the management and household activities to get a grasp over more accurate and useful information accessible to every common individual(Atzori *et al.*, 2010) The easily available information revolutionized the current irrigation system and made it more feasible for a common man. These revolutionary advancements has the power to change the fate of agricultural system boosting the consumer utility relationships with information relating to the excess and deficit of water level (Boyle *et al.*, 2013)

The climate change phenomenon has disturbed human life in different ways associated with the consumption and management of water system. Society needs to adopt changes in many ways, new forms of living and working will replace the old remote ways through all over the globe. In order to cope with new social and climate change, there might be advent of new scientific disciplines and awareness programs to meet the new and revolutionary ways of modern irrigation system (Shove, 2010)

2.7 Water and Water Scarcity in Pakistan and Khyber Pakhtunkhwa

Sustainable conservation and proper utilization of fresh water while protecting the ecological system is one of the important challenge for 21st century. The increase in demand and less supply of water has pressurize the whole world and put major parts of world under scarcity. New approaches are required to satisfy human needs, manage and provide water for ecosystem health, agriculture, social and political stability. Extensive work is required to keep the ecosystem healthy, provide water to human and conserve the natural system. In this regard reduction of consumption by household needs determined approaches (Postel, 2000).

Pakistan is the county having one of the largest irrigation system in the world. Having capacity of 20 billion cubic meters covering 16.6 million hectare of land. It has 45 main irrigation canals, 23 barrages, siphons and head works. It is considered as the only sector of the country covering about one quarter of the GDP. However in recent years due to high demand and less supply the crop production is reducing at extensive level which by 2011 was 11% reduced and by the year 2025 reach to 31%. Per capita of water availability is reduced to 1000m3 which was once 5600m3 in 1947. Keeping in view the gap between supply and demand the country is about to be having shortage of food by70 million tons in 2025. The reasons for the scarcity may include obsolete irrigation system, aquifer mining, less reservoirs, low water productivity, and underutilization of dry land, reduction in water quality, pollution and awareness amongst the masses. To cope these circumstances a higher political commitment and well is needed (Ashraf, 2015).

In Pakistan, Indus River is the mightiest of all coming from the foothills of Himalayas region. River Kabul along with their 6 tributaries collects to the Indus basin collectively comes across 4 countries and meeting the needs of 215 million population. Due to demand from each country the river is going to be having high pressure in the next few years (Fazilda, 2017). While on the other hand River Kabul emerges from Hindu Kush region, flows through Afghanistan and then enters Pakistan where it is augmented by River Punjkora and river swat before it joins the mighty Indus River (Imran et al., 2018). The river Kabul is vital to provide water for irrigation, drinking and other purposes to about 2 million masses of Khyber Pakhtunkhwa province. It also provide about 250 megawatt power at warsak Dam. This river supplements the Indus River with 20-28 million acre feet of water (Kakakhel, 2017). It also recharge the aquifer of many districts of Khyber Pakhtunkhwa where majority of the population in these areas rely on own wells and underground water sources (Imran et al., 2018).

While in the Khyber Pakhtunkhwa province majority of the population in the urban areas have lack of access to safe drinking water. The population rely on tube wells and bore wells which are contaminated by different pollutants from the surrounding areas i.e. poor sewage system, toilets and percolation of contaminated water (Khan et al., 2013).

2.8 Water Management in Pakistan and Khyber Pakhtunkhwa

Pakistan lacks the proper planning while considering the water issues and trajectories. No planning has been made and worked to construct new dams where it is blessed with major

rivers. The population being the most ignorant, government being the less progressive and not bothering with the importance of such issues, a continuous pollution of these rivers and lakes is on the way. This implied a huge deterioration on the health of masses, contaminating the aquifer and destruction of fish inhabitants. Government is always investing on non-developmental projects and reconstruction of infrastructure. Billions of rupees has been invested in rehabilitation of flood affected areas. In addition billions are investing on health while not considering the root causes. On the other hand population has increased manifolds in recent decades (Amin & Malik, 2019).

Chapter 3

RESEARCH DESIGN

3.1 Rationale of the Chapter

This chapter explains the methodology used for the conductance of the research thesis. This may include nature and procedure of the study, Universe of the study, the methodological frame work, sampling method, sampling size, sampling population, data analysis tools, delimitation of the study and ethical considerations.

3.2 Nature and Procedure of the Study

The nature of the study was both quantitative and qualitative. The results are both in statistical and descriptive form. The study investigated the changing patterns of water availability in district Dir Lower and way forward for the sustainable water management in the district. The study assessed the changes that has occurred in water supply and demand due to different environmental and anthropogenic factors such as climate change, changes in population dynamics, deviations in built and natural environment, and water consumption and conservation. . The study area was selected because it was once a water abundant but are now facing water scarcity. Since last decade, the district is facing severe water shortage due to erratic rains accompanied by reduction of water in both surface and underground aquifers, natural springs are disappearing, low flow in River Punjkora manifold increase in water consumption . Keeping in view the objectives of the research, various questionnaires were developed for random survey from communities, Focused Group discussion will be carried out with communities facing the water scarcity issues and Semi structure interviews w conducted with different officials from relevant departments. The quantitative data was analyzed through SPSS while qualitative data was analyzed through descriptive analysis techniques. The statistical data results were presented in graphs while that of qualitative data in descriptive form.

3.3 Introduction to the Study area

Dir lower is located in Province of Khyber Pakhtunkhwa in Malakand Division with coordinates 34.9161° N, 71.8097° E. The District has boundaries in North with District Upper Dir, North West with Afghanistan, East with District Swat, West with Tribal District Bajaur and South with District Malakand. It has population of 1,435,917 people in 2017

while 1583 square kilometers area covered (Pakistan, 2018). The district is dominated by the mountains and hills of southern Hindu Kush ranges. In the north the mountains are much high, reaching up to 3000 meters. In the south the height shows rapid decrease and at the juncture of river swat and Panjkora, it is just 600 meters. These ranges have been deeply cut by rivers, streams with flood plains. Most of settlements are situated in valleys. Agriculture is practiced on the flood plain. However; in hilly areas terrace agriculture is also practiced.

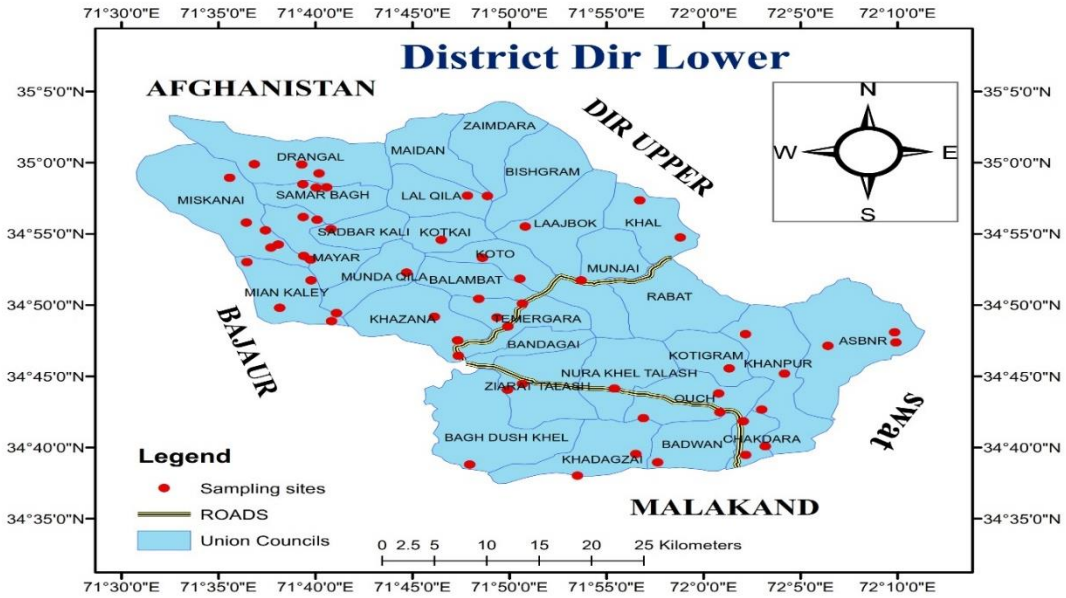

Figure 3.1 UC map of District Dir lower containing sampling sites

3.4 Methodology

Mixed method research was adopted for this study. Mixed method research integrate both quantitative and qualitative research methodologies. For the purpose of this study both qualitative and quantitative data was collected and analyzed. Quantitative data was collected through closed ended questionnaire from the community randomly to identify water scarcity hotspot in the district. Then Focus Group Discussions were conducted in those places where people were facing from moderate to severe water shortage in the district. Moreover, Semi structured interviews were then conducted from the government officials in the district.

3.4.1 Sampling

The population of interest is usually too large to evaluate and survey them all. So in order to answer the research questions there is need to select a sampling technique to reduce the number of cases. (Taherdoost, 2016). To achieve the target both random and non-random

sampling techniques were used. For questionnaires, probability cluster sampling has been used ensuring equal opportunity of participation to all population of the district that is scattered along long distances occupying both semi-urban and rural spaces. . Population was first divided in to household levels which incurred about 155,338. For administrative purposes the district is divided into 7 Tehsils, so the sampling was obtained by randomly including members from all the tehsils—involving both the semi-urban and rural population in each tehsil of Dir lower. Non-probability Quota sampling technique was also used to purposely identify suitable respondents for key informants survey and focus group discussions. This helped to reach the most relevant part of the community for FGDs and most relevant officials in different Line departments concerning water availability and management in the district.

3.4.2 Sample Size

Sample size is generally carried out to get a random number from the population which respectively high in ratio. It reduces the errors and biases (Taherdoost, 2017). In order to get the sample size from such a diversely spread and large population, Sample size calculation formula was used with 95% "confidence level" 5% "Margin of Error", z-score 1.96 and population of household with 155,338.

$$\text{Sample size} = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)}$$

Where N = population size, e = Margin of error (percentage in decimal form), z = z-score (Rea & Parker, 2014)

Hence utilizing this formula, a sample size of 384 respondents was enough to conduct this study. Such a high sample size increased the accuracy of the data while reduce margin of error in the analysis.

3.4.3 Data collection tools

Depending on the nature of the required information, both primary and secondary data was collected from the relevant sources. A wide range of instruments have been used to collect

data from target population i.e. Questionnaire, Key Informant interviews, Focus group discussions, Reports, books, articles and internet sources.

3.4.4 Primary data

Primary data was collected from the residents of the district Lower Dir. A total of 384 questionnaires were filled from individuals in all the 7 tehsils. Key informant interviews were conducted with the official personnel from relevant departments. Focus Group discussion sessions were arranged with different homogenous groups i.e. farmers, youth, old age groups. In addition, statistical data was also collected from different departments regarding their activities: including data about their perception on water related problems in the district as well various projects they are conducting or planned to conduct for water management in the district. .

3.4.5 Secondary data

All the relevant data regarding the topic and study area were collected from the existing sources. These sources included annual reports, journal articles, thesis, lectures, newspapers, books and internet. The required images were downloaded from relevant sources.

3.5 Data interpretation and analysis

As both qualitative and quantitative data was collected during the research. Hence, each data was analyzed accordingly.

3.5.1 Qualitative Data Analysis:

Qualitative data that was collected from FGDs and SSIs was analyzed utilizing the thematic analysis. It is the processes of identifying patterns in the data and then presenting it in a summarized form. The qualitative data was first coded i.e. a codes are a words given to major themes or titles that were identified in the data. The coding process was followed by identifying patterns and connections in the data. This step focused on identifying the most common answers and narratives from the official and community members to particular questions that were relevant to the research objectives. For example, establishing connection between population growth and increase in water consumption leading to water scarcity. Hence, clear themes in the data emerged which were then defined and analyzed thoroughly. Finally, the results were presented in summarized form addressing the research objectives.

3.5.2 Quantitative data analysis:

Quantitative data that was collected through questionnaires randomly from the population was analyzed through SPSS software. The data was coded with different values assigned. Then frequency distribution analysis was run to generate the frequencies and percentage of the responses for each question. These were presented thoroughly in tables and Bar graphs to show the exact responses of the respondents. At the end these graphs and tables were put in to the analysis chapter for detailed discussion.

3.6 Ethical Consideration:

We take a great care regarding ethical consideration during collection of research data. Every time when we visit to area our focus was on both male and female but due to our culture. Other thing which we think ethically means a lot is hope, we were not giving hope to anybody that we are working on this and the government will give you funds or will work immediately for you people. We simply told them that we are students and conducting our research so for that purpose we are collecting data. Furthermore we sit with people of locality talk to them in very polite manner and make a friendly environment with them so that they share their information. Our focus was on elders and literate people because they have more information. That was very good moments we enjoyed a lot because we sit and talk to many type of beautiful and nice people.

3.7 Delimitation:

The study is delimited to the study area on the subject assessing the changing patterns of water availability and adaptation to water scarcity through sustainable water management in lower Dir. The data was collected to assess the changing patterns of water availability on household level as well as for agriculture activities.

Chapter 4

DATA ANALYSIS

4.1 Rationale of the Chapter

This chapter elaborates the primary data that was collected through Questionnaires, Semi structure interviews and Focus group discussion. The already available data from different departments i.e. Pakistan Metrological department is added accordingly. The provided statistics regarding different areas will also be evaluated for the strength of arguments. The data is converted into Figures and tables and presented in form of tables as well as in description approach. Data has been analyzed and interpreted with help of SPSS and presented in simple way to obtain understandable results.

4.2 Demographics of the Study area

The district lower Dir is the southern part of the Dir region situated on the North West of the province. It is spread over an area of 1598 square kilometer, around2% of the total area of Khyber Pakhtunkhwa. The demography of District Dir lower includes population data, age groups of the respondents, family members, type of family and socio economics of the respondents.

4.2.1 Population Data

Administrative units	Household	Male	Female	All sexes	Population 1998	Sex ratio 2017	Average Annual Growth rate
District Lower Dir	**155,338**	**710,335**	**725,576**	**1,435, 917**	**717,649**	**97.90**	**3.71**
RURAL	150,723	689,443	706,096	1,395, 544	673,314	97.64	3.90
URBAN	4,615	20,892	19,480	40,373	44,335	107.25	-0.49

Table 4.1 District Census report 2017

According to Census report 2017, lower Dir has population of 1,435,917 persons which includes 710,335 male, 725,576 female and 155,338 households. The district has average annual population growth rate of 3.71%. (Pakistan, 2018).

4.2.2 Age group of the respondents

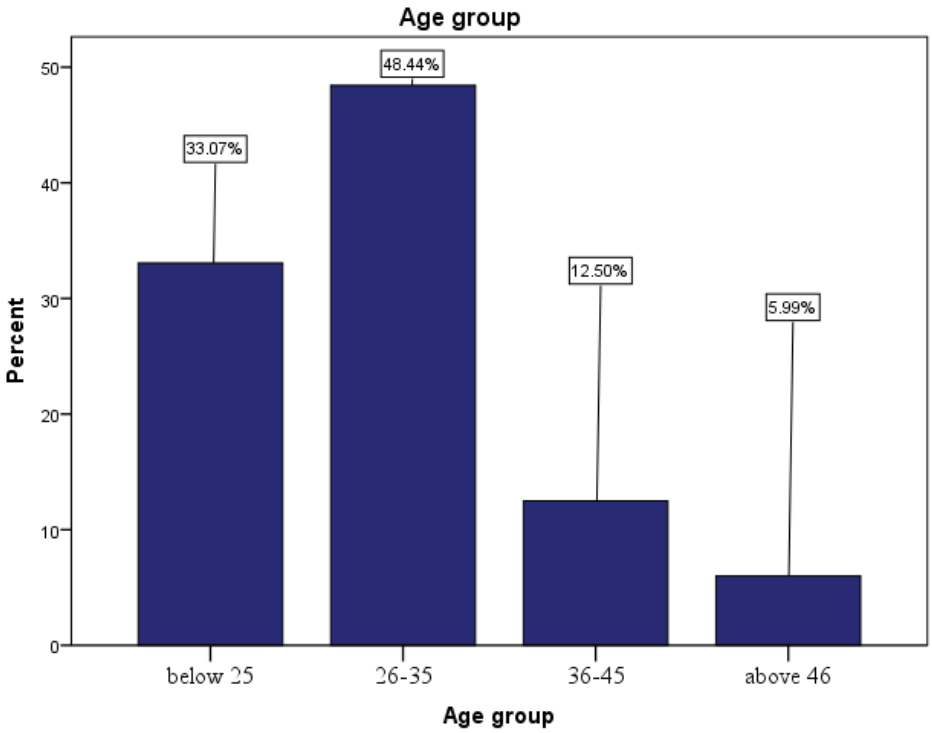

Figure 4.1 Age group of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	below 25	127	33.1	33.1	33.1
	26-35	186	48.4	48.4	81.5
	36-45	48	12.5	12.5	94.0
	above 46	23	6.0	6.0	100.0
	Total	384	100.0	100.0	

Table 4.2 Age group

Table 4.2 defines the age group of the respondents that were involved in questionnaires data collection. In the total questionnaires of 384, 33% of the respondents were below the age of

25. 48.4% respondents were between the age ranges of 26 to 35. 12.5% were in the middle of 36-45 and 6% of the respondents were above the age of 46. All the respondents belonged to the district Lower Dir in which almost 87% were male while 3% were included female.

4.2.3 Family type of the respondents

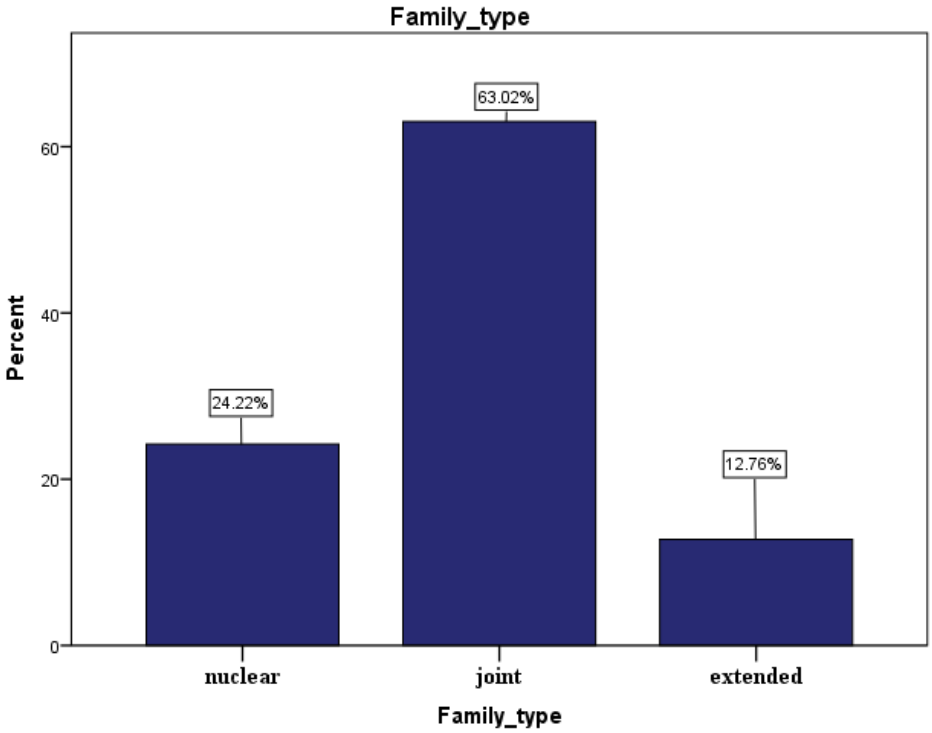

Figure 4.2 Family Type of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	nuclear	93	24.2	24.2	24.2
	joint	242	63.0	63.0	87.2
	extended	49	12.8	12.8	100.0
	Total	384	100.0	100.0	

Table 4.3 family type

The above table 4.3 shows the family type of the respondents in the district. 24% of the people lives in nuclear family having up to 5 members includes parents and children. 63% of

the people lives in joint families which is the higher trend of this society. Being the less developed district and having remote areas, 12.8% population of the district lives in extended families in houses having up to 45 members per household or more.

4.2.4 Family Members

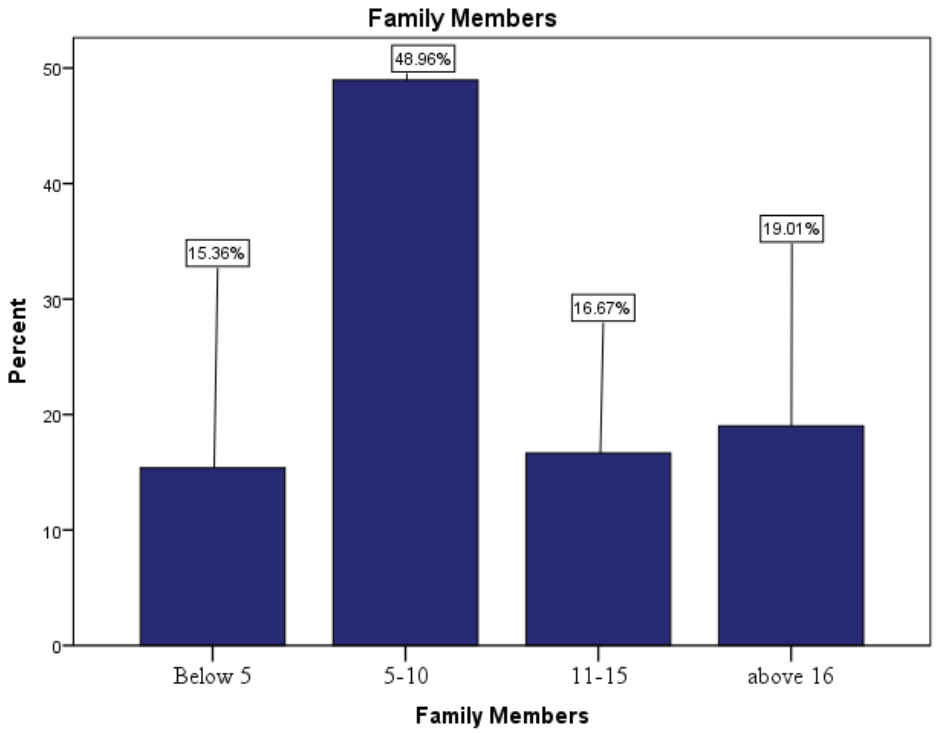

Figure 4.3 family Members

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 5	59	15.4	15.4	15.4
	5-10	188	49.0	49.0	64.3
	11-15	64	16.7	16.7	81.0
	above 16	73	19.0	19.0	100.0
	Total	384	100.0	100.0	

Table 4.4 family members

In table 4.4 were the number of family members in household level. 15% were below the total of 5 members. 49% were between the ranges of 5-10 members. 16% were amongst 11-15 members while 19% of families lives above the ranges of 16 members per household.

4.2.5 Socio Economic status of the respondents

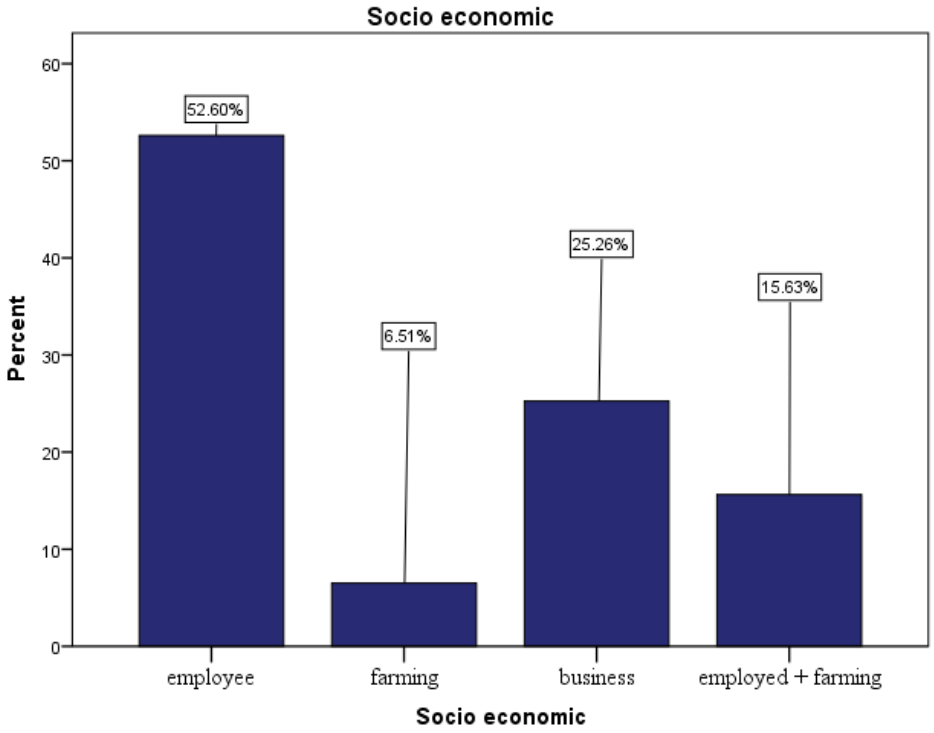

Figure 4.4 socio economic condition of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	employee	202	52.6	52.6	52.6
	farming	25	6.5	6.5	59.1
	business	97	25.3	25.3	84.4
	employed + farming	60	15.6	15.6	100.0
	Total	384	100.0	100.0	

Table 4.5 Socio Economics

The above table 4.5 shows the socio economic condition of the families in the district. It discloses that 52.6% of the people are linked with the jobs that may be government or non-government as well as in foreign countries i.e. Gulf. Only 6.5 % people are attached with farming. 15% of the population are engaged in different business of their own or with partners. While 15.6% of the population is surviving with multiple economies like having

jobs and business, jobs and farming, or businesses and farming. Most of the people belongs to middle class having average socio economic conditions.

4.3 Water availability

4.3.1 System of water for daily usage

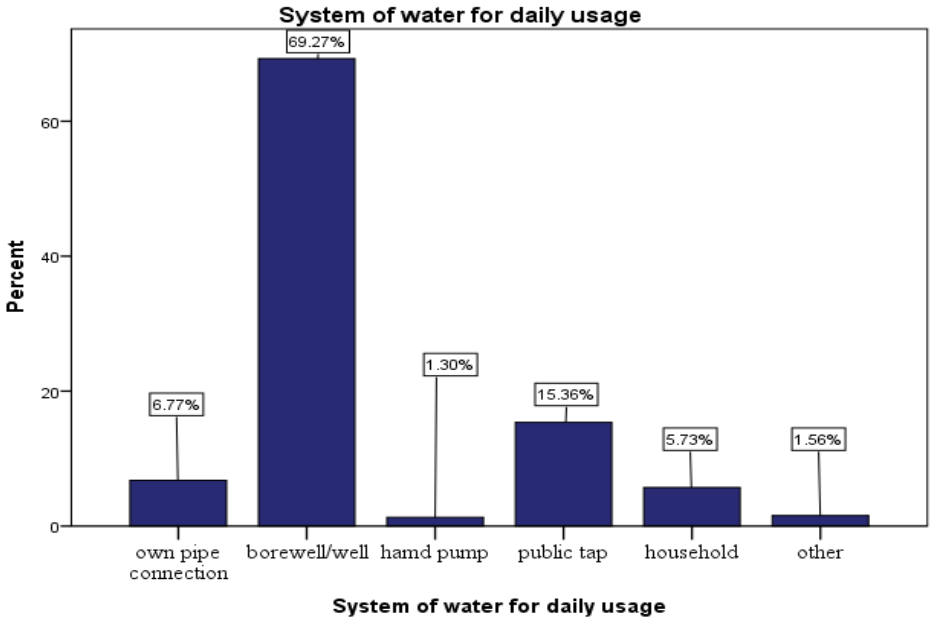

Figure 4.5 system of water for daily usage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	own pipe connection	26	6.8	6.8	6.8
	bore well/well	266	69.3	69.3	76.0
	hand pump	5	1.3	1.3	77.3
	public tap	59	15.4	15.4	92.7
	Household	22	5.7	5.7	98.4
	Other	6	1.6	1.6	100.0
	Total	384	100.0	100.0	

Table 4.6 System of water

The above table 4.6 shows the system of water people use for daily usage at household level. There were multiple responses from the respondents that 6.8% population has installed their

own pipe connection. That connection is from community water tanks, springs and torrents. 69.3% of houses contains bore well or simply dug well in their houses as there is no other option for them to get water from other near source. Only 1.3% of the population rely on Hand pumps and get their water from these sources as they have no access to public tab, or community tube wells. 15.4% of the population get their water from public taps that are provided by government through tube wells and large water tanks in the villages. 5.7% of the population receives their water from the community wells or tube wells and water is supplied. While 1.6% of the population has no access to household water supply and they get their water from springs, torrents, river with gallons or containers etc.

4.3.2 Management of water system

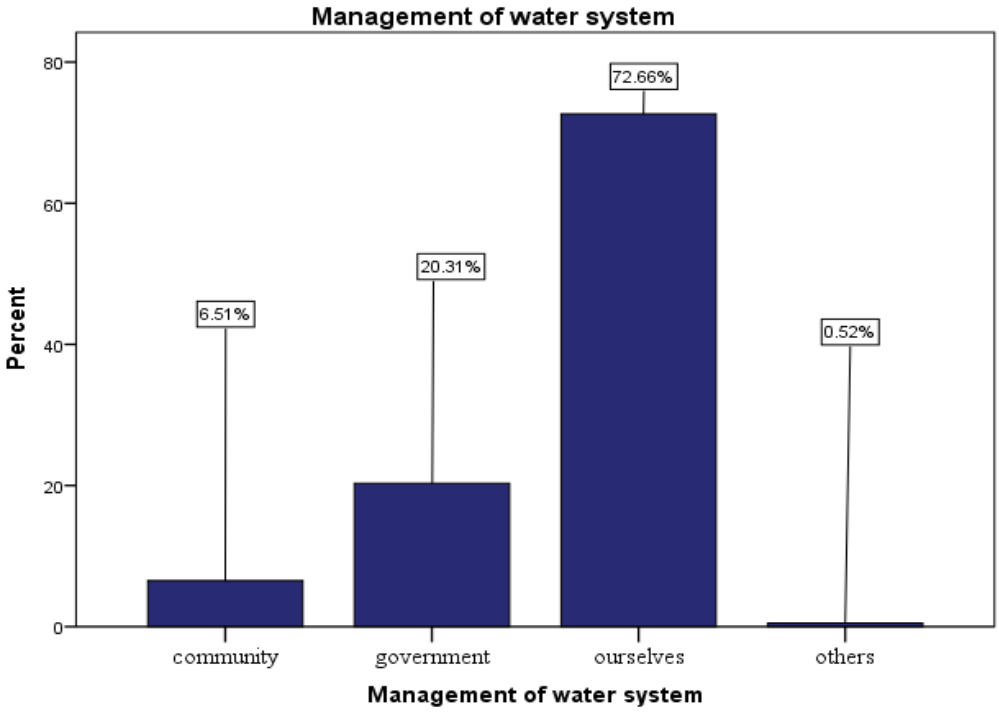

Figure 4.6 Management of water system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	community	25	6.5	6.5	6.5
	government	78	20.3	20.3	26.8
	ourselves	279	72.7	72.7	99.5
	Others	2	.5	.5	100.0
	Total	384	100.0	100.0	

Table 4.7 management of water system

Table 4.7 elaborate the management of water system, which shows that 6.5% of water systems are managed by the community itself in the form of community committees. These are the wells or tube wells which are owned by community itself. 20.3% water schemes are managed and sustained by the government departments such as Tehsil Municipal administration (TMA's) and Public health Engineering Department (PHED). Amongst the 7 Tehsil municipal administration only 2 TMA's are owning tube wells that are TMA Timergara has 21 Tube wells providing water to 3300 households and TMA Balambat owns 3 tube wells providing water to 1008 households. 198 water supply schemes are managed by PHED in the district.

4.3.3 Water System sufficiency

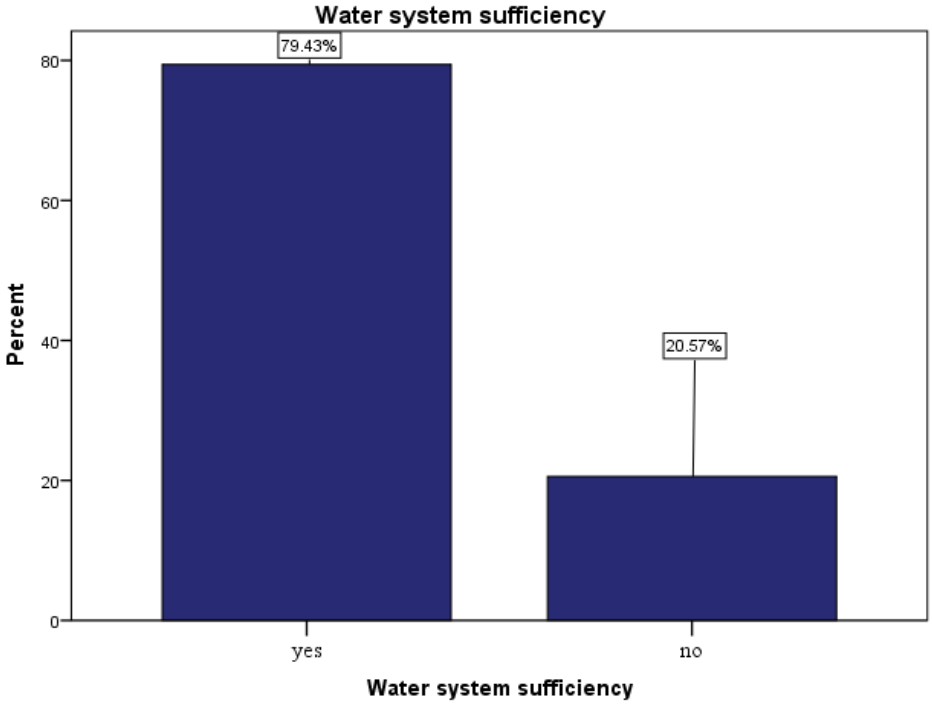

Figure 4.7 water system sufficiency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	305	79.4	79.4	79.4
	No	79	20.6	20.6	100.0
	Total	384	100.0	100.0	

Table 4.8 water system sufficiency

Based on the statistics in table 4.8, almost 80% of the population has access to sufficient water resources based on their daily consumption. While less than 20% population don't have access to sufficient water for their domestic use. They faces issues of accessibility to water sources, depletion in water table and least storage capacity at household level.

4.3.4 Distance of water sources

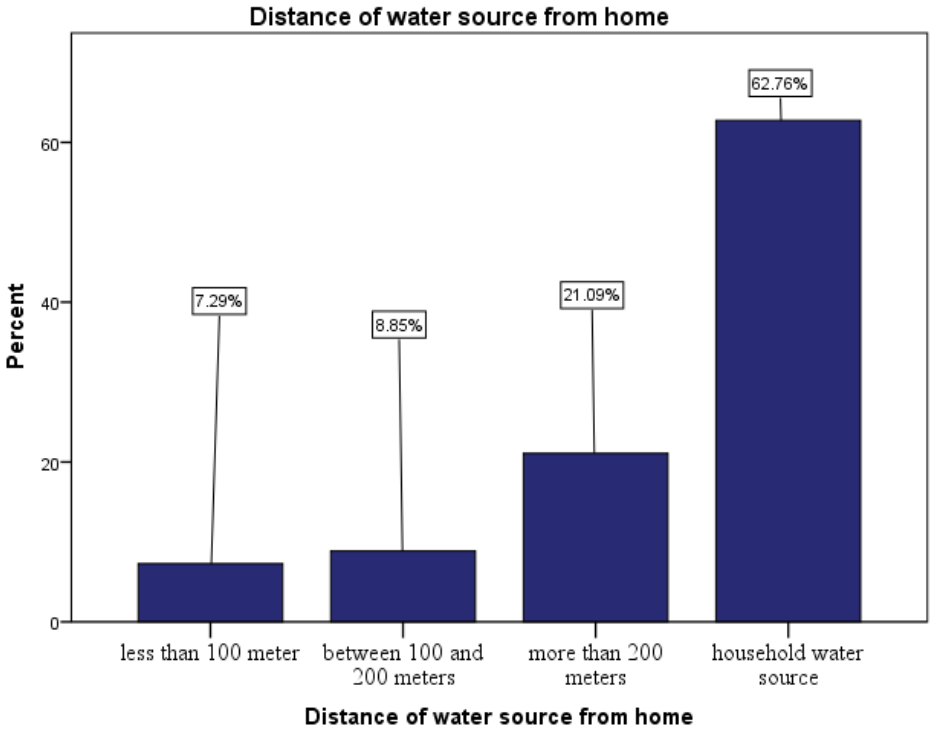

Figure 4.8 distance of water from home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 100 meter	28	7.3	7.3	7.3
	between 100 and 200 meters	34	8.9	8.9	16.1
	more than 200 meters	81	21.1	21.1	37.2
	household water source	241	62.8	62.8	100.0
	Total	384	100.0	100.0	

Table 4.9 Distance of water sources from home

Table 4.9 shows the distance of water systems from the household. 37% of the houses are distant from the water sources from less than 100 meters to above 200 meters. These sources

may be public taps, community wells, government tube wells, hand pumps or springs and torrents. They distant population brings water through pipes or with gallons and containers. 62% population has pipe connection at household levels as they have wells and bore wells at their houses and they extract water through electric motors.

4.3.5 Methods of water storage at household level

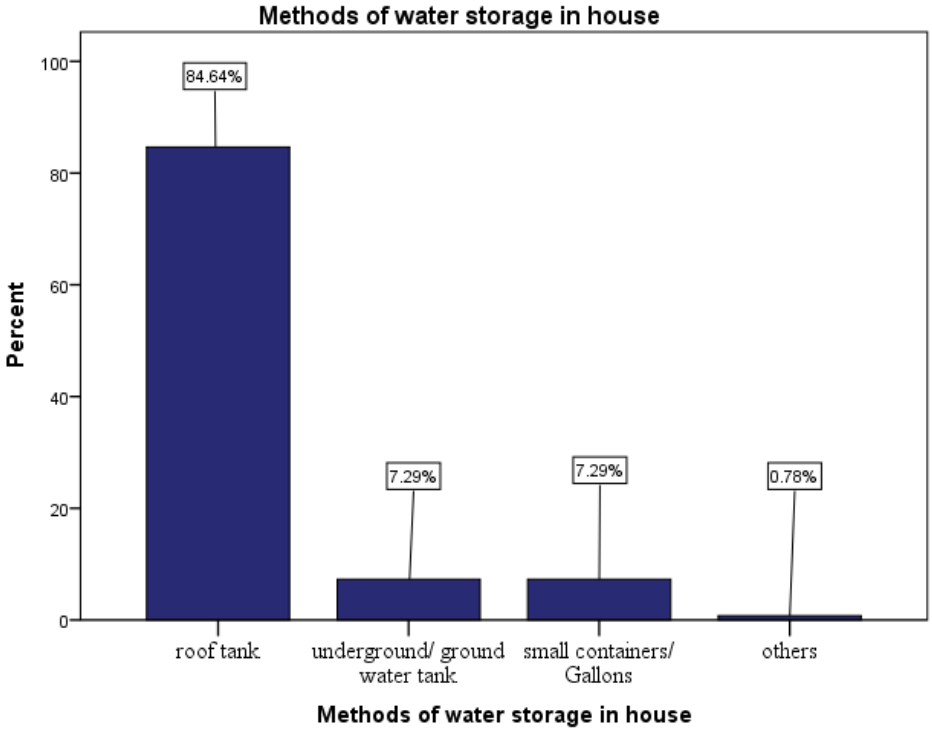

Figure 4.9 Methods of water storage at household level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	roof tank	325	84.6	84.6	84.6
	underground/ ground water tank	28	7.3	7.3	91.9
	small containers/ Gallons	28	7.3	7.3	99.2
	Others	3	.8	.8	100.0
	Total	384	100.0	100.0	

Table 4.10 Methods of water storage

People use various methods to store water for their daily consumption. Above table shows that 84.6% of population use roof tanks to store water that comes from different sources i.e. Tube wells, bore wells, springs etc. 7.3% people store water in the ground or underground

water tanks, these tanks are made because of the water pressure which may not reach the roof top. 7.3 % are those who store water in small containers. They brings water from hand pumps, springs or other sources. Mostly they belong to remote areas where water table is quite low and government schemes are not present there. Less than 1% of people use different methods to store water or they do not even store water for daily consumption. They have connections from springs and continuous water supply so they do not store water.

4.3.6. Storage capacity

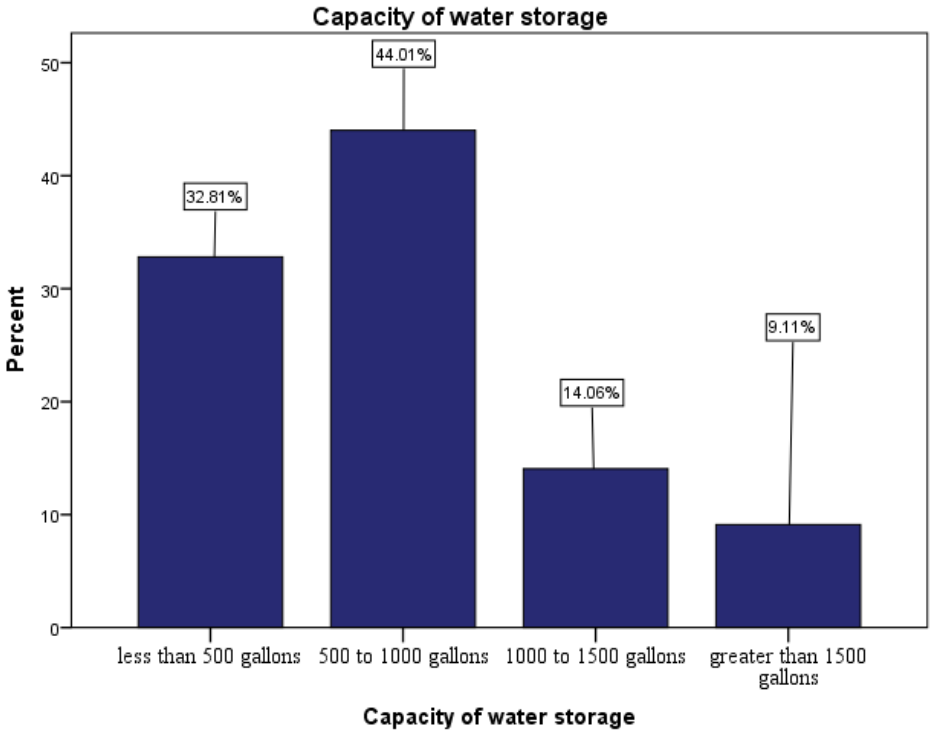

Figure 4.10 capacity of water storage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 500 gallons	126	32.8	32.8	32.8
	500 to 1000 gallons	169	44.0	44.0	76.8
	1000 to 1500 gallons	54	14.1	14.1	90.9
	greater than 1500 gallons	35	9.1	9.1	100.0
	Total	384	100.0	100.0	

Table 4.11 capacity of water storage

People store water by different methods in roof tanks, underground tanks, small containers and gallons for daily consumption. The capacity of these storage systems range from less

than 500 gallons to more than 1500 gallons respectively. Table 4.11 illustrates that 32% population have less than 500 gallons capacity of water storage, 44% ranges from 500 to 1000 gallons, 14% have capacity between 1000 to 1500 gallons while only 9% people have water storage capacity more than 1500 gallons.

4.3.7 Storage sustainability in recession period

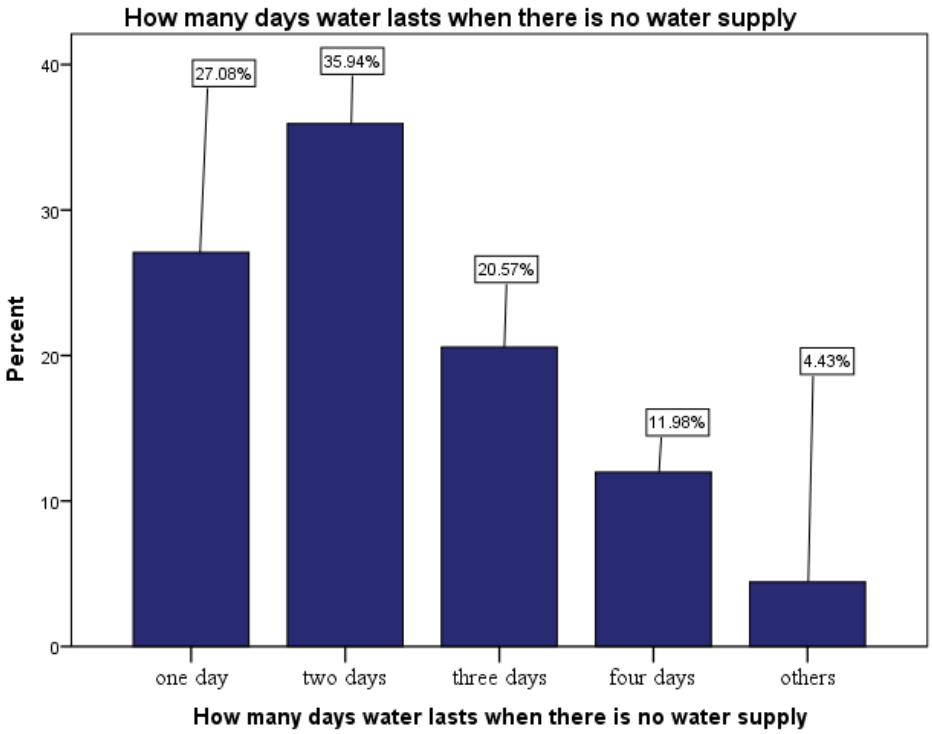

Figure 4.11 water storage sustainability in recession period

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	one day	104	27.1	27.1	27.1
	two days	138	35.9	35.9	63.0
	three days	79	20.6	20.6	83.6
	four days	46	12.0	12.0	95.6
	Others	17	4.4	4.4	100.0
	Total	384	100.0	100.0	

Table 4.12 Storage sustainability in recession period

Table 4.12 shows the sustainability of water in recession period that how many days water storage lasts when there is no water provision. Amongst the population different opinions

were put according to their family members and storage capacity. 27% has argued to lasts their stored water for only one day when there is no water provision. Almost 36% survive with 2 days, 20.6% with 3 days 12% with 4 days while 4.4% have storage lasts up to 1 week or more.

4.3.8. Water provision on daily basis

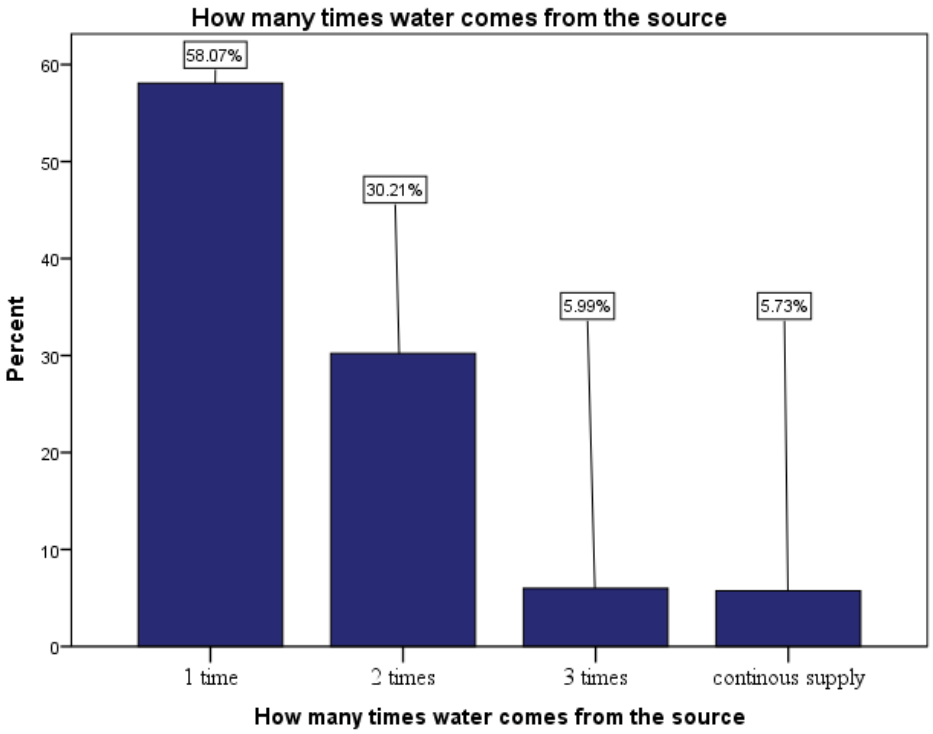

Figure 4.12 water provision from source

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 time	223	58.1	58.1	58.1
	2 times	116	30.2	30.2	88.3
	3 times	23	6.0	6.0	94.3
	continuous supply	22	5.7	5.7	100.0
	Total	384	100.0	100.0	

Table 4.13 Water provision on daily basis

In Table 4.13 the respondents claims the provision of water on daily basis. 58% population is provided water once in a day that may be from the government source, tube well, or bore well

at household. 30% get water twice a day based on their consumption. 6% get it thrice while 5.7% have continuous water supply from springs, community water tanks or other sources.

4.3.9. Water availability

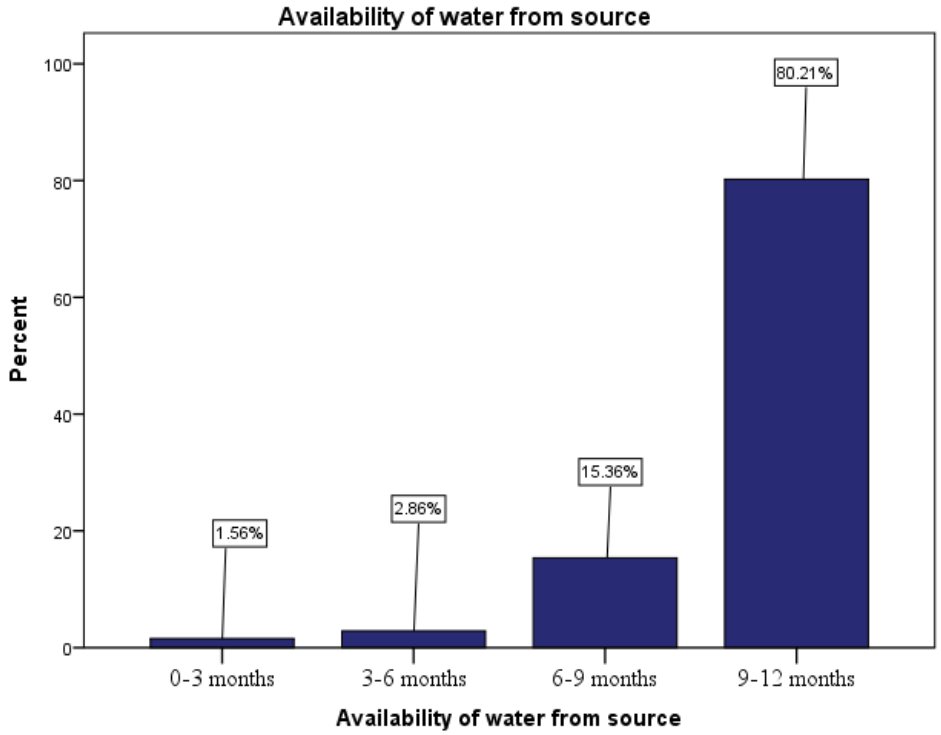

Figure 4.13 water availability from source

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-3 months	6	1.6	1.6	1.6
	3-6 months	11	2.9	2.9	4.4
	6-9 months	59	15.4	15.4	19.8
	9-12 months	308	80.2	80.2	100.0
	Total	384	100.0	100.0	

Table 4.14 availability of water from the source throughout the year

Table 4.14 shows the availability of water for household consumption round the year. Around 1% of population have availability of water for up to 3 months. These may be the areas where they get their water from seasonal torrents or wells which dries in most part of the year. 2%

people have water availability for up to 6 months a year. 15% population has access to about 9 months of water availability while 80.2% people get their water throughout the year.

4.3.10. Consumption of water on daily basis

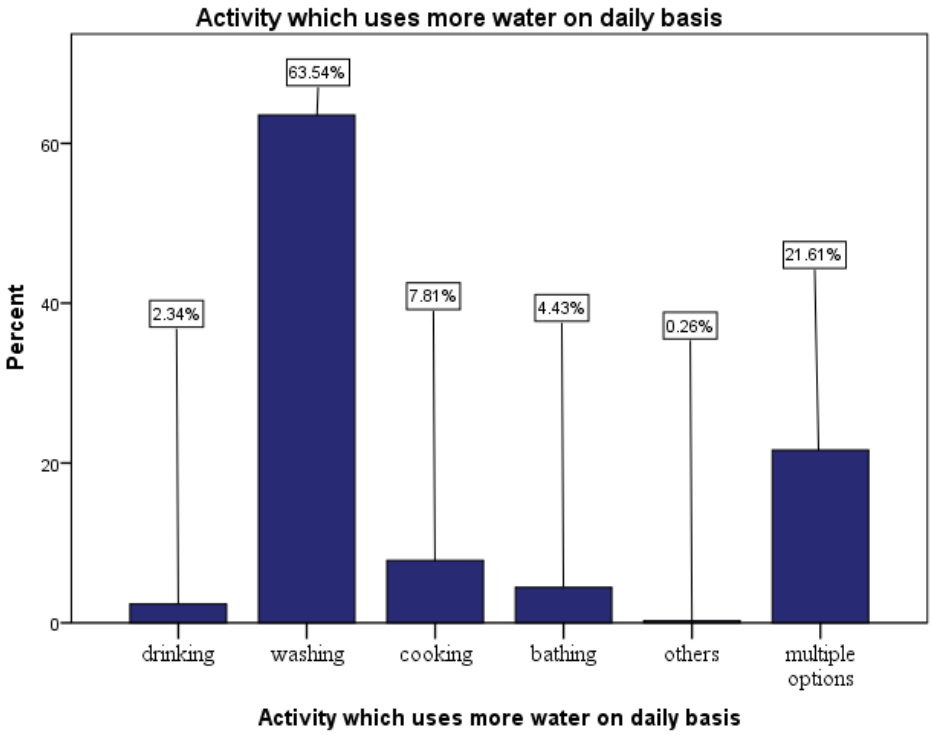

Figure 4.14 activity utilizing more water

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	drinking	9	2.3	2.3	2.3
	washing	244	63.5	63.5	65.9
	cooking	30	7.8	7.8	73.7
	bathing	17	4.4	4.4	78.1
	others	1	.3	.3	78.4
	multiple options	83	21.6	21.6	100.0
	Total	384	100.0	100.0	

Table 4.15 consumption of water on daily basis

Table 4.15 elaborates the perception of people regarding the consumption of water on daily basis. They respond with different opinions. About 2% responded drinking as the higher utilization of water on daily basis. 63.5% says washing consumes more water on daily basis. 7% respond to cooking, 4.4% responded to bathing, less than 1% population has selected the "other" in which they means ablution consumes more water, while 21% have adopted multiple options in their responses.

4.3.11 drinkability of water

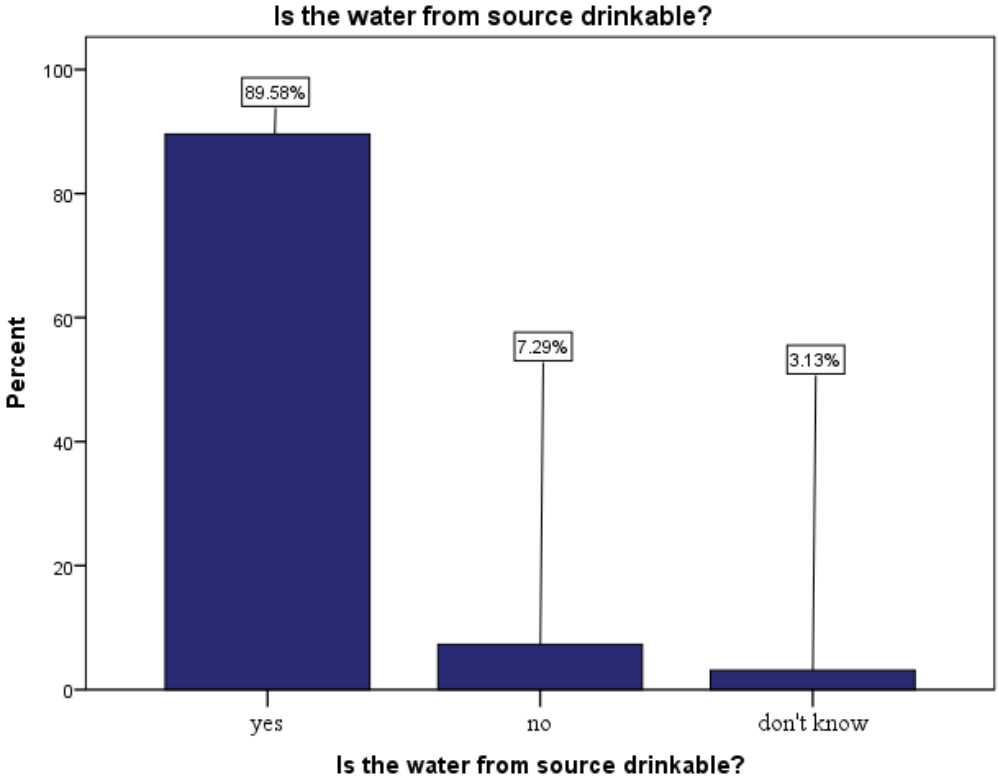

Figure 4.15 water drinkability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	344	89.6	89.6	89.6
	no	28	7.3	7.3	96.9
	don't know	12	3.1	3.1	100.0
	Total	384	100.0	100.0	

Table 4.16 Drinkability of water from the source

The above table 4.16 shows the drinkability of water from the source that are they feasible for drinking or not. About 90% population has shown their satisfaction on drinkability while 7% have not shown their satisfaction regarding water drinkability. Moreover about 3% of population doesn't know about the drinkability of water.

4.3.12 Water quality

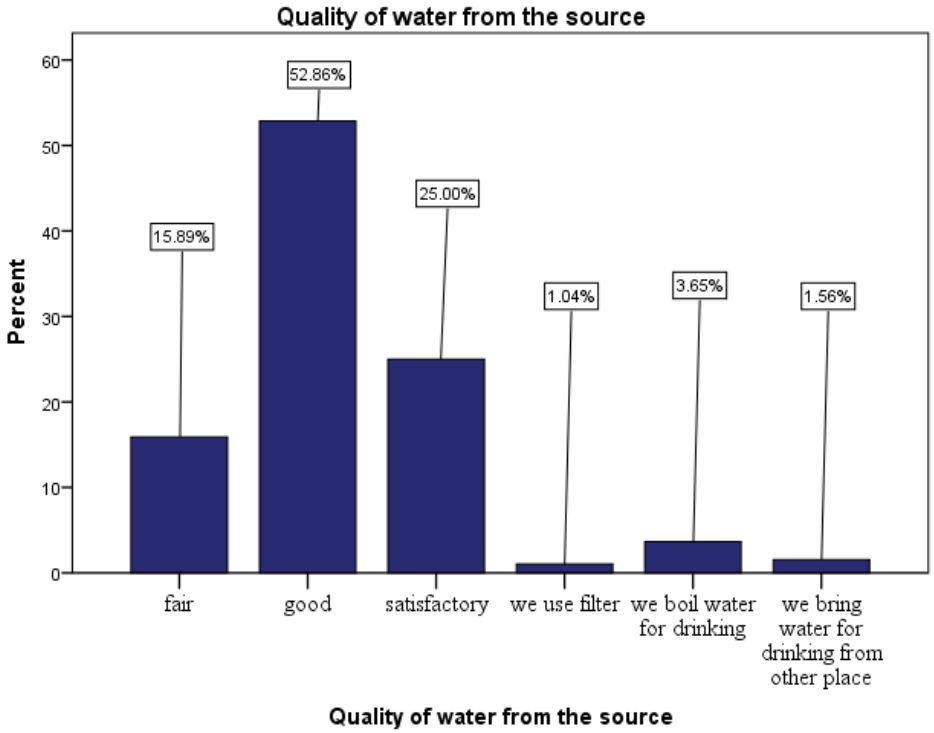

Figure 4.16 water quality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fair	61	15.9	15.9	15.9
	Good	203	52.9	52.9	68.8
	Satisfactory	96	25.0	25.0	93.8
	we use filter	4	1.0	1.0	94.8
	we boil water for drinking	14	3.6	3.6	98.4
	we bring water for drinking from other place	6	1.6	1.6	100.0
	Total	384	100.0	100.0	

Table 4.17 Quality of water

Table 4.17 shows the quality of water as people perceived. About 16% graded the water quality as “Fair”. 52.9% people have scaled it to “Good”. 25% people shown their satisfaction about the quality of water. 1% says they use filter for drinking water, above 3% boil water for drinking while more than 1% brings clean water for drinking from other sources.

4.3.13. Payment for water

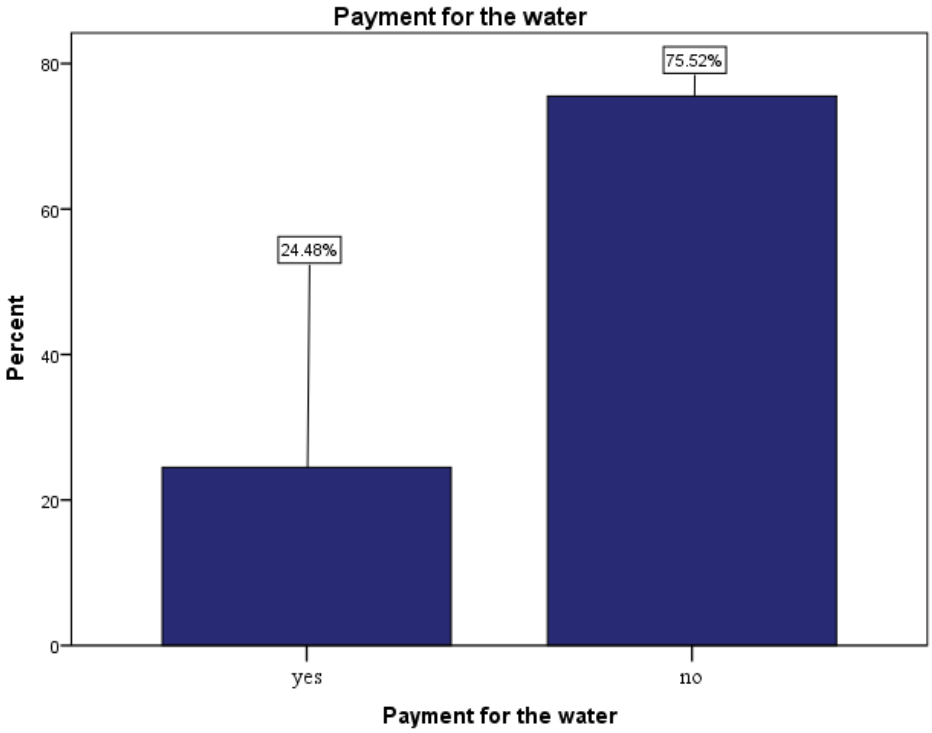

Figure 4.77 Payment for water

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	94	24.5	24.5	24.5
	no	290	75.5	75.5	100.0
	Total	384	100.0	100.0	

Table 4.18 payment for water

Table 4.18 shows that about 24% of people pay for the water. These water are provided by TMA's, PHED or community tube wells. The government organizations get payment quarterly up to Rs.1200 from those households whom they provide water while the community tube wells get less payment because they only get maintenance and electricity cost form the households. 75% of the population does not pay for water because they have bore wells in their houses or brings water from springs and hand pumps.

4.3.14. Alternate source of water

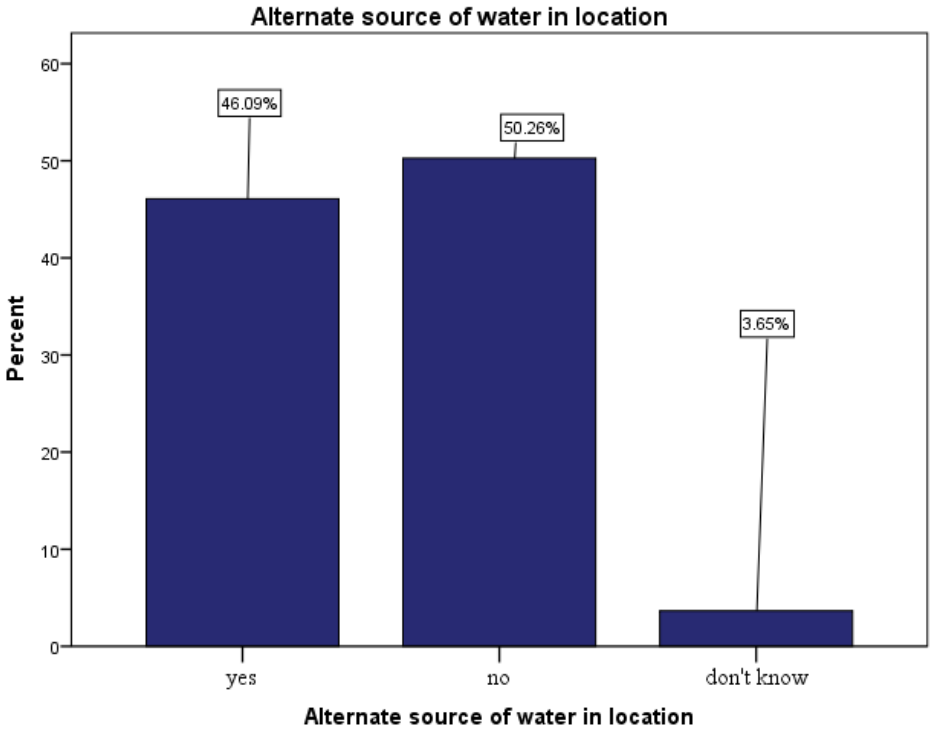

Figure 4.88 presence of alternate water sources

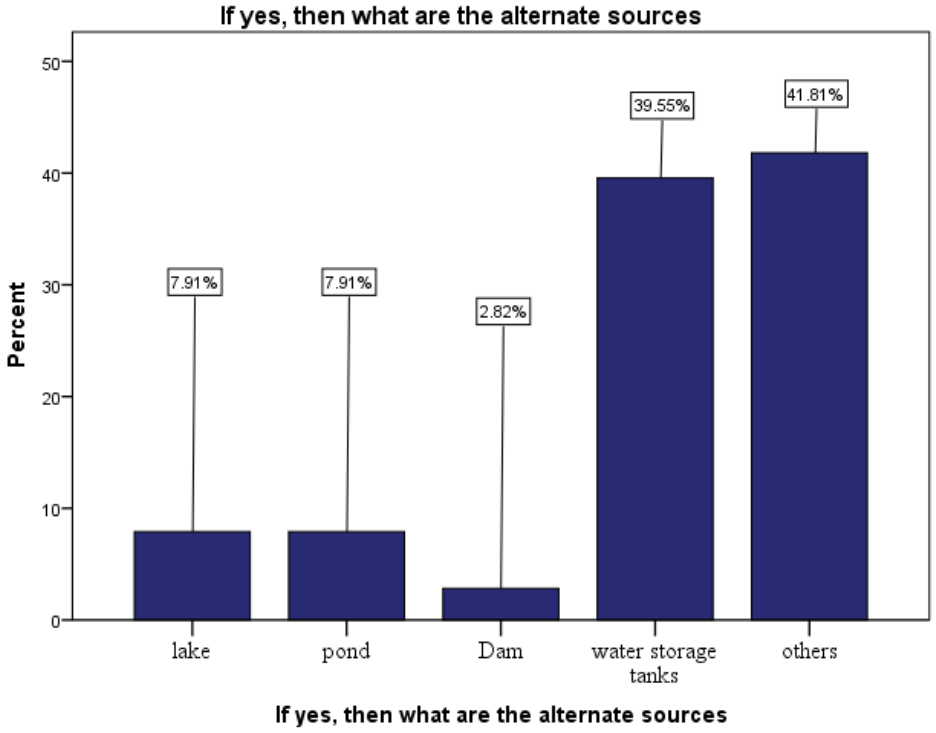

Figure 4.99 alternate water sources

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	177	46.1	46.1	46.1
	no	193	50.3	50.3	96.4
	don't know	14	3.6	3.6	100.0
	Total	384	100.0	100.0	
if yes, then what are the alternate source					
Valid	lake	14	3.6	7.9	7.9
	pond	14	3.6	7.9	15.8
	Dam	5	1.3	2.8	18.6
	water storage tanks	70	18.2	39.5	58.2
	others	74	19.3	41.8	100.0
	Total	177	46.1	100.0	
Total	384	100.0			

Table 4.19 Alternate source of water

Table 4.19 shows the alternate sources of water near to communities. 46% of the households answered in affirmative. These includes lakes, ponds, Dams, water storage tanks or other water reservoirs. 50% population have no access to any alternate source of water in time of water scarcity/shortage. Amongst all more than 3% does not know about any alternate source of water in their premises.

4.4. Water scarcity

4.4.1 Issue of water scarcity faced by households

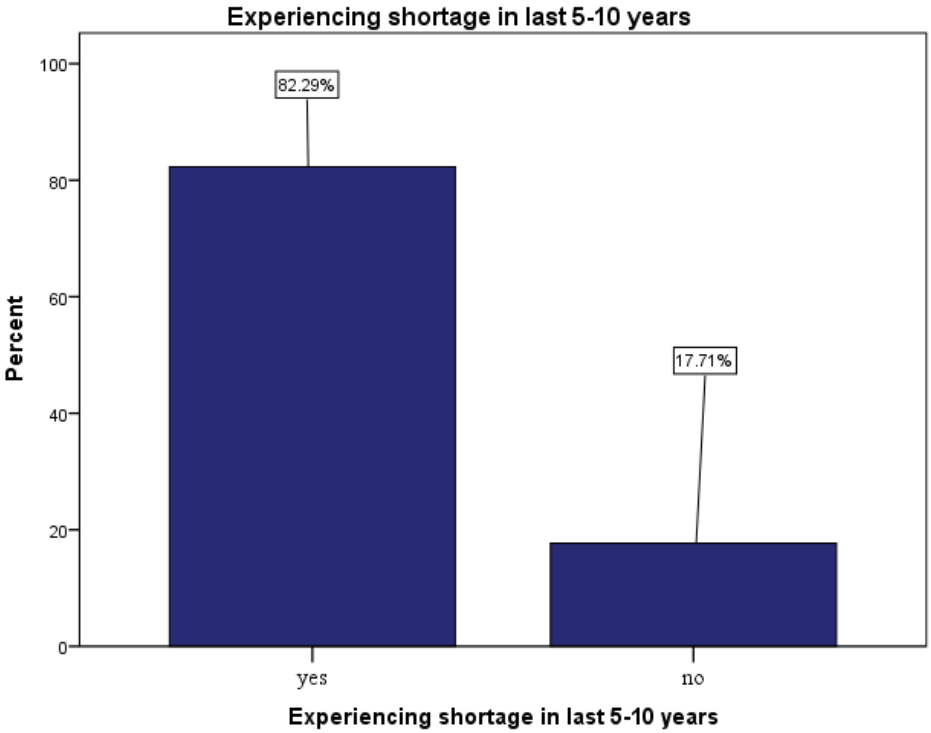

Figure 4.20 experience of water shortage

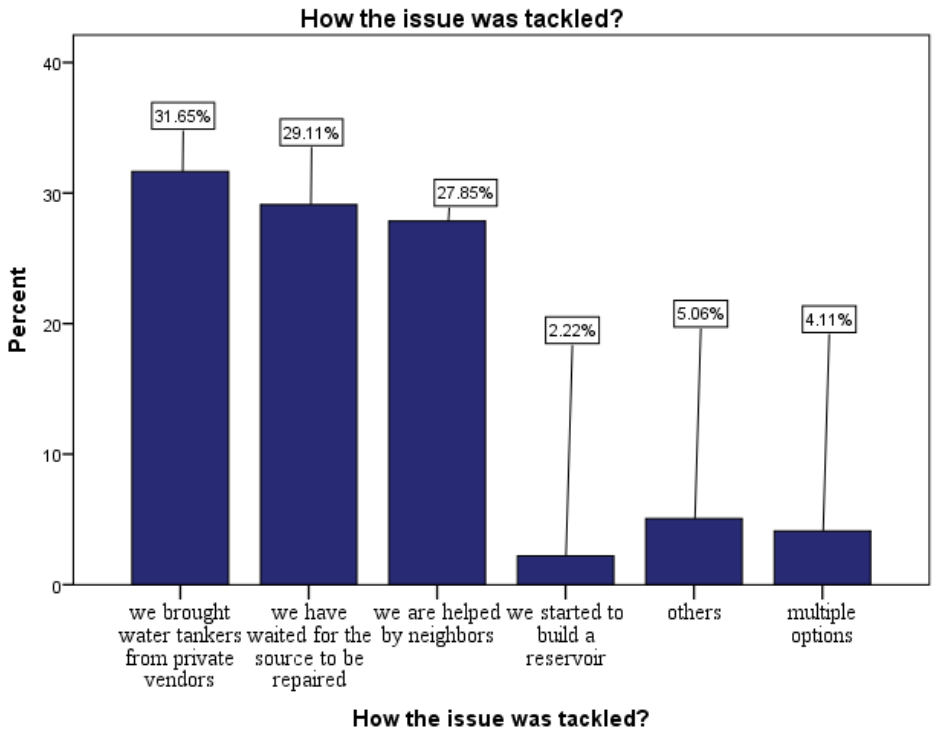

Figure 4.21 water issue tackled

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	316	82.3	82.3	82.3
	no	68	17.7	17.7	100.0
	Total	384	100.0	100.0	

How the issue is tackled?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	we brought water tankers from private vendors	100	26.0	31.6	31.6
	we have waited for the source to be repaired	92	24.0	29.1	
	we are helped by neighbors	88	22.9	27.8	
	we started to build a reservoir	7	1.8	2.2	90.8
	others	16	4.2	5.1	95.9
	multiple options	13	3.4	4.1	100.0

		Frequency	Percent	Valid Percent	Cumulative Percent
	Total	316	82.3	100.0	
Missing	System	68	17.7		
Total	384	100.0			

Table 4.20 Experience water shortage in last decade

The above table elaborates the water scarcity phenomena in last decade. According to the respondents almost 80% of the population has faced water shortage in last decade. These includes drying of tube wells/bore wells/ dug wells, or springs etc. 20% of population hasn't faced any issue of water shortage or scarcity in last decade. These population lives near to river Punjkora and river Swat, torrents or water canals which maintains the water table in their wells. Moreover, they use water of springs in the hilly areas with Snowy Mountains. The merged table describes the means by which they have tackled the issue. That includes bringing water from private vendors, wait for the repair of source, helped by neighbors, start building reservoirs or water tanks or else other means which are provision of water by different social welfare and non-profit organizations. Some people have tackled issue by adopting multiple options.

4.4.2. Resources depletion in recent decade

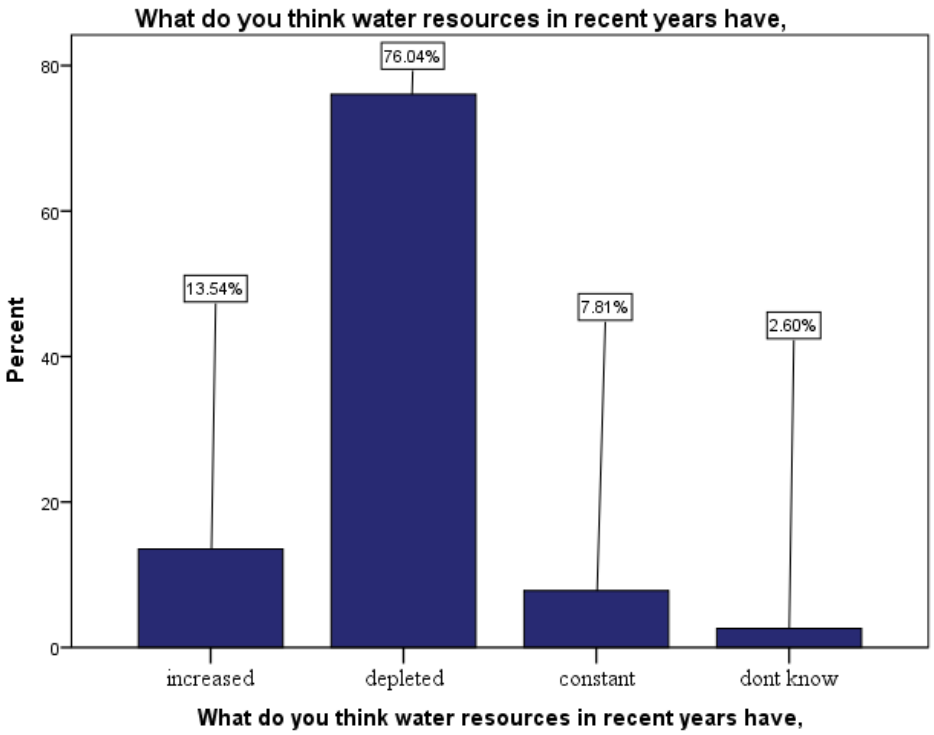

Figure 4.22 water sources situation

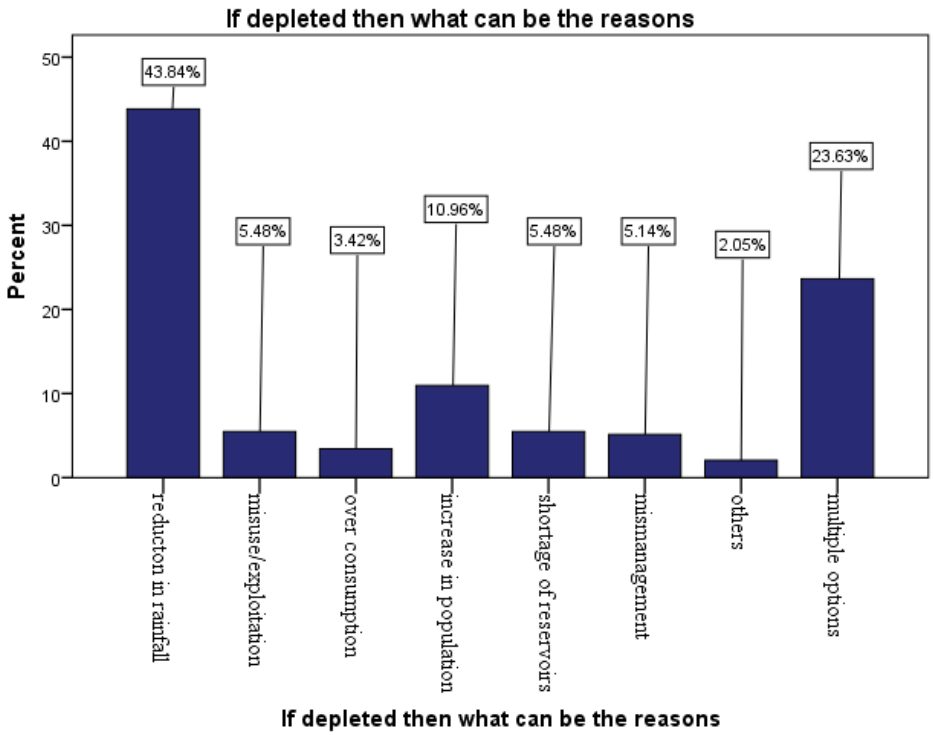

Figure 4.23 reasons of depletion

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	increased	52	13.5	13.5	13.5
	depleted	292	76.0	76.0	89.6
	constant	30	7.8	7.8	97.4
	don’t know	10	2.6	2.6	100.0
	Total	384	100.0	100.0	
if depleted then what may be the reason					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	reduction in rainfall	128	33.3	43.8	43.8
	misuse/exploitation	16	4.2	5.5	49.3
	over consumption	10	2.6	3.4	52.7
	increase in population	32	8.3	11.0	63.7
	shortage of reservoirs	16	4.2	5.5	69.2
	mismanagement	15	3.9	5.1	74.3
	others	6	1.6	2.1	76.4
	multiple options	69	18.0	23.6	100.0
	Total	292	76.0	100.0	
Missing	System	92	24.0		
Total	384	100.0			

Table 4.21 Resources depletion

Above table 4.21 elaborates the people perception regarding the resource depletion. 13% of the respondents have perceived that the water resources have increased in last decade. This is because that in the last decade from River Punjkora “Balambat Irrigation canal” of about 248,000 feet length has been constructed in the district with discharge of 125 cusec of water and irrigate 11363 hectares of land. That has increased water table in many villages. In

addition, from River Swat "Badwan Khareef Irrigation canal" with length 72000 feet and discharge 20 cusec while irrigating 1475 hectares of land has also increased water table. In the recent decade, Government department i.e. PHED and TMA's has also provided to communities with shortage of water. 7% of the respondents have responded to the consistency of water that their water provision is not affected. These are those communities who lying on River Punjkora and River Swat Premises. 2.6% of the people haven't notice any changes in water resources or they don't know about the scenarios. Amongst the population 76% respondents have noticed the depletion of water sources in recent decade. They responded with different opinions. Some think that the depletion is triggered due to reduction in rainfall (figure 1), some says it's due to misuse/exploitation, over consumption, increase in population (Table 4.1) shortage of reservoirs or mismanagement. Few adopted "other" option while 18% of respondents adopted multiple option as they think there are various causes of water resource depletion.

4.4.3 Precipitation data of Dir lower

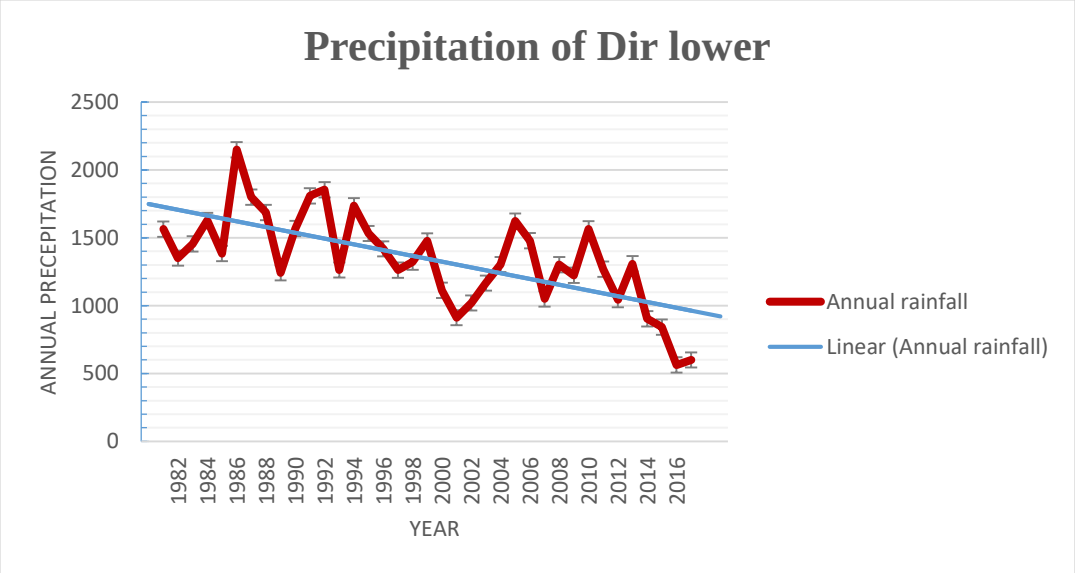

Figure 4.24 Precipitation data of Dir lower

Graph 24 shows the rainfall data of lower Dir from 1982 to 2017. The red color curve represents the annual average rainfall over the year while the blue color straight line represents the trends of the rainfall over the last three decades.

4.5. Water conservation

4.5.1 Conservation of water

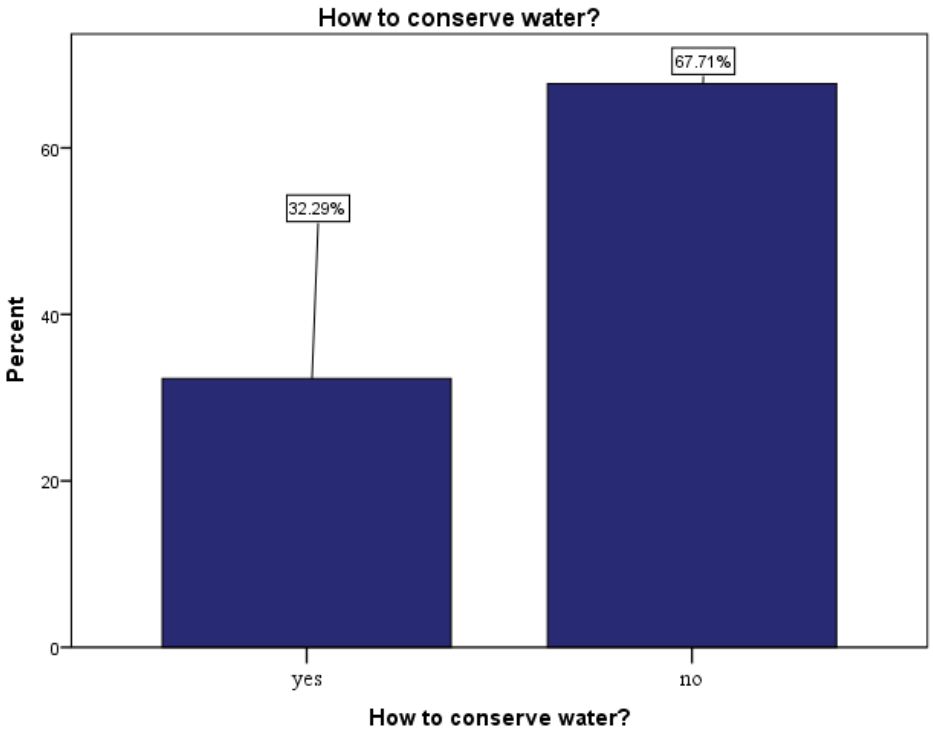

Figure 4.25 water conservation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	124	32.3	32.3	32.3
	no	260	67.7	67.7	100.0
	Total	384	100.0	100.0	

Table 4.22 conservation of water

The respondents were asked if they know how to conserve water, only 32% of the respondents answer in affirmative. According to them, there are different methods through which we can conserve water such as, avoiding misuse, building reservoirs on rivers, construction of Dams, avoiding Eucalyptus trees, building water tanks for storage and its proper maintenance, management of water system, check dams on torrents and water sheds, reduce outdoor watering, checking pipes for leakages and repairing it to avoid misuse, reduce consumption on daily activities, community driven preservation programs, improve piping

systems, improve utilization of well water, installation of water treatment plants on rivers, insulation of water tanks, recycling and reusing of water, metering of water, plantation, reduce underground extraction of water, reduce water pollution, storage of rain water, taking short shower and reduce consumption while washing. The rest more than 67% people didn't know how to conserve water.

4.5.2 Practicing conservation

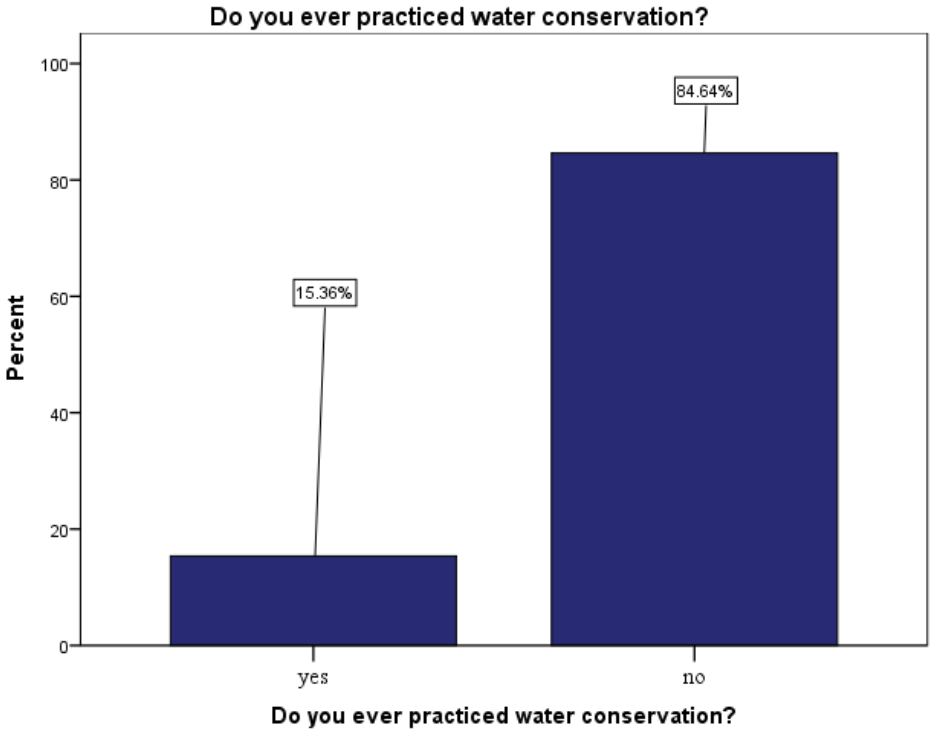

Figure 4.26 practicing conservation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	59	15.4	15.4	15.4
	no	325	84.6	84.6	100.0
	Total	384	100.0	100.0	

Table 4.23. Practicing water conservation

Amongst the 384 respondents, more than 84% do not practice any conservation while about 15% population do conservation practices. These practices includes avoid wastage of water at household level, building of underground water tanks for storage extra water, collection of rain water, store water in tanks, barrels and gallons, construction of check dams in their

premises on torrents at upper catchments, improving piping system, maintenance of water tanks and repairing leakages of taps and tanks, reduce consumption while washing and watering plants at night time to reduce evaporation.

4.5.3. Rain water Harvesting

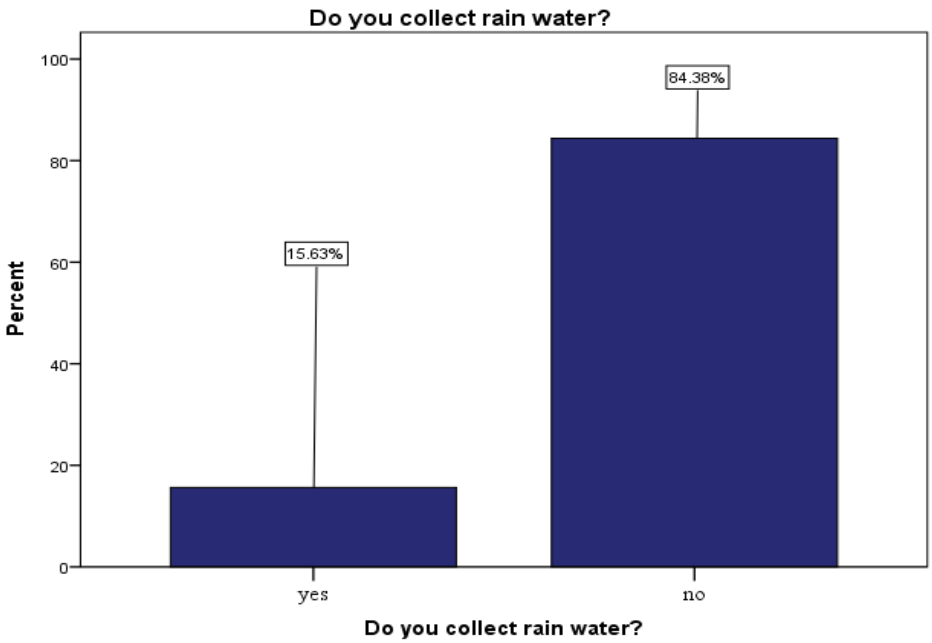

Figure 4.27 Rain water Harvesting

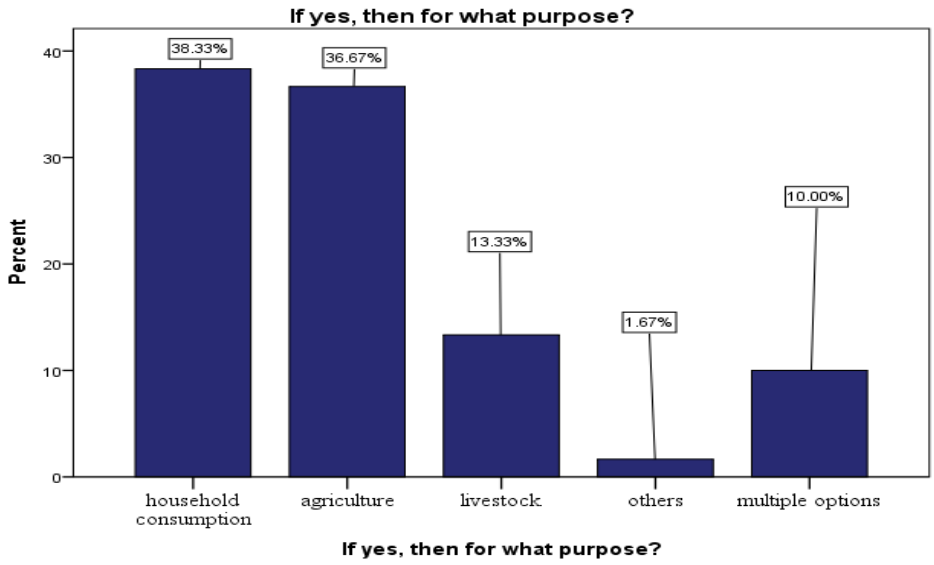

Figure 4.28 purpose of Rain water harvesting

4.6 Qualitative Data Analysis

The qualitative data was collected through Focus group discussions and Semi Structure interviews from community and officials concerned.

4.7 Focus Group Discussions

Two different focus Group discussions were conducted with community and farmers.

4.7.1 Farmers

The major crops grown by the community are wheat, Rice and maize. These are irrigated through flood irrigation and rain fed methods while very few with tube wells. In the recent years the provision of water has been reduced extensively due to reduction in rainfall and reduction in river water. Failure of water canals system also stops the provision of water. Mostly water recession is observed with seasons as summer provides more water while in winter the water capacity decreases or even completely get scarce. The water systems and canals are normally managed and repair by the local community by themselves as they have local committees for its management. In the recession/ scarcity period agriculture production is affected extensively as farmers doesn't have any alternate sources for irrigation. In the response to the scarcity and provision of water for irrigation purposes government has extended the link canals to some population and installed tube wells where needed in some areas. There is no practice of water conservation, storage and recharge of aquifer and water resources. Community only practice retrofitting of water canals to reduce leakages.

They face some challenges as well which are discussed as;

1. Water is not distributed to the fields equally. The more you are near to the canal system the more you will get water.
2. Length of the canal is also affecting the water provision as water is consumed more by the near fields and left less for those who are at the extremes of the canals.
3. Water distribution is not equal. Those farmers who are influenced get more water and poor farmers do not get their portion.
4. Production is also affected with this unequal distribution.
5. Production is affecting due to the infertility of land as well because of the mismanagement and frequent growing of same crops.

6. There is no use of hybrid or more yield crops and farmers are using the traditional seeds.
7. No technology has been introduced or practiced to increase the production of the crops and reduce the consumption of water.

4.7.2 FGD with community

There are different sources of water in communities for consumption i.e. bore wells, tube wells, springs, government tube wells and private vendors. These water are consumed in different activities like drinking, washing, bathing, cleaning of houses and gardening. Major proportion of population is using source of bore wells at their homes. In recent decade people have faced water scarcity in different way. These includes extensive reduction in aquifer, reduction in rainfall, increase in population, drying of springs and failure of government water systems. These issues are tackled by approaching private vendors, deepening of wells and involvement of government in repair of the systems. The issue of water scarcity is still prevailed in most of the areas especially in higher terrains where in some villages the water has increased because of the canal constructed in recent years. In response to the water scarcity, government has built tube wells in some areas. Small check dams and small reservoirs are also constructed in some places. But there is no proper system of aquifer recharge and conservation of water resources. People of the communities does not have any awareness regarding water conservation practicing. Very few people collect rain water to use it for their domestic uses especially for gardening and livestock.

4.8 Semi Structure Interviews from departments

Semi structure interviews were followed by different departments that are stated as;

4.8.1 Irrigation department

Irrigation department is providing water to the fields through Tube wells, water ponds, canals and civil channels. They are managed and sustained by the department. They have managing overall 21 tube wells in which 4 are non-functional due to reduction in water table and 17 are functional. 300 small ponds have been constructed in different locations of the district especially in the upper terrains on streams. 2 large canals which are Badwan Khareef Irrigation canal build on River Swat which provides water to fields for 6 months during April to September, its length is 72000 feet, discharge of 20 Cusec and irrigating land of 1474

Hectares while Balambat Irrigation canal is built on River Punjkora having length of 248,000 feet, discharge 125 cusec and irrigating 11363 hectares of land. Up to 200 civil channels are also built on all the relevant sources i.e. canals and streams. The Proposed projects for the upcoming years are Sanam Dam at Asbanr Adenzai which would be used for irrigation and water table adaptation. 10-15 check dams are also proposed at different locations in the district. Punjkora left right canal is also proposed which will be used for irrigation purposes as well as 70% of district water table issue will be resolved.

Currently there is no reservoir in the district for irrigation or conservation purposes. Extensive water scarcity has been observed in different streams of the district which includes Maidam khwarh, Laajbok khwarh, Samarbagh and Talash khwarh. In addition these torrents had heavy mining's. Moreover, water deficiency has also been observed in the civil channels and water canals in recent decade. To tackle the issue of scarcity people have started to use alternative sources for irrigation or have changed crops patterns.

4.8.2 Agriculture Department

Both major and minor crops are grown in the district. Crops includes Wheat, Rice and Maize. Fruits orchards includes Citrus, Peach, Apricot and pear. Vegetables includes Tomatoes, Onion, Turnip, Reddish and coriander. Cereal crops are irrigated with flood irrigation and rain fed techniques. Orchards and other crops are irrigated through tube wells and civil channels. Maize and rice needs huge amount of water while rest need less water. Productive land in the district is 46701 hectares. In the total rough estimate 66 % of land is unirrigated while only 34 % is accessible for irrigation. Different hybrid seeds are used only for the sake of resistance towards pests and insects but not for the sake of least water consumption. Diseases that attack in crops are rust and smut on wheat. Blight, Cate, mosaic, powdery mildew, downy mildew and purple bleach on vegetables and Gummosis, Blight, short whole and fruit fly on fruits.

Currently no technology or hybrid seeds to reduce to consumption of water in crops and increase the yield. But government is planning to introduce sprinkles and drip irrigation. In addition, innovative techniques for field leveling is not available but only tractor blades are used of it.

4.8.3 Public health Engineering department (PHED)

According to the PHED major parts of the districts is receiving clean water as reference to different research studies and sampling testing's. The water quality of areas near to riverine water were somewhat with the parameters of WHO as they contain some bacteriological contaminations. A total of 198 water schemes are functional in different locations of the district while 37 schemes are non-functional (either they have completed their life span or damaged). Water is provided to the communities though GI Pipes from the sources (tube wells, wells). According to them 658,252 population has been provided water which is almost 46% of the total population. Treatment of waste water is the major issue in the district where there is no system of water treatment before disposal to the river. Until now there is no water management and conservation policy implemented in the district.

A total of 217 water schemes are proposed over the next thirteen years to gradually fill the gap between supply and demand in the district. Moreover detailed feasibility survey are conducting by PHED to identify places for Rain water harvesting schemes which are intended to be completed till 2030. In addition Greater Khaal water plan project is also under feasibility survey in which a large water tank will be constructed and water will be provided to the communities through gravity.

4.8.4 Municipal Administration

In district lower Dir only 2 TMA's are providing water to the community which are TMA Balambat and TMA Timergara respectively. 4408 households are provided water through 20 tube wells in urban councils. According to their estimate per household is divided into 8 members and water needed for each one is 4-5 gallons per day in normal routine. Payment for the water provision is carried out on quarterly basis with about Rs.1200. Water is cleaned/treated through chlorination quarterly by adding chemicals in their major outlets and are tested quarterly. There is no system for waste water treatment before disposal to river. Sanitation services are active and sanitation services are carried out on daily basis in the major places of the district. Solid waste is usually collected on weekly basis and is disposed in safe places. Only one testing laboratory is available in the district. There is no observatory or gauge installed on tube wells. As per their calculations 176,320 gallons are withdrawn from tube wells on daily basis. Where there is no system for water recharge, but only rely on

rainfall. In mountainous regions the ground water resources have depleted as observed from the wells and tube wells.

Currently no water management and conservation strategy and policy is implemented on ground. No Dam for water conservation, only river Punjkora, River Swat and Precipitation is naturally recharging the aquifer. In future plans, there is only plan for the water recycling plant.

Chapter 5

FINDINGS AND RECOMMENDATIONS

5.1 Rationale of the chapter

This chapter summarizes the research work/data and findings. On the basis of these findings the researcher gives recommendations and suggestions that should be applied to cope with that situations or should be implemented to solve the issue or make corrections that are necessary. A short comprehensive form of the research is also presented under the title of conclusion.

5.2 Findings

1. **Supply of water**
   - Communities of Dir lower are mostly relying on different sources of water for their consumption 69.3% on bore wells, 1.3% on hand pumps, 15.4% on public taps, 5.7% on own household pipe connection from any source, and 1.6% rely on other sources.
   - Surface water includes water from River and streams/ torrents are mainly utilized for agriculture (more than 90%) and livestock purposes.
   - Ground water includes tube wells and bore wells that are managed by government (they own 21 tube wells), communities and at household levels.
   - These water sources are supplied to the communities and agriculture land through pipes, gallons, private tankers, canals and small water channels.
2. **Demand/ consumption**
   - People utilize water in different activities at household level i.e. Washing (63%), cooking (7.8%), bathing (4.4%) and drinking (2.3%) purposes, in which washing contributes to the major utilization.
   - Large amount of water is also used for agriculture purposes as people grow mainly wheat, rice and maize which are more water consuming crops.
   - More than 90% of the land is irrigated through flood irrigation where the water is provided through canals and small water channels.
   - Small and medium industries uses water as per their needs.

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3. **Changing patterns of water supply and demand**
   - In recent years huge amount of reduction in water supply has been noted due to reduction in rain fall (from 2300mm to 500mm per annum) owing climate change phenomena.
   - Due to over exploitation and disturbance in recharge of underground water resources, these reservoirs have started depleting at a rapid pace.
   - Moreover, due to exponential increase in the population (average annual growth rate 3.71%) of the district demand and consumption of water has also been increased manifold.
   - Because of these two reasons i.e. reduction in water supply and increase in the demand for water consumption has created water scarcity in the district.
4. **Management of water**
   - Government has made 2 major canals in the district for irrigation purposes that are Balambat irrigation canal and Badwan khareef irrigation canal which as a whole covers up to 13000 hectares of land.
   - In addition about 300 ponds are also constructed at different spots on torrents. More than 200 tube wells are functional and are utilizes for provision of water to households and agriculture.
   - Sanam Dam, Punjkora left right canal, Greater Khall plan few check dams and tube wells are under feasibility for the management of water system.

5.3 Conclusion

- Water scarcity problem has been aroused in the district due to decrease in the supply of water and increase in its demand for consumption.
- River Punjkora Swat and torrents are the main sources of water supply for irrigation purposes while springs, tube wells and bore wells are used for domestic consumption.
- Due to unavailability of reservoirs and unsustainable practices of irrigation available water gets wasted.
- Increase in population has placed enormous stress on the ground water reservoirs. It has not only disturbed the natural recharge of ground water but increased over exploitation.
- There is no awareness regarding conservation at any level.
- Rain water harvesting measures are used by population in a negligible amount.

5.4 Recommendations

1. Drilling of the bore wells should be banned furthermore to avoid exploitation of the underground water table.
2. Government should provide water to the communities through pipes by installing tube wells in every community. This will keep the underground water from over exploitation. Government will have a proper check and balance of the water supply and demand. An opportunity for the revenue generation will also be provided which will help the government to build reservoirs and small ponds for aquifer recharge and storage of rain water. In addition, the provision of water to the community by the government will reduce burden on power sector and household by reduction in electricity utilization.
3. Water from river Punjkora and River Swat should be utilize properly by building small reservoirs and canal system to cover the district which will improve water table and more land will be utilize for irrigation purposes.
4. Government and communities should built small check dams over the torrents at different places which will reduce the velocity of water in rainy seasons as well as recharge of aquifer.
5. People should repair water pipes, taps and tanks to avoid leakage.
6. For agriculture lands, new technologies should be used to avoid misuse of water i.e. laser levelling, drip irrigation, and sprinkles. Flood irrigation should be stopped at priority basis because it wastes extensive amount of water.
7. Improved varieties of crops should be introduce which will utilize less water and improve yield. Moreover these crops should be drought resistant.
8. Fields should be irrigated at night time to reduce water evaporation.
9. Awareness should be raised through different channels of the community especially at mosques to mobilize communities regarding the importance of water at individual and household levels. Because mosques are the places where they have extensive exploitation of water for ablution. Different seminars and discussions should be conducted in the hearts of communities to conserve water.
10. Methods of rain water harvesting should be common amongst the household's. Water of rainfall should be stored in small water tanks and shall be used for washing and agriculture purposes.

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Annexure # 1

Semi Structure Interview Guide

(Departmental)

Semi Structure Interview Questions (interview guide) from Irrigation department

1. What are the main sources of water in the District/Area?
2. How are they managed?
3. Are the available water resources sufficient for irrigation needs/purposes?
4. Is there any water canal system for irrigation? And how much area it has covered?
5. Did you face any water scarcity issue in recent decade?
6. If yes! What was the extent and how did it affect the irrigation?
7. How many Tube wells are registered for irrigation?
8. Is there any reservoir for water storage?
9. How we can manage existing water resource sustainably?

Semi Structure Interview Questions from Agriculture department

1. What are the main crops in the district?
2. How they are irrigated?
3. Which crop is consuming more water?
4. How much area is crop productive?
5. How much is the share of irrigated agriculture land?
6. How much agricultural land is irrigated by rain, flood and canal system?
7. How much the fluctuation in the crops productivity occurred during last decade?
8. Do you use hybrid seeds to reduce water consumption?
9. What are the practices to irrigate the fields?
10. What are diseases relevant to crops production and how much pesticides and fertilizers are used annually?
11. What technologies are used in field leveling and crop irrigation?

Semi Structure Interview Questions from Population department

1. How much is the population of the district according to the latest census?
2. How much is it increased or decreased during the last decade?
3. What is the level of urbanization?

4. How much is population density in urban areas and rural areas?
5. Is there any migration occurred in the last decade?
6. What is the main livelihood of the people?
7. Percentage of population with access to drinking water?
8. Percentage of population with access to sanitation services?
9. GDP per capita?

Semi Structure Interview Questions from Metrological department

1. How much is average annual precipitation?
2. Does it increased or reduced since last decade?
3. Which season has more flooding?
4. How much is ground water recharged annually?
5. Is there any dry spell round the year? If yes, how much it persists?

Semi Structure Interview Questions from Pubic health department

1. How much people has access to clean drinking water?
2. How much people has access to safe sanitation services?
3. How water is provided to communities? (sources)
4. How many wells and tube wells are registered?
5. How water is treated?
6. How water of sanitation is thrown into River? (treated /untreated)
7. What are diseases relevant to water in the district?
8. How much is annual water withdrawal?
9. How much is annual water recharge?
10. Which areas are water scarce and why?
11. Is there any policy implementing regarding water conservation and management?
12. How much is domestic water use per capita?
13. What is storage volume in the district?
14. What are total renewable water resources?
15. What is consumptive usage of water?
16. How much is ground water withdrawal?

Semi Structure Interview Questions from District Municipal Administration

1. How much people has access to clean drinking water?

2. How much people has access to safe sanitation services?
3. How water is provided to communities? (sources)
4. How many wells and tube wells are established by TMA to provide clean drinking water to people?
5. How water is treated?
6. How water of sanitation is thrown into River? (treated /untreated)
7. How is situation of sanitation system? And how many times it is cleaned in a month?
8. Is the water tested before provided to communities?
9. Is there any process of regularization installation fee for people?
10. How many ml of water is provided to community on daily basis?
11. Is there any gauge meter installed on the tube wells?
12. Is there any billing procedure?(monthly / quarterly)
13. How much is annual water withdrawal?
14. How much is annual water recharge?
15. Which areas are water scarce and why?
16. Is there any policy implementing regarding water conservation and management?
17. How much is domestic water use per capita?
18. What is storage volume in the district?
19. What are total renewable water resources?
20. What is consumptive usage of water?
21. How much is ground water withdrawal?
22. How much are ground water resources?
23. How deep is the aquifer?
24. Is the waste from industries and other sources being treated before throwing it to the sanitation channels?

Annexure # 2

Focus Group Discussion (Guide)

Questions for Focused group discussion interview guide (community)

1. How many sources of water are available in your area?
2. What are your sources of water consumption?
3. Did you face any water scarcity phenomena in the recent decade?
4. How long was it prevailed?
5. Is the problem of water scarcity still exists or being reduced or increased?
6. What is your response to the water scarcity issue?
7. How is the government response to the water scarcity issue?
8. How deep is the aquifer?
9. Is there any procedure to recharge the water resources?
10. Do you conserve water?
11. Is there any conservation practices followed in your area?

What could by your suggestions to conserve and manage water sustainably?

Annexure # 3

Questionnaires

Assessing the Changing Patterns of Water availability and adaptation to water scarcity through sustainable water management in Lower Dir.

Basic Information

Name_____ Age_____

Location _____ type of family (nuclear/ joint/extended)

Number of family member's _____ socio economic (economic condition)

Employed/ farming/ Business.

Water availability

1. What system of water do you use for your daily usage?
    a. Own pipe connection
    b. Bore well/ well
    c. Hand pump
    d. Public tap
    e. Household water supply (piped)/ tube well
    f. Other_____
2. Who manage the water system?
    a. Community
    b. Government
    c. Ourselves
    d. Other_____
3. Is the water supply system reliable/sufficient?
    a. Yes
    b. No
4. How far is the water source from your home?
    a. Less than 100 m
    b. Between 100 and 200 m
    c. More than 200 m
    d. Household water source.

5. What method of water storage do your household use?
    a. Roof tank
    b. Underground/ ground water tank
    c. Small containers/ Gallons
    d. Other_____
6. How much is the capacity of water storage?
    a. < 500 gallons
    b. 500-1000 gallons
    c. 1000-1500 gallons
    d. > 1500 gallons
7. How many days can your water storage last when there is no water supply?
    a. One day
    b. Two days
    c. Three days
    d. Four days
    e. Other_____
8. How many times water comes from this source on daily basis?
    a. 1 time
    b. 2 times
    c. 3 times
    d. Continuous supply
9. Availability of water from source?
    a. 0-3 months
    b. 3-6 months
    c. 6-9 months
    d. 9-12 months
10. What activity utilize more water on daily basis?
    a. Drinking
    b. Washing
    c. Cooking
    d. Bathing
    e. Other_____
11. Is the water from source drinkable?
    a. Yes
    b. No
    c. Don't know
12. How would you evaluate quality of drinking water from your source?

a. Fair
b. Good
c. Satisfactory
d. We use filter
e. We boil water for drinking
f. We bring drinking water from other places

13. Do you pay for the water?
    a. Yes
    b. No
    c. If yes! Then how much_____

Water Scarcity

14. Is there any alternate source of water in your area for household use?
    a. Yes
    b. No
    c. Don't know
15. If yes, what are the alternate sources?
    a. lake
    b. pond
    c. Dam
    d. Water storage tank
    e. Other_____
16. Did you experienced water shortage/scarcity in last 5 years?
    a. Yes
    b. No
17. If yes, how did you tackled this issue?
    a. We brought water tanker from private vendor
    b. We have waited for the source to be repaired
    c. We are helped by neighbors
    d. We started to build a reservoir
    e. Other_____
18. What Do you think water resources in recent years have:
    a. Increased
    b. Depleted
    c. Constant
    d. Don't know
19. If depleted then what may be the reason?

a. Reduction in rainfall
b. Misuse/ exploitation
c. Over consumption
d. Increase in population
e. Shortage of reservoirs
f. Mismanagement
g. Other_____

Water Conservation/ management

20. Do you know how to conserve water?
    a. Yes
    b. No
21. If yes then what can be the suggested methods?

    _____

    _____
22. Do you ever practiced water conservation?
    a. Yes
    b. No
23. If yes, what methods do you practice?
    a. _____

       _____
24. Do you collect and store rain water?
    a. Yes
    b. No
25. If yes then for what purpose?
    a. Household consumption
    b. Agriculture
    c. Livestock
    d. Other _____
26. Do you have any suggestion regarding water conservation in communities?

    _____

    _____

    _____