Groundwater Rights and Water Scarcity: Evidence from Selected Sectors of Islamabad

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CERTIFICATE

This is to certify that this thesis entitled: ***"Groundwater Rights and Water Scarcity: Evidence from Selected Sectors of Islamabad"*** submitted by Ms. Sumera Jalil is accepted in its present form as satisfying the partial requirement of the degree in **Master of Philosophy in Environmental Economics.**

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TABLE OF CONTENTS

List of Figure

LIST OF TABLES

ABSTRACT

The overexertion and excessive use of groundwater depletes this precious resource. The governments are trying to tackle this challenge using various options. To develop and implement the groundwater rights is one of the important options. The objective of this study is to make a situational analysis of groundwater laws and the willingness of the residents on the implementation of groundwater laws in Islamabad. Moreover, the study also evaluated the cost borne by local residents due to the absence of groundwater laws. To achieve the objective of the study, primary data was collected from the local residents through questionnaires. The primary data were analyzed through descriptive statistics. The information about groundwater laws in other countries was obtained from the available literature. This study concluded that the implementation of the groundwater laws were lacking in the study area suffering the local residents. The local residents showed willingness for the implementation of groundwater rights. The study recommends that appropriate groundwater rights should be developed and implemented by the government and local water authorities to tackle the water scarcity issue in the area.

Chapter 1

INTRODUCTION

Groundwater is natural water that maintains the underground water table by being replenished by the surface water. This water eventually flows back naturally to the surface. It is used for agricultural, industrial and municipal use through wells, underground bores, tube wells etc. (Bhutta & Alam, 2011). In Pakistan; groundwater is also used for these purposes. The depletion of groundwater is caused due to increase in pumping water out of the ground faster than it is replenished naturally. The volume of groundwater is in shortage in many areas of our country due to excessive water pumping. Groundwater depletion is primarily caused by unauthorized groundwater pumping.

The surface water is not depleted as the groundwater level decreases and take a long time by aquifers to fill-up. Groundwater is used for drinking purposes pumped from wells, and pumped groundwater also for agricultural irrigation. According to the report of IMF with each individual's annual accessibility of water at 1,017 cubic meters, Pakistan is fast closing in at 1,000 cubic meters, which shows Pakistan is a water-scarce country (Baloch, 2018).

The Punjab area of Pakistan is facing a serious threat of depleting water table went down by 90% and the remaining 10% is mixed with arsenic particles (Paracha, 2018). According to official figures, the underground water level is depleting regularly. In 2012, the underground water level was five feet in Islamabad, in 2013 it went down to 7 feet, in 2014 to 10 feet, in 2015 to 12 feet and in 2016 it went down dangerously to 30 feet. In some areas of Rawalpindi, the level of groundwater is available between 150-200 feet. Most of the people living near this area are adversely affected by this problem (Jawad, 2017).

Pakistan is among the top 10 countries where clean water is not available near homes and about 21 million people have no access to clean drinking water. Only 36% of Pakistani people have access to safe drinking water (Jamal, 2018).

According to the Mayor of Islamabad, it is estimated that 250 million gallons of water per day (mg/d) is needed in Islamabad. The available supply is only 120 million gallons per day (Mehboob, 2019). Accepting that Metropolitan Cooperation Islamabad (MCI) has no short or long term planning to meet growing water needs, he says, Policies and their implementation need funds and they are already in a financial crisis due to a delay in the issuance of funds (Mehboob, 2019).

According to statistical data of population census 2017 of CDA, the present population of Islamabad is 1,657 million. The water supplied from CDA comes from Simli and Kanpur dam and few tube wells and water passed to different areas of Islamabad through filtration plants. The supply of water depends on the weather conditions, water table of dams and electricity, so there is no average supply. During monsoon season, the demand of water production accumulative level is at peak i.e. 84 million gallon per day. But at drop down water production is 62 million gallon per day in normal days. The average demand is 176 mg/d while water shortage is 106 mg/d. Water production average demand vary per day (CDA).

Water can be used both private and public goods. These features mean that water is not a pure public good. Water should be deliberated as private or public goods can be depending on it use and the nature of resources (White, 2015).

The ultimate difference in the southern cultures and northern is a basis for many crisis in the world. The assessment of water is beyond it economic terms in southern societies. In our culture water belong to the earth and for all species. It’s a human right and public trust to be protected by local peoples, nations and communities, and authorities that represent them at the state, local and international level. Government have responsibility to provide clean water to the people and cannot transferred it to the private sector (Withange, 2015).

At global level, the stress of water scarcity also increases not by climate change but due to increase in economic development, population and deprived management leading to this

problem. In the world, 14 of the 20 megacities face the issue of drought and water scarcity. As such 4 billion people live in those areas where at least one month of the year is spent facing severe problem of water scarcity. In 2008, Spain, Barcelona, imported freshwater tankers from France. As a solution, it is said that there is an urgent need to better strategies for water management and to produce and grow things in a sustainable way (Leahy, 2018).

In Pakistan, groundwater is also an important source of water. It is difficult to recognize the effects of human activities because the groundwater flow is slow. Also, it is costly and difficult to clean the groundwater when it is polluted. Surface water systems are replenished by groundwater flow which allows rivers and streams to keep running even in dry weather. It is also an important support source for wetlands and their ecosystems.

In US, groundwater used is increasingly to meet water demand. And they thinking about the proper management for the sustainable use of groundwater. US government state are responsible for the management of groundwater regulations, laws and policies. Their professionals survey about the water quality some respondents said, the increase in groundwater pumping need to attention on it in future (Petersen-Perlman, et al., 2018).

According to an analysis Washington D.C World Resources Institute's Aqueduct Water Risk Atlas that 1.8 billion people in seventeen countries or quarter of the world are in water crisis and appear to be severe deficiencies. According to WRI, countries facing the water stress using 80% available surface water and groundwater supply in an average year and due to climate change are composed to increase. Paul Reig said that we are highly depend on the groundwater to meet our demands and he is person who leads Aqueduct and World Resource Institute corporate assignation on water (Dormido, 2019).

In Pakistan, there are no specific laws implemented for it. Groundwater can be used at any time because it is a consistent resource. Most of the developed countries follow the US groundwater rights. In different states of United States groundwater doctrines are used that are the Reasonable use, Absolute ownership/ English rule/ Common law rule, Correlative use, Prior appropriation, Beneficial purpose doctrine/ Restatement (second) of Torts (Joshi, 2005).

In conclusion, laws for groundwater are still an undiscovered chapter in lawmaking in many countries of the world. They are mostly followed in a few developed countries while the developing nations are far behind on this legislative work. Being on the brink of global water scarcity, groundwater rights need to be established so that water wastage can be stopped and water security issues can be tackled efficiently.

1.1 Problem Statement

Water is the main source of human beings survival. Since groundwater laws are an uncovered area in Pakistan and a negligible amount of work is done on this issue. The problem of water scarcity increases suffering the local residents in different areas. The local residents use bore water to fulfill their basic needs while farmers use groundwater for irrigating urban agriculture. Due to increase in the population and extension in the housing sector in Islamabad, the extraction of groundwater water further intensify the depletion of groundwater. As a matter of fact, the majority of local residents of sector G are mainly uses groundwater to meet their daily needs except for drinking purpose. Because, the local residents already use bottle water for drinking purpose. The groundwater depletion does not affect the demand for bottle water but to meet the water requirement for other purposes, it costs the households additionally in the form of purchasing the tanker water. If the groundwater further depletes overtime, it will impact the household budget, house rents and urban agriculture. This is also unfortunate that the absence of groundwater rights and excessive use of water push the study area into further water scarcity and this problem may further increase if serious actions are not taken. Keeping in mind such issues this study made

a situational analysis of groundwater laws in different countries and in the study area. The local residents have also been asked for showing their willingness for the implementation of groundwater laws in Islamabad. The study also evaluated the cost borne by local residents due to the absence of groundwater laws.

1.1 Research Questions

The following research questions have been developed for study:

1. Are groundwater laws practiced in Islamabad?

2. Are the residents willing to accept the implementation of groundwater laws?

3. Do the local residents bear any cost in absence of groundwater laws?

1.1 Objectives

The present study aims:

1. To make a situational analysis of groundwater laws in different countries followed by the study area.
2. The willingness of the local residents on the implementation of groundwater laws in Islamabad.
3. To evaluate the perception of groundwater depletion in Islamabad.
4. To evaluate the cost borne by local residents due to the absence of groundwater laws.

1.1 Organization of the study

In chapter 1, I discussed about the background of the study area, problem statement, research questions, and objectives of the study. In chapter 2, literature has been reviewed focused on the management, establishment of groundwater rights in developed and developing countries and overcoming the problem of water scarcity. Chapter 3 explained the methodology of the study covered profiles of the study area, data type, analytical tools, and sampling design. Chapter 4, discussed the results derived. In chapter 5, the conclusion and recommendations have been presented.

Chapter 2

LITERATURE REVIEW

2.1 Groundwater Management

DuMars & Minier, (2004) studied the development of groundwater rights and management in the western United States and New Mexico. Generally, the public property water rights are initiated and then are converted as a public resource. It is necessary to have a society for these rights so these laws are protected by property laws principles. In the United States, five laws are implemented for controlling groundwater rights. But the problem raised by the stream system i.e. hydraulically attached and by leading court cases is that groundwater non-replenished aquifers have been determined. The associations of the policies linking the combined management of surface and ground water cannot be inflated. They are determined to take initiative related to the depletion of groundwater in the future which can affect stream system. For this it is necessary to plan the ultimate system for exploitation, utilization and, management of water resources to overcome the problem of water scarcity in the future.

Vaux, (2011) states that in the 21st century, water scarcity is a major problem in the United States and all over the world. Water scarcity arises partly due to climate change, an increase in population and economic growth. So, we need to protect our environmental resources. For this purpose, groundwater management is necessary for the protection of groundwater which needs to be developed locally for yielding better results. From the evidence of the United States, it is suggested that applying regulation on the recharge and additional water sources can be beneficial. Evidence from South Asia suggests that the regulation of water recharge and extraction is more effective if we take indirect measures for groundwater and auxiliary variables like electricity.

Koundouri, (2007) researched the issues related to the economic management of groundwater resources and current issues in the economics of groundwater resource management. According to him, in many regions, a real fear throughout the world is groundwater management. The objective of his study was to determine the ways to think about the complex resources and how to deal with the economic issues arising from it. The study concluded that the implementation of the invented regulatory schemes generally ignores the information and knowledge needed for it. They recommended basic conditions and reforms for the success of groundwater management.

Ahmad, Mulk, & Muhammad, (2002) discussed groundwater management in Pakistan. About 16.2 billion hectare area is covered by the Indus Basin, representing Indus Basin as a groundwater aquifer. The study assessed the characteristics of the quality and quantity of groundwater management in the Indus basin. It discussed the current issues present in the country and the management of resources. In the Pakistan Water Partnership (PWP) workshop, they discussed the issues and suggested recommendations on groundwater management.

Bhutta & Alam, (2011) worked on prospective opportunities and limits of groundwater use in Pakistan. Groundwater use is increasing rapidly in different ways for agriculture, domestic purposes and industry. There are no specific laws implemented for groundwater usage or conservation. In 1965, the yearly groundwater perception escalated from 10 bcm to 68 bcm in 2002. The study conducted countrywide salinity profile and soil surface surveys in years 1953-54, 1977-79 and 2001-03. The salinity survey indicates that approximately 56 to 73 percent of salt-free land has increased in the comparison data. The tube wells used for irrigation are more than 600,000 in number which causes depletion of groundwater (GOP, 2003).

The main problem of groundwater arises due to pollution generated by different reasons e.g. industrial activities, human activities, poor drainage causing salinization and waterlogging. In 1980, pesticide use had increased to 665 tons and in 1999 to 45,680 tons. Groundwater pollution arises due to excessive use of pesticides and fertilizers. To overcome these problems, it is recommended to develop a groundwater regulatory framework, expedite the transfer of public sector SCARP tube wells to the private sector, strengthen monitoring efforts to determine sustainable groundwater potential and use along with launching awareness/extension campaign for better water management.

Iglesias et al., (2007) discuss the challenges of Mediterranean countries related to water management. Firstly, they estimated and reviewed the current issues and future pressures on the environment related to water resources and climate change. In their result, they found out that the pressure of water remains the same throughout the region. Secondly, they estimated adaptation plans to manage water scarcity including technology, management, and procedure of planned groundwater. They suggested a structure to overcome the problem of water scarcity established on awareness, not on crisis approach.

Megdal (2018) analyzed that the fast growing population increases the needs of people for food, daily human uses and energy. The author also studied the impact of climate change on the supply and demand of water, and in result, increasing dependence on groundwater. And in many places groundwater is depleted fast than nature can refill. In this paper they discussed and highlighted the survey in United States and other global case studies. They focused on invisible water reserve earlier on which causes water depletion or pollution and in result it causes environmental, economic and social growth disorders. For the betterment of groundwater use and sustainabilty, there is a need for proper governace and management of it. Water policymakers, users,

researchers, and citizens must focus attention on this invisible water resource before pollution or depletion of it results in severe economic, environmental, and social dislocations.

Novak, (2006) studied that the quality, quantity and management of aquafer could be throughly estimated when developing and magnifying groundwater supply. The author described four case histories. The annexations of new groundwater rights have been frozen in the Garden city and Kansas areas. The local problems between Wheatland Electric Cooperative and Garden City related to the water quality and water rights can be solved by public-privater ownership.The existing industrial water rights of Wheatland can be converted and 6.5-MGD converse osmosis blended treatment plant could be used to sell water to clients. The community of Garden City is back on track by providing quality groundwater and proper management. In 1973, the City Lake Havasu, Arizona, provided water to the people. People voted for the removal of manganese and aresenic from drinking and for the installation of new water treatment plant. Arkansas Union City recognized for so many years that their groundwater supply aquifer, Sparta, was speedily dewatering. They recommended the use of surface water from river Ouachita which could supply cold water for local and industrial users and leave Sparta aquifer for municipal and domestic use. Union countries owned and operate river supply, pumping sation, pretatment capacity and large miles of water lines. The management of their water resources saved both Sparta and Union country from extermination.

Raza et al., (2017) examined that after the Millennium Development Goals' implementation of the groundwater is used for drinking purposes. Anthropogenic actions, like industrial waste, open dumping, mining and domestic waste, activated the groundwater impurity leading to poor quality ground water. There is urgent need for proper demonstrations to achieve the Safe Water for Drinking Agenda 2030. They recommended proper legislation, the need to install treatment plants and development

of proper network of monitoring.

Gain et al., (2016) wrote that from the seventeen goals of Sustainable Development Goals (SDG's) United Nations ensured water security to be one of them (Goal 6). Over coming era, at international level many rivers basin shows low water security. Water security is not entrenched only due to physical accessibility of resources of freshwater to meet the water demand but also other reasons like social, economic problems e.g. management tactics, to provide water facilities at institutional level, better water planning and policy for sustainable economy. Recently, advanced tools and technology is available for the valuation of water security. Doing this study they provide the framework of spatial multi- criteria analysis assessment of water security at global level. The indicators used are related to Goal 6 of SGD's. The recommended Global Water Security Index (GWSI) is calculated by aggregating indicators values on a pixel-by-pixel basis, using the ordered weighted average method, which allows for the exploration of the sensitivity of final maps to different attitudes of hypothetical policy makers. The assessment suggested that the countries of Africa, South Asia and Middle East experienced very low water security. Other areas of high water scarcity, such as some parts of United States, Australia and Southern Europe, showed better GWSI values, due to good performance of management, safety and quality, and accessibility. The GWSI maps showed the areas of the world in which integrated strategies are needed to achieve water related targets of the SDGs particularly in the African and Asian continents.

Konikow and Kendy (2005) studied in this article the groundwater depletion as a global problem. The groundwater is decreasing day by day but its use is becoming more increased in every future day. Globally, groundwater withdrawals ranged a total 750–800 km3/year in 2000. However, in many places, groundwater reserves have been depleted to the extent that well yields have decreased, pumping costs have risen, water quality has deteriorated, aquatic ecosystems have been damaged, and land has

irreversibly subsided. It is only when problems of serious aquifer drawdown become apparent and start to imperil socio-economic development that regulatory responses are set in place. Reallocating water resources will play an increasingly important role in groundwater management. In the next few decades, groundwater depletion will likely continue to grow, but at a reduced rate. The change in trend is already evident in several depleted aquifers in the western US, and results in large part from positive management actions, but also to some degree from the tendency towards self-limitation of depletion imposed by hydraulic and economic constraints. The conclusion of the study is that we should not waste our fresh water, and also less use in agriculture and industrial sectors, along with an urgent need to manage our water.

2.2 Establishment of Groundwater Rights

Joshi (2005) studied that in the past, water rights implementation in the United States was full of clashes over acute water resources of tangible and non- tangible nature. The establishment of groundwater rules and regulations was a challenge for them because of its definite conditions. In different states, rules and regulations established were based on different principles. The groundwater consistency in Texas had serious restrictions because of extreme issues of water quality and pumping. The main objective was to apply the groundwater laws in the fifty states of the United States. After the analysis of different states finally, the study established groundwater rights for new Texas.

Santato et al., (2016) worked on the "Water Abstraction License" (WAL) organization in Italy and records that it is not adequately flexible to manage the challenges posed by human-induced and universal environmental changes. In the 1930s, the existing rule was established but modified in 1990s for the devolution of the governing competences from national to the local authorities. The authors examined the most important system in Italy (WAL) and the administrative areas including the Po River Basin District (PRBD). This system PRBD includes a severe and dispersed WAL normative that delays the act, encounter resolve mechanisms at a basin scale, the scheme for the allocation of water

i.e. water pricing is not inspiring, absence of registration of WAL, a water pricing scheme that does not encourage efficient water allocation; and the lack of a central WAL register, and in some circumstances influence environment and effect in the providing new licenses or renovating current ones. They argued that the reduction in these shortages affects the reliability of the riverine ecosystem and economic water usage.

Mechlem, (2016) studied the management of groundwater to protect it and to achieve the goal of bearable water use. The study focused on the permit system of managerial water rights with a need to have a limited level of water usage to deal with the community, customary and casual arrangements. It was concluded that increasing the implementation of domestic groundwater law will strengthen and rate parity with the surface water laws, which ideally cohesively deal with all water resources. The legal framework for groundwater rights has to form an important part for the groundwater authority and have been amended to each country's financial, institutional competences and technologies. It has been made suitable for the environment and geography, duties, values, political systems, and prevalent practices.

Mukherji & Shah, (2005) studied the governance and sociology of groundwater and reviewed the policies of nominated countries. The first objective of the study was to deliver a stable and favorable view and dejected use of groundwater especially in the sector of agriculture. The intensive use of groundwater in countries like Pakistan, Bangladesh, India, Spain, Mexico, and China was under investigation. The second objective of the study was to analyze how to influence the use of groundwater in an organized manner in these countries and which policies have been used and how to simulate an efficient governance model. The study argued that the countries need to change current groundwater pattern from control to governance method.

Wegerich, (2006) explored the management problems of groundwater in the urban and agricultural sector in developing countries. The study argued that groundwater rights were not imposed and established. Access of groundwater rights to everyone lead to rights of land which caused depletion of natural resources and economic instability. This paper suggested that to focus on implementing groundwater rights it is necessary to control the infrastructure in urban areas and set restrictions on installing and using tube wells.

Khalid & Khan (2016) presented that water is vital indegredent for the protection of human beings on earth. Pakistan, like other world countries, particulary in Asia, is facing high population growth, climate changes. Development and governace glitches have compelled and created stress in the country related to water resources. They discussed in the analysis about most dispositions and water security encounters in the areas. It observed about responsible factors about this issue and evaluated impacts for the security of human development and also suggested some recommendations.

Jamal (2018) studied the biggest industrial city, Faisalabad, in Pakistan. During the survey, the study collected data from the households of this area examining the domestic use of water. The method used by them was an instrumental method to check the problem of water pricing endogeneity issues. The study concluded that water pricing is not an effective way of managing the consumption of water. It also suggested starting a campaign for water conservation in developing countries.

Giordano (2009) studied global groundwater and also discussed about issues and solution. Groundwater plays a major, often unrecognized, role in both hydrologic and human systems. The majority of the world's drinking water probably comes from groundwater and in the last half century, there has been an amazing, if largely ignored, boom in agricultural groundwater use that has provided improved livelihoods and food security to billions of farmers and consumers. However, increased use of groundwater

has also created problems, and there are fears sometimes challenged that the boom may soon turn to bust. Researcher in this article compared different countries about water groundwater use. The developing countries waste more water than developed countries; a big example is agriculture sector. Researcher concluded that although a variety of technological and institutional options have been identified and applied to improve groundwater outcomes, the open-access nature of the resource and the political economy of water management have limited their success, particularly as related to the largest consuming sector, agriculture. The governance mechanisms to manage groundwater use have not kept pace with the changing situation. As a result while there are still options for expanded use in some regions, quality decline and aquifer depletion are now major issues in many parts of the world. The suggestion is there is evidence that even where traditional groundwater interventions have failed, policies based on a broad view of resource systems and human adaption could provide new solutions.

2.3 Overcoming Water Scarcity

Rijsberman (2006) discussed water scarcity and was startled to see that water has been scarce in the real sense at a global level and is not managed in a better way. They used Falkenmark indicators for measuring water scarcity. The Falkenmark indicator is very popular and easy to apply but not so much accurate in helping to find out the nature of water scarcity. The Falkenmark indicator is a water stress indicator that is used to measure water scarcity and availability of fresh water for each person in any region in the whole year. It has become a global necessity at a national level for the development of water scarcity management and to assess demand as well as the accessibility of supply. Water is the main source for agriculture, especially in Africa and Asia, which requires a need for the proper management of water. The study recommended a soft path for water scarcity and a focus to increase water productivity.

Veldkamp et al., (2016) studied that the socioeconomic situations and the increased hydro-climatic changes have put pressure on fresh water resources. It is also expected to

aggravate water scarcity conditions towards the future. In this study, they provided a risk based assessment and used Gamma distribution to estimate water scarcity conditions at the global scale under historic and future conditions, using multiple climate change and population growth scenarios. They found out that population growth compensated the impacts of climate change at global and regional scales.

Boretti & Rosa (2019) viewed that the United Nation World Development report in 2018 showed that 6 billion people will suffer water scarcity problem of clean water by 2050. In the event of population increase, there will be increase in water demand; increased demand will lead to the reduction of water resources. It is underestimation that the need of clean water will worsen by 2050. This paper aimed to higlight the interlink between economic growth, population and water demand. There is a need to take steps to regualte economy and demography and enforcement to preserve aquifers, save water and limit the pollution and provide water equally to all.

Postel (2000) stated that freshwater is a finite and non-renewable resource. There are abundant signs around the world that show human water resource use has increased sustainable level. The most water stress indicators are groundwater depletion, level of pollution increase and unreal flow of rivers. New approaches are required to fulfill the demand of water, shortage of food and protecting the environmental services. In this paper they proposed the effort at global level to ensure freshwater ecologies quality and quantity and time of flow needed to accomplish their ecological purposes. To achieve these challenges, policies are needed to promote, rather than discourage water efficiency.

2.4 Summary of Literature Review

The literature mainly talks about the importance of groundwater conservation and management along with suitable groundwater laws, both in developing and developed countries. Most of the developed countries in the world focus on water management issues through the implementation of water laws. Different laws are practiced in different parts of the world. In Pakistan, there is only 1999 irrigation act for water usage

in the agricultural sector while there are no groundwater laws for the urban sector. This type of study has not been conducted in Pakistan, it would be the first of its kind case study in Islamabad which could be replicated in other cities or areas also and it will give us an insight into what people think about groundwater rights. Since Islamabad is a city with a high literacy rate so we can get insight about what people think regarding groundwater rights; whether they should be adopted or not.

Chapter 3

DATA AND METHODOLOGY

3.1 Study Area

The study area of this research comprises selected sectors of Islamabad i.e. G-10, G-11 and G-13. These areas have been selected because of the continuous issue of irregular water supply by the CDA as well as decreasing underground water level. The water supply of these sectors is badly affected. It has been reported that most of the residents of these sectors have to wait in lines outside water regulatory authority offices for securing public water tanker for their house (Rizvi, 2020). Metropolitan Corporation Islamabad (MCI) have also confirmed about this, adding that they have daily basis complaints about water shortage. Collectively, this evidence has highlighted water shortage problem in these sectors particularly which is the reason behind the selection of these sectors.

3.2 Data Type and Methodology

In this study both primary and secondary data was used detailed as under.

- Since there is no published record of groundwater rights in Pakistan, so for the analysis, secondary data was used.
- To check the willingness of the local residents about the implementation of such laws in Pakistan, primary data has been collected through a questionnaire.

There are some groundwater laws in different countries that have been adopted for domestic, agricultural and industrial purposes. These have provided an efficient framework that can be used for identifying the willingness for the adoption of such laws in Pakistan. The data has been collected through various journal articles, published reports and scholarly articles. For achieving objective 1, data was analyzed through narrative analysis. To achieve objectives 2,3-4, questionnaires was used filled from

residents of the targeted areas i.e. sectors G10, G11, and G13. The results of the questionnaires were further analyzed through descriptive statistics.

3.3 Analytical Tools:

The analytical tools applied to the data are simple descriptive analysis as the objectives of the study do not require any elaborate statistical methods.

3.4 Sample Size Calculation and Allocation

The confidence level used is 95% and a confidence interval is 6. The total population of Households (HH) is 17,340 while the total sample size is calculated to be 263. It is proportionally allocated to the study areas namely G10, G11 and G13 with samples of 115, 109 and 39 respectively. The details of the sample size breakup are given below.

Table 3.1: Sample size and allocation

Area	Total no of HH	Sample size
G10	7,562	115
G11	7,184	109
G13	2,594	39
Total	**17,340**	**263**

Chapter 4

RESULTS AND DISCUSSION

4.1 : Descriptive Analysis of the quantitative variables:

A summary of descriptive analysis of the variables used in the questionnaire has been presented in Table 4.1. Majority of the houses in the sample had single bore while some also had 2 bores. The maximum depth of bore is 350 ft. which is considered sufficiently deep. Average bore usage time ranges from half hour to 1 hour (a maximum of 4 hours has also been recorded). It means that the groundwater level is decreasing due to deep and excessive boring. These reasons also cause depletion of the groundwater level.

The local resident pays on average Rs. 500 per month for water tanker in case of absence of CDA water.

The installation of bore duration is a maximum of 9 years. The average age of installed bore is approximately 3 years. Installation of bore increases due to less availability of water from CDA. Descriptive results show that the installation of bore increases with time. As the increase of bore installation causes depletion of groundwater which is a serious threat for the water authorities.

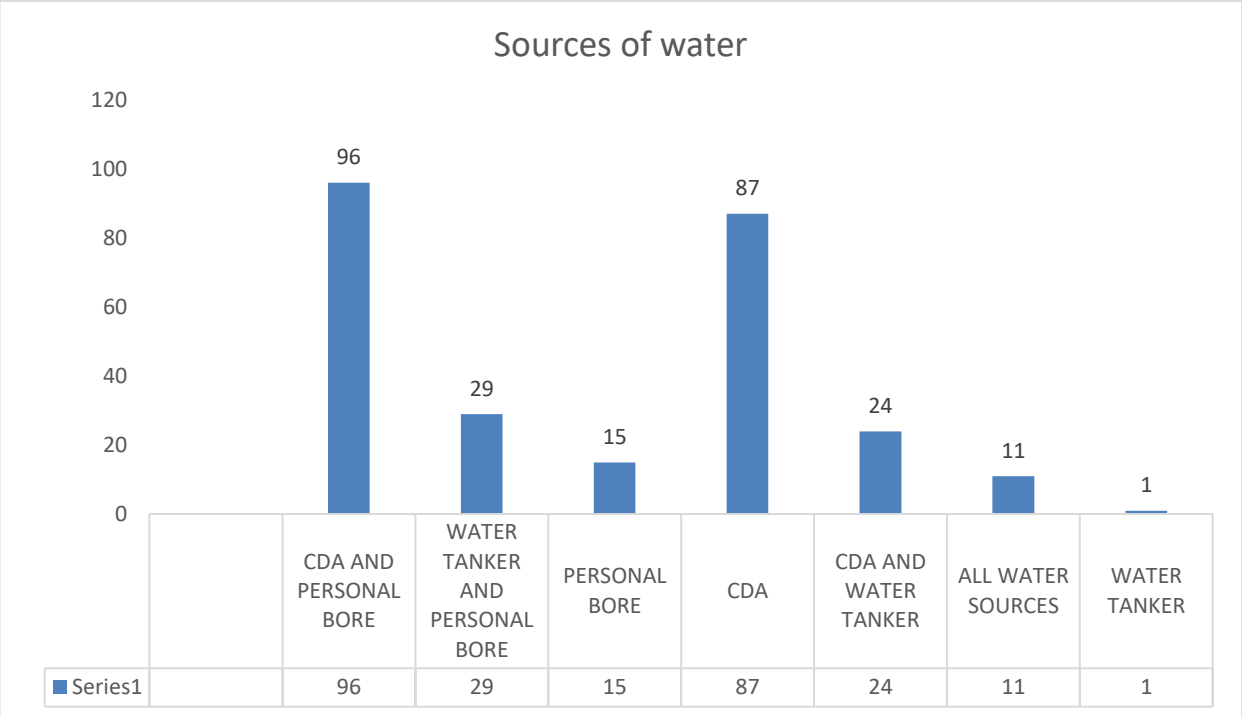
Table 4.1: Descriptive Analysis of Data

	Minimum	Maximum	Mean	Std. Deviation
No of bores	0.00	2.00	0.57	0.58
Depth of bore (Ft)	0.00	350.00	168.0	150.43
Tanker cost per month	0.00	4000.00	500.76	882.14
Reason of depletion	0.00	2.00	0.78	0.84
The available time of bore water (hours)	0.00	4.00	1.00	1.04
Installation of the bore (years)	0.00	9.00	1.50	1.90
Depth of water tank (Ft)	0.00	12.00	3.19	3.24
Water obtained from bore (underground water)	0.00	4.00	1.10	1.23
Independently living or share with tenant	0.00	1.00	0.19	0.40
Share with tenants	0.00	1.00	0.16	0.37
Use bore with tenants/ Neighbors	0.00	3.00	1.04	0.66
Total sample size		**263**		

Source: Author's own calculation

4.1.1: Sources of water

Figure 4.1: Various sources of water used by the respondents



As seen from the literature, it is evident that as yet no law in Pakistan exists for authorizing or regulating underground water for commercial use. Figure 4.1 graphically represents the questionnaire data regarding source of water and shows that from a sample of 263 respondents, only 15 respondents are dependent on personal bore and 87 are using only CDA water. Majority of the respondents (96), were using multiple combinations of water sources such as CDA water and personal bore, water tanker and personal bore, personal bore, CDA water, CDA water and water tanker and all water sources and water tanker. Overall it can be seen that the absence of water laws in the commercial sector is promoting people to rapidly shift towards higher numbers of bore installation due to the provision of free water as 151 out of 263 respondents have a water bore installed in their house. It also negatively affects the underground water level and is a major cause of water depletion from the underground water reservoirs.

4.2: Descriptive statistics of the Qualitative Data:

Permission by respondents for bore installation from CDA:

Table 4.2 shows that only 1.5% of local residents got permission for bore installation from CDA. It means there is no restriction from CDA for the installation of the bore. That is why local residents do not take permission from CDA. This leads to the increased installation of the bore which also causes the problem of water scarcity.

Table 4.2: Permission by respondents for bore from CDA

Responses	Frequency	Percent
No	223	84.8
Yes	4	1.5
Don’t know	36	13.7
Total	263	100.0

Source: Author's calculation

Depletion of Groundwater Level:

Table 4.3 shows that 51.3% of local residents accepted that the groundwater level is depleting. The groundwater level may be depleted due to various reasons i.e. due to the abundance of water bore, lack of water in that area or maybe a technical fault in that area. Since water is not available to fulfill the basic needs of the residents that is why they prefer to install bore. The installation of the bore is boundless which is aiding in the cause of groundwater depletion.

Table 4.3: Feel any Decrease in Groundwater Pumping of the bore

Responses	**Frequency**	**Percent**
No	128	48.7
Yes	135	51.3
Total	263	100.0

Source: Author's calculation

Presence of Odor in Water:

Table 4.4 shows that only 8.7% of local residents complain about the presence of odor in their water while 91.3% of local residents do not feel the presence of odor. The groundwater quality of a particular area may be compromised as compared to other areas. The absence of odor is a good thing as water with bad odor can be a cause of many health problems.

Table 4.4: Found odor in bore water

Responses	Frequency	Percent
No	240	91.3
Yes	23	8.7
Total	263	100.0

Source: Author's calculation

Knowledge of Groundwater Rights:

Results displayed in Table 4.5 show that 94.7% of the respondents do not know groundwater rights. Due to the ignorance of groundwater rights, the issue of water scarcity may not be properly recognized. This may further cause the wastage of a precious water resource.

Table 4.5: Knowledge about groundwater rights

Responses	Frequency	Percent
No	249	94.7
Yes	14	5.3
Total	263	100.0

Source: Author's calculation

Willingness to Establish Groundwater Rights:

About 85% of the local residents are willing for the establishment of groundwater rights and 93% recommend various groundwater laws that are already implemented in developed countries. The residents thought that the establishment of groundwater rights is important as it is beneficial for everyone, including future generations. It is also necessary to tackle the increasing problem of water scarcity. They install bore to overcome this problem without any restriction which further intensify the groundwater depletion. However, the establishing of groundwater rights can ensure to resolve this problem.

Table 4.6: Willingness to Establish of Groundwater Rights

	Responses	Frequency	Percent
Do you think groundwater rights should be established?	No	40	15.2
	Yes	223	84.8
Would you like to recommend local/ provincial/ federal water authorities to establish groundwater rights for Residents?	No	18	6.8
	Yes	245	93.2
Total		263	100.0

Source: Author's calculation

The willingness of the Local Residents for Respective Groundwater Rights:

Table 4.7 shows that most preferable laws by the local residents are Restatement law, Reasonable Use, and Correlative Right doctrine. About 88% respondents are willing to recommend Restatement law. The Reasonable use is also preferred by local residents as 81% show willingness for this law while the Correlative Right Doctrine is preferred by 71% of the local residents. This shows that the local residents are keen to recommend applicable water rights and ensure groundwater availability and safety. Thus, by proper preliminary surveys and research backed evidence, groundwater rights can be considered applicable in the area as the local residents have registered their willingness for its application.

By adopting these groundwater rights we can control bore installations in a systematic way in which certain number and specified depths of bore are allowed in an area. This will not only ensure that the water table in the area is not disturbed but also that the bores do not run dry after some time. The unwarranted installation of bores in an area drastically decreases the water table of that region which is a sign of danger not only for the local residents but for the public authorities also. For this purpose, it would be

better to restrict new bore installations for at least 5 years in these sectors i.e. G10, G11 and G13. The restriction should be imposed by the competent water authorities such as CDA which will ensure that no transgressing of the restriction takes place. During this period, the underground water table will have time to replenish itself after which new bore installations should be allowed under proper regulations and in a limited number. This will ensure that the new installations will not disturb the water table and will continue to provide water to the bore owners as compared to the current ones which run dry after only a couple of months use. The guidelines of all the recommended laws, details for which are given in Chapter 4.1.2, have a thorough account as to how it can be guaranteed that safe and sustainable amount of water is extracted for use from these bore installations. Another way can be for the authorities to install public hand-pumps or water taps at different locations of markaz in every sector from which all residents can draw water at certain times a day. This will ascertain water availability to everyone without unnecessary bore installations in an area.

By taking all these steps, the government can make sure that ground water is used intelligently and sustainably while also guaranteeing its availability to all the local residents. Although the benefits are not immediate, they are certain and much needed in these water scarce times. Thus, the recommendation for the adoption of appropriate groundwater laws should be carefully considered by the water authorities.

Table 4.7: Willingness of the Local Residents for Respective Groundwater Rights

Laws	Responses	Frequency	Percent
Common-Law/ English Rule	No	168	63.9
	Yes	67	25.5
	Neutral	28	10.6
Restatement Law	No	27	10.3
	Yes	232	88.2
	Neutral	4	1.5
Correlative Right Doctrine	No	52	19.8
	Yes	186	70.7
	Neutral	25	9.5
Prior Appropriation Law	No	161	61.2
	Yes	44	16.7
	Neutral	58	22.1
Reasonable use Law	No	37	14.1
	Yes	213	81.0
	Neutral	13	4.9
Total		263	100.0

Source: Author's calculations

Awareness about Groundwater Rights of Bore:

Table 4.8 shows the results for the awareness of groundwater rights for bore that only 3% of local residents know about groundwater rights.

Table 4.8: Awareness about bore Groundwater rights

Responses	Frequency	Percent
No	255	97.0
Yes	8	3.0
Total	263	100.0

Source: Author's calculation

4.2.1 Situational Analysis of Groundwater Rights in Islamabad

The area of the study included G10, G11 and G13 sectors of Islamabad. In these areas, there is an issue of water scarcity affecting the local residents. They meet their water requirements from boring water in their houses. The excessive use of groundwater in this area created water scarcity. There are no rules and laws for the use of groundwater rights. Everyone uses groundwater in any quantity without any restriction costing the other residents as well. The situation of groundwater in Islamabad is getting worsened day by day. So, there is a need to take action to handle this situation for future generation.

4.2.2 International Groundwater Laws:

These laws are US groundwater rights and most of the developed countries follow these laws. Some developing countries also practice these laws.

I. Absolute ownership/Common law rule/ English law rule:

Absolute ownership/Common law/ English rule in which the owner of land owns the groundwater and can withdraw water at any rate/ time even if it harms his neighbors. This law was introduced in 1843 and is still in use in different US eastern states such as Texas. In Texas, it is practicable where water pumping of the landowners is allowed even if it harms the neighbor landowners. (Joshi, 2005)

II. Reasonable Use Law:

Reasonable Use is the law in which the owner of land owns the groundwater below but he/ she can only extract a reasonable amount of it. The origin of this law is traced back to 1862 and it is still in practice. It is also called the American Law and is implemented in Arizona, New York, Oklahoma and many other states of the US. In 1983, this law was defined by the legislature that landowners will extract water by a rational share only (Joshi, 2005).

III. Restatement Law:

Restatement law states that the landowner has a right on the groundwater below his land but he/she can only extract a reasonable amount which does not reduce the water level for others. This law is a mixture of English rule and American rule. This law is practiced in Ohio, Wisconsin, and Michigan. The objective of this law is to protect small owners of wells (Joshi, 2005).

IV. Correlative Right Doctrine:

The correlative right doctrine states that landowners of a common water reservoir have equal rights over it. This law is practiced in Hawaii, New Jersey, California, Arkansas, Delaware, Iowa and some other states of the US. The correlative right doctrine may be taken as granted if excess water is present in the basin and this excess water is not needed by overlying users (Joshi, 2005).

V. Prior appropriation law:

Prior appropriation law holds state as the owner of groundwater and the rights are forwarded on the base of first come, first serve. Under this law, that state is responsible for groundwater. This law is practiced in the western states of the US like Oregon, Utah, Idaho, and Washington, etc. The key problem of this law is that older users may prevent new users from pumping because it may affect the existing

user (Joshi, 2005).

These laws are presented in Table 4.9 below:

Table 4.9: Situational Analysis

Group	Names of Countries	Laws
Developed countries	US, Canada, and Italy, etc.	Common law/English law, Restatement law, Prior appropriation law, correlative right doctrine and reasonable use
Developing countries	Pakistan, Bangladesh and India etc.	There are no specific laws for groundwater

The developed countries mostly follow US groundwater laws. And in developing countries, groundwater laws are not present. Due to the absence of groundwater laws, these countries face serious problems of water scarcity. Water scarcity itself is a big threat as it leads to the shortage of food also. Nowadays, water scarcity is a serious problem in many countries of the world, especially for all the developing countries. Developed countries worked on it by implementing groundwater rights and in this way they have overcome the problem of water scarcity. Developing countries also need to work on it.

4.3 Willingness to Accept Groundwater Rights

During survey willingness of the local residents was checked about the implementation of groundwater rights. In Table 4.6, we see that 85% of local residents are willing to accept groundwater rights and also 93.2% recommend to local/ provincial and federal water authorities to establish these rights.

4.4 Perception of Groundwater Depletion

It is revealed in Table 4.3 that 51.3% of local residents have perceived the depleting groundwater levels. Decreasing underground water levels are being credited to overpopulation, house hire, excess bore installation and lack of check and balance by the concerned water authorities. People are forced to buy water from water tanker associations, which are both public and private. This has resulted in increasing water charges as water bills are separately received by CDA and the cost of water tanker is an addition to it.

4.5 Cost Borne By Local Resident

Due to inadequate or absent water supply from CDA, the local residents are using alternative ways to fulfill their basic need for water consumption. One of them is bore installation, which is a one-time expense and roughly estimates from 1.5 lakhs to 3 lakhs. These information have been taken from pilot survey from the study areas. The second alternative is water supply through water tankers. The maximum cost borne by the residents in the absence of water is Rs 4000 per month, as shown in Table 4.1. Water tanker cost is not one-time and the tanker prices range from Rs 500, in case of the public tanker, to Rs 1500 for private tankers. This is the additional cost that is born by the residents apart from the water supply bills from the CDA.

Chapter 5

CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Conclusion

Groundwater is used for both agriculture and commercial purposes. The massive use of groundwater not only causes water depletion in a specific area but also results in overall water scarcity. After studying the policies of different countries, we can see that some of the developed countries have established groundwater rights which are lacking in developing countries. These laws are namely Restatement Law, Reasonable Use Law, Correlative Right Doctrine, Common/ English law and Prior appropriation law.

During the survey, it was revealed that the local residents are not properly aware of the ongoing situation of depleting water resources underground, although when presented with an option for sustainable water use, they were willing for the implementation of groundwater laws. Most preferable groundwater laws were the Restatement Law with 88.2% acceptance, Reasonable Use Law with 81.0% acceptance and the Correlative Right Doctrine with 70.7% acceptance, as we can see in Table 4.7. The CDA water is not adequately available so local residents have installed bore in their houses which have further caused depletion of groundwater. Due to the depletion of groundwater, local resident prefers other resources such as the use of water tanker to fulfill their basic need of water. They bear a maximum Rs 4000 cost when they use water tankers per month. So, local residents of these sectors are willing to accept groundwater rights established and implemented by the concerned water authorities.

5.2 Recommendations

The study recommends the establishment of commercial groundwater rights to overcome the problem of water scarcity in the residential sectors. These groundwater laws are implemented in developed countries where they have proven to be excellent. They are very beneficial if the government and water authorities work on it. For this purpose, the federal and local government authorities need to take serious action to make efforts for the implementation of groundwater rights. The groundwater rights we recommend are Common/ English law, Restatement Law, Prior appropriation law, Reasonable use, and Correlative right doctrine. In our result, most recommended groundwater rights are Restatement Law, Reasonable Use and Correlative Right Doctrine.

Government must impose regulation on water bore in Islamabad city, because it is not just promoting bore culture because of high price variation but it will also decrease the underground water level on very disturbing level.

Along with this, additional efforts can be done regarding the awareness of sustainable water usage in local residents. Thoughtful water consumption can be a major game changer in conserving water.

5.3 Future Research

For future research, it is suggested to work on the implementation of groundwater laws and also the introduction of new ways to protect groundwater. Along with this, significant work can also be done on the water meter system and water pricing on the use of groundwater.

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APPENDIX-1:

Sector	Circle	HH
G-10/2	501140101	253
G-10/2	501140102	207
G-10/2	501140103	230
G-10/2	501140104	164
G-10/2	501140105	158
G-10/2	501140106	76
G-10/2	501140107	182
G-10/3	501140201	111
G-10/3	501140202	263
G-10/3	501140203	228
G-10/3	501140204	185
G-10/3	501140205	134
G-10/3	501140206	298
G-10/3	501140207	180
G-10/3	501140301	144
G-10/3	501140302	229
G-10/3	501140303	222
G-10/3	501140304	201
G-10/3	501140305	275
G-10/4	501140401	152
G-10/4	501140402	240
G-10/4	501140403	338

G-10/4	501140404	240
G-10/4	501140405	290
G-10/4	501140406	129
G-10/4	501140407	292
G-10/4	501140408	286
G-10/1	501140501	357
G-10/1	501140502	280
G-10 Markaz,G-10/4	501140503	207
G-10/1,G-10/4	501140504	204
G-10/1,G-10/4	501140505	265
G-10/1	501140506	246
G-10/1	501140507	296
	Total	**7,562**
G-11/2	501030101	368
G-11/2	501030102	196
G-11/2	501030103	401
G-11/2	501030104	305
G-11/2	501030105	193
G-11/2	501030106	313
G-11/3	501030107	321
G-11/3	501030108	315
G-11/3	501030109	254
G-11/3	501030110	162
G-11/3	501030111	441

G-11/3	501030112	248
G-11/1	501030201	232
G-11/1	501030202	212
G-11/1	501030203	289
G-11/1	501030204	282
G-11/1	501030205	367
G-11/1	501030206	320
G-11/4	501030207	170
G-11/4	501030208	220
G-11/4	501030209	124
G-11/4	501030210	253
G-11/4	501030211	320
G-11/4	501030212	280
G-11/4	501030213	108
G-11/4/G-11 Markaz	501030214	200
G-11/1	501030215	134
G-11/1	501030216	156
	TOTAL	**7,184**
G-13/4	501030402	161
G-13/1	501030403	281
G-13/2	501030404	369
G-13/2	501030405	676
G-13/1	501030406	274
G-13/3	501030414	113

G-13/4	501030430	264
G-13/4	501030431	101
G-13/4	501030432	54
G-13/4	501030433	169
G-13/4	501030434	132
	Total	**2,594**

Group_____

Groundwater Rights and Water Scarcity: Evidence from Selected Sectors of Islamabad

Survey Questionnaire:

I am an MPhil research student at the department of Environmental Economics in Pakistan Institute of Development Economics (PIDE), Islamabad. My research is relevant to groundwater rights and water scarcity in the G-10, G-11 and G-13 sectors of Islamabad. Your cooperation is appreciated.

Thank you

Section 1

a. Name _____

b. Age _____

c. Qualification _____

d. Marital status _____

e. Family member's _____

f. Gender _____

g. Occupation _____

Section 2

1. How long have you been living in this area?
    a) 0-6 months
    b) 7-12 months
    c) 1 year
    d) > 1 year
2. What is your source of water supply?
    a) CDA
    b) Personal bore
    c) Both a & b
    d) Water tanker
    e) Both c & d
3. If option b/c in in Q-2, then did you take permission from CDA before having a bore?
    a) Yes
    b) No
    c) Don’t know
4. If option b/c in in Q-2, then how many bores do you have in your house?
    a) 1
    b) 2
    c) >2
5. If option b/c in in Q-2, then did you submit any application for bore to CDA
    a) Yes
    b) No

c) Don’t know

6. If option d for Q-2, then how much cost you bear for water tanker per month_____?

7. Did you face any restrictions on bore construction from the authority?

a) Yes

b) No

8. How deep is your bore?_____feet

9. Do you feel any decrease in groundwater pumping of your bore?

a) Yes

b) No

10. If yes for question 9, then state the reason

a) Abundance of water bore in the area

b) Lack of water in that area

c) Technical fault in the bore

d) Any other (specify please) _____

11. What is the quality of water obtained through bore?

a) Clear water

b) Murky water

c) Muddy water

12. What is the color of water obtained through bore?

a) Colorless

b) Yellow

c) Brown/ Muddy

d) Any other

13. Have you found any odor in your bore water?

a) Yes

b) No

14. If yes for Q-13, then what kind of odor is present?

a) Rotten egg

b) Earthy smell

c) Fishy

d) Any other

15. For how much time is bore water available daily?

a) < Half- hour

b) Half-one hour

c) 1-2 hours

d) > 2 hours

16. Do you know about groundwater rights?

a) Yes

b) No

17. Do you think groundwater rights should be established?

a) Yes

b) No

18. If yes for Q-17, would you like to opt for the "common law/ English rule" in which the owner of land owns groundwater and can withdraw water at any rate/ time even if it harms his neighbors?

a) Yes

b) No

c) Neutral

19. If yes for Q-17, would you like to opt for “Restatement law”, in which the land owner has a right on the groundwater but can only extract a reasonable amount which does not reduce water level for others as well as the surrounding takes and well?

a) Yes

b) No

c) Neutral

20. If yes for Q-17, would you like to opt for correlative right doctrine, in which the land owners of a common water reservoir have equal rights over it?

a) Yes

b) No

c) Neutral

21. If yes for Q-17, would you like to opt for prior appropriation law which holds state as the owner of groundwater and the rights are forwarded on the base of first come, first serve?

a) Yes

b) No

c) Neutral

22. If yes for Q-17, would you like to opt for reasonable use law in which the land owner owns the groundwater he/she can only extract a reasonable amount of it?

a) Yes

b) No

c) Neutral

23. Would you like to recommend local/ provincial/ federal water authorities to establish groundwater rights for residents?

a) Yes

b) No

24. How many years ago you have installed a bore in your house?

_____(Years)

25. Are you aware of any groundwater laws for bore?

a) Yes

b) No

26. How deep is your water tank?_____Ft.

27. How much water is obtained from bore in your underground water tank?

a) Full tank

b) ¾ of full

c) Half tank

d) \¼ of tank

28. Would you suggest permission from other residents when someone wants to have a bore?

a) Yes

b) No

c) Neutral

29. Do you live independently in this house or share it with a tenant?

a) Independent living

b) Sharing with tenants

30. If option b for Q 28, how many tenants do you share it with?

a) One

b) Two

31. Do you use the bore independently or share it with tenants/neighbors?

a) Independent use

b) Share with tenants

c) Share with neighbors