SUSTAINABLE WATER SUPPLY SYSTEM FOR ISLAMABAD – THE CAPITAL OF PAKISTAN

By

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THESIS ACCEPTANCE CERTIFICATE

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<u>Dedication</u>

To my beloved Parents

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(Fauzia Rizwan)

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List of Acronyms

ADB	Asian Development Bank
BWSSB	Bangalore Water Supply and Sewerage Board
CDA	Capital Development Authority
CDWP	Central Development Working Party
DOE	Department of the Environment
DWI	Drinking Water Inspectorate
ECNEC	Executive Committee of the National Economic Council
GWSSB	Gujrat Water Supply and Sewerage Board
ICT	Islamabad Capital Territory
IMF	International Monetary Fund
IUWM	Integrated Urban Water Management
KUWSDB	Karnataka Urban Water Supply and Drainage Board
L/c/d	Liters per capita per day
MAF	Million Acre Feet
MCI	Municipal Corporation Islamabad
MGD	Million Gallons per Day
MLD	Million Liters per Day
NRW	Non-revenue water
O&M	Operation & Maintenance
OECD	Organization for Economic Co-operation and Development
PC-I	Planning Commission - 1
PCRWR	Pakistan Council of Research in Water Resources

PPP	Polluter Pays Principle
PSP	Private sector participation
PSDP	Project Supervisor Design Process
Q.A.U	Quaid – e – Azam University
SPSS	Statistical Package for the Social Sciences
UN	United Nations
UPP	User Pays Principle
WHO	World Health Organization

Abstract

World Water Development Report (2013) developed global physical and economic water scarcity map exhibiting Pakistan under ‘physical water scarcity’ and ‘approaching physical water scarcity’. Pakistan is a water stressed country with 1700 cm/c/d water availability, destined to become water stressed by the year 2035.

Islamabad, the capital of Pakistan is facing a huge gap of 52% in the water supply in comparison to the water demand in city. It has a population of 2,006,572 with an annual growth rate of 4.71%. Around 58 MGD water is being provided in the city while the actual demand of the city was 120 MGD. This study aims to investigate the existing situation of water supply system in Islamabad and assessing the issues pertaining to sustainable supply of water. The indicators of sustainable supply of water have been reviewed. Case studies regarding water supply situation, challenges faced, and sustainable solutions and strategies adopted, in developed and developing world, have also been discussed. Structured interviews have been carried out with concerned government officials at Municipal Corporation Islamabad to gather their opinions and issues about the subject matter. Public perception survey has been carried out from select sample in Zone-I residential sectors of Islamabad to inquire resident’s satisfaction level regarding water supply system and their willingness to contribute if any interventions/improvements are carried out.

The study revealed that un-metered water supply is being provided to nearly all residents of Zone-I of Islamabad through MCI pipelined water supply. One-third of the water being supplied is lost due to line losses and illegal connections/water theft. The system is old laid, damaged and expenses borne on water supply are 6-8 times more than the recovery made. YIS Satisfaction Index developed through public opinion survey shows that the respondents are not satisfied with the volume/quantity, pressure, quality, continuity (both in summers and winters), schedule of supply,

service quality and overall management of the water supply system. They graded the water tariff being charged as normal and are willing to pay more than double of existing in case of improvements/interventions in water supply system.

Recommendations for control of leakage, illegal connections/water theft have been drawn, along with, allocation of budget for maintenance of reservoirs and supply system; quantifying the exact demand in capital based on latest standards, realization of planned projects; and metering and pricing of the system to ascertain efficient use of water supply.

1 INTRODUCTION

1.1 Background

Clean drinking water is undoubtedly the most essential requirement of life on Earth but the last few decades have witnessed decrease in availability of clean drinkable water in different regions of the world (Pedro-Monzonís, Solera, Ferrer, Estrela, & Paredes-Arquiola, 2015; Tomory, 2015). The availability of fresh drinking water is very rare as 3% of the water on this planet is fresh, while rest of the 97% is in the ocean which is not drinkable. The freshwater is further distributed, where, 69% forms the glaciers and 3% lays underground which leaves only 1% groundwater for use (Black, 2016). Water-stress and potential scarcity of water will become a major concern in the years to come. Although the issue of water scarcity was viewed as a part of the collective global issues like climate change, depletion of energy sources and poverty; it has now become the prime concern for the world (Postel, 2014).

Studies have shown that approximately two-thirds of the total population of the world currently resides in regions that are facing the problem of water shortage for at least 30 days annually. Additionally, almost 500 million people are currently residing in regions where water consumption has surpassed the locally available renewable resources of water by a factor of two. Non-renewable assets like fossil groundwater is being used in the most vulnerable regions of the world but those resources are also decreasing at a fast pace. As a result, those regions are now highly dependent on provision of water from areas that have water abundance (Barlow & Clarke, 2017). More than 1.7 billion population of the world is residing in river basins at present. The use of in these basins exceed recharge which results in desiccation or dryness of rivers, deterioration of ecosystems and diminution of groundwater (United Nations Department of Economic and Social Affairs (UNDESA), 2015).

Furthermore, the quality of water is inherently associated with its availability and tends to decrease with the decrease in the quantity of water available for use by the community. Another reason for degradation of the quality of water is untreated sewage coupled with inefficiently treated wastewater from the industrial sector and agricultural runoff (Vörösmarty et al., 2010).

Continuation of current trends can lead to further degradation of water quality, especially in developing and under-developed countries which can endanger the overall ecosystem and life on Earth. Degradation of water quality can further contribute to scarcity of water which can result in restraining sustainable economic development (Pearce, Barbier, & Markandya, 2013).

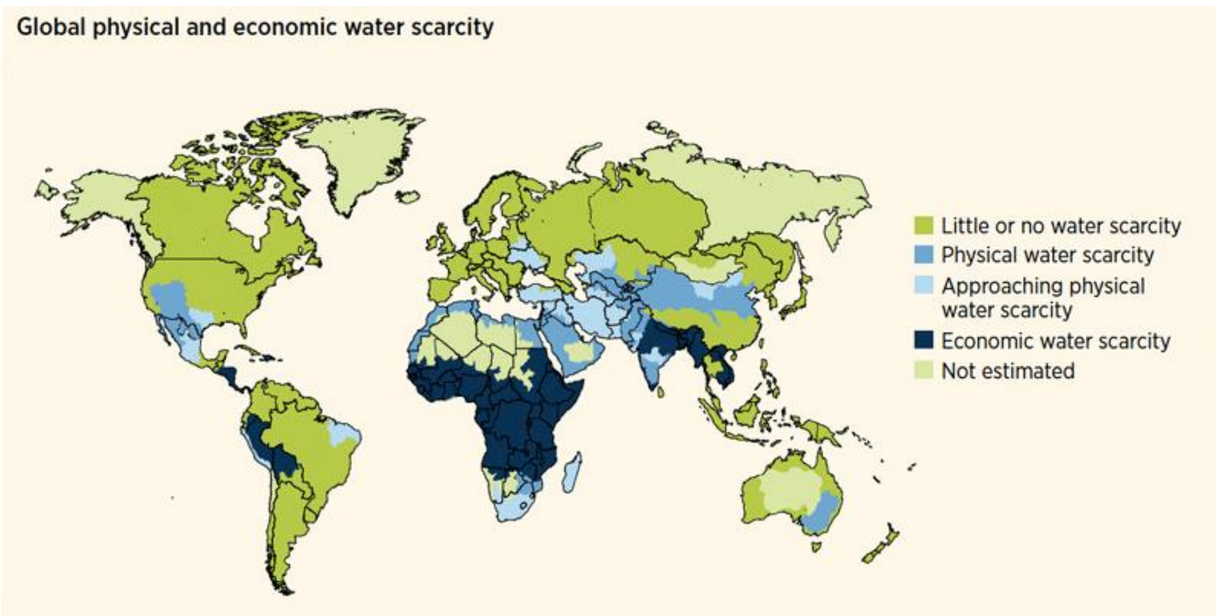


Figure 1-1: *World Water Scarcity Map*
Source: (United Nations, 2013)

In 2016, World Water Development Report, Water and Jobs was launched by United Nations which claimed that 75% of all the jobs are dependent on water worldwide. This further signifies that shortage of fresh water can adversely affect the economic growth globally as water is termed as the one of the most significant factors required for provision of employment opportunities because different industries like health, power, agriculture, and fishing are highly dependent on availability of fresh water (United Nations Educational, Scientific and Cultural Organization, 2016).

A recent water scarcity map shared by the UN is shown in figure 1, whereby parts of Pakistan lies under the areas highlighted as ‘Physical water scarcity’ and ‘approaching physical water scarcity’ (United Nations, 2013). A report by UNDP has highlighted the impending water crisis that awaits Pakistan in the near future and has become a severe threat for the stability of the country. According to this report, the experts have claimed that Pakistan will most likely dry up by the year 2025 (United Nations World Water Assessment Programme, 2017). This issue was highlighted by Pakistan Council of Research in Water Resources (PCRWR) in 2017 as well (The Express Tribune, 2017).

The Pakistani Water and Power Development Authority have stated that policies for water management and storage are non-existent in the country which has further aggravated the problem of water scarcity. In 1990, Pakistan reached the "water stress line" but no action was taken at that time which led to crossing of "water scarcity line" by the country in 2005 (Shah, 2017).

Furthermore, this problem is intensified due to the fact that the masses are competing for this resource and the competition will further increase with the passage of time as the shortage of water grows with the passage of time (Lee & Schwab, 2005). One major reason for this is that with the increase in size of population and high standard of living, the demand for clean and drinkable water increases which further aggravates the tension and competition among the users. This situation can worsen in the near future as most of the industrialization, urbanization and irrigation of the world is regarded by unsustainable patterns of use of fresh water (Abedin, Habiba, & Shaw, 2014).

1.2 Problem Statement

Pakistan has been ranked fourth globally, in terms of rate of use of water due to dependency of its economy on agriculture. Pakistan has the highest rate of water usage in the world which signifies the quantity of clean water in cubic meters that is utilized per unit of its GDP (Sharif, 2011). This indicates the level of dependency Pakistan has on fresh water for growth and development of its economy. International Monetary Fund (IMF) has already pronounced Pakistan as the third most water-stressed nation internationally which is in line with the reports given by World Bank (Mekonnen & Hoekstra, 2016).

World Bank has reported that during the year 2000, Pakistan became a water-stressed country (1,700 cubic meters per capita per year). Pakistan is facing a risky situation as water availability per capita has declined from 5000 cubic meters to 1500 cubic meters over a stretch of hardly 50 years. Water scarcity is defined as annual availability of water below 1000 cubic meters, so Pakistan is destined to become water scare by the year 2035 (Archer, Forsythe, Fowler, & Shah, 2010).

Islamabad is the capital city of Pakistan with a total population of 2,006,572 and an annual growth rate of 4.71%, the highest as compared to anywhere else in the whole country, according to the Census Survey 2017 (Pakistan Bureau of Statistics, 2017). Around 64 MGD water is being provided in the city. The print media, especially newspapers have highlighted water-stress in the city indicating a demand of 123.8 MGD in 2010. This seems to be a huge gap indicating water stress in the city. Moreover, water demand management and current metering and pricing systems are also prime areas of concern for the authorities (The Express Tribune, 2017).

1.3 Research Questions

Following are the research questions aimed to be answered from this research;

1. What is sustainable water supply?
2. What are the factors affecting the sustainable supply of water?
3. What are gaps in water supply and demand in the capital city of Islamabad?
4. What are the problems/issues faced based on the factors affecting the sustainable supply of water to the residents of Islamabad?
5. What is the perception of the municipality officials, operators and residents towards the issues pertaining to efficient water supply?
6. What are the challenges faced by MCI or other stakeholders in this context?
7. How can metering and pricing systems effect water demand management in the capital?

1.4 Research Objectives

Following research objectives have been developed keeping in view the nature of the problem to be studied;

1. To investigate the existing situation of water supply in Islamabad
2. To identify parameters/factors for sustainable water supply
3. To study issues pertaining to efficient water supply system
4. To devise strategies for sustainable water supply system
5. To study willingness of residents of Islamabad towards interventions in water supply system

1.5 Rationale of Study

This study aimed at assessing the current situation of water supply and gaps associated with its demand at present and in the years to come under the current growth strategies. Also it aims at studying the current water supply system of Islamabad in the context of physical infrastructure, operation of the system along with its maintenance and lastly; the water pricing and metering mechanism. The study aimed to come up with recommendations in current water supply system operation, maintenance and pricing in context of the current urban growth strategies. Such a comprehensive study would bring about a clear picture of the current water crisis in Islamabad along with areas of concern requiring efforts for improvement. The conclusions and recommendations would be helpful for the government officials in order to understand the major issues and measures needed to solve the crisis.

1.6 Scope and Limitations

Additional time and resources would be needed for acquiring a more detailed study of the current state of the water scarcity and its consequent effects on the environment, residents, and social setup of the city. Nevertheless, due to lack of necessary resources required for carrying out a more comprehensive study; and time constraints, only selected sectors (F, I, and G) of Islamabad were chosen for collection of primary data. As far as the sample size for data collection is concerned, it was also dependent on limited human and financial resources in addition to lack of availability of time.

1.7 Research / Thesis Organization

Chapter 1 provides general introduction of water demand and stress, problem statements, research questions and objectives. Chapter 2 presents the literature review in the light of the research study topic and research objectives. Chapter 3 is the research methodology which sheds lights on the entire process of the research, selecting the study design, sample size, selection of instrument for data collection and data analysis techniques. Chapter 4 includes data collection and analysis. Chapter 5 includes findings and discussions while Chapter 6 includes conclusion and future research. At the end, references for the research study are provided.

2 LITERATURE REVIEW

2.1 Defining Water Stress and Water Scarcity

International Water Management Institute has reported that although clean water is the most essential necessity for humans, approximately 1.2 billion people still do not have access to clean water (Gleick, 2014). World Wildlife Federation has claimed that by the year 2025, two-thirds of the total population on this Earth could be exposed to the issue of water shortage as the freshwater supplies that are currently available at present are diminishing at a fast pace (Garcia, 2003). Additionally, UNESCO has reported that demand of water will see a 40% rise by the year 2030 (United Nations Educational, Scientific and Cultural Organization, 2016). By the same time, the global population is projected to cross the 9 billion mark which will consequently put pressure on means of water supply (Schewe et al., 2014).

The concept of water scarcity describes the lack of clean water resources for humans and their various needs. Due to the diminishing sources of clean water, the issue of water scarcity is progressively being identified as a growing concern in numerous countries (Sachs, 2012).

The ‘Falkenmark indicator’, also known as the ‘water stress index’, is the most popular method employed for measuring the level of water scarcity. This method is based on the concept of defining the water scarcity in terms of all the available resources of water for the population of a particular state or region. Scarcity of water can be measured as the volume of the available renewable freshwater for every individual each year. A country is said to be water-stressed if the volume of renewable water in that particular country is lower than 1,700 cubic meter / person / year. Furthermore, a country is categorized as a water-scarce region if the volume of renewable water in that particular country is lower than 1,000 cubic meter. Likewise, the volume of renewable water lower than 500 cubic meter is characterized as the absolute water scarcity (Falkenmark et al., 2007).

2.2 Water Stress and Water Scarcity around the globe

Urbanization, globalization, population growth, industrialization, energy and food security policies, trade and its macro-economic procedures and constantly changing consumption patterns are some of the main sectors that influences the overall demand of water globally, and the demand for water is most likely to increase in all of these sectors in near future (WWaP, 2012). As mentioned earlier, the population all around the globe will be facing an increased 40% of water deficit by 2030 if the business-as usual situation continues (2030 WrG, 2009).

The ever increasing population has resulted in highly localized pressure on the resources of available freshwater specifically in regions that are drought-prone. Approximately 50% of the total population of the world is urbanized now; and 30% of the population of cities lives in slums. By 2050, the total urban population of the world is expected to rise to 6.3 billion (W. WWAP & WWAP, 2012). Reports have shown that 93% of the urbanized population lives in the developing nations, out of which, 40% will be living in slums by 2030 as the urban population in Asia and Africa is most likely to be doubled by that time (UN-Habitat, 2010).

Apart from urbanization, water consumption for production of energy and agriculture will further intensify the issue of water scarcity in near future. Production of energy uses 15% of the total water resources of the world at present. And this number is expected to reach 20% by the year 2035. Additionally, the agricultural sector is known as the biggest sector that is responsible for almost 70% of the freshwater withdrawals worldwide, and more than 90% in majority of the least-developed nations of the world (U. WWAP, 2014).

2.3 Defining Sustainability

2.3.1 Sustainable Development

According to WCED (1987), p.43:

"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

2.3.2 Dimension of Sustainability

There are five major dimensions of sustainability;

1. Social
2. Cultural
3. Environmental
4. Economic
5. Governance (Seghezzo, 2009).

2.4 Sustainable use of Water

Water-resource planning does not merely focus on deciding the type of projects that need to be built for catering to the needs of or simply assessing the type of schemes that would be most cost-effective (Ghaffour, Missimer, & Amy, 2013). Water has recently been termed as a community resource and a common good, but due to its extensive use in commercial sector, it has also been categorized as an economic commodity. Successful implementation of principles related to equity and sustainability can play a vital role in bridging the gap between different sectors that are competing for acquisition of this commodity (Marlow, Moglia, Cook, & Beale, 2013).

Sustainable use of water can be defined as the use of water by a community in such a manner that would help in maintaining the anticipated flow of benefits that would not be diminished over time. Demand for water is comprised of needs as well as wants of the people of the society. This latter part of the demand for water is potentially much greater than the fundamental needs (Gleick, 2014). This definition of sustainable use of water is flawed as it benefits one group of users by compromising the other group. A better definition of sustainable use of water would focus on integrating the benefits of all groups of users and maintaining efficient provision of water to all users without adversely affecting the natural ecosystem (Marlow et al., 2013).

This definition can further be improved by taking into account the requirements of future generations. The sustainability of use of water needs to be maintained by considering the benefits of present generation without affecting the aptitude of provision of equivalent remunerations into the future; this is in line with the definition established during the work of the World Commission on Environment and Development (WCED, 1987). Benefits of water and its use can be further subdivided in numerous categories based on the nature of its use including; industrial, domestic, agricultural use and its use in the natural ecosystem and so on. Use of water is categorized by the well-being that is provided by use, like satisfaction level, human and ecological health, economic wealth and so on. Sophisticated methods of water use based on well-being are rather challenging to quantify but once quantified, they give a comprehensive picture of the consequences of the use of this as compared to the conventional method of simple quantities of per capita use (Marlow et al., 2013).

Use of water is unsustainable if the services provided by water resources and ecosystems, and desired by society, diminish over time. Equity also requires that a reduction of services over time to one user group be declared unsustainable even if other users are able to maintain their desired services (Smith & Lant, 2010). After considering all of the aforementioned issues, Gleick (2014) came up with definition of sustainable use of water which is as follows:

"The use of water that supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depend on it"

2.4.1 Components of Sustainable Water Supply

The sustainable water supply components include;

Storage Reservoirs; These can be surface water reservoirs like dams, lakes or ponds; or storage tanks or overhead water tanks constructed with the purpose to store water.

Physical Water Supply System; The waterline comprising main conduction lines from reservoirs to pumping stations or overhead tanks, the primary and secondary lines taking water supply to the end users, valves etc, form the main physical water supply system.

Treatment Facilities; The water supplied to users is treated before supply to improve its quality uptill the standards devised by WHO, treatment facilities are therefore an important part of the whole system of water supply.

Operation & Maintenance System; The municipality or city managers entrusted with the supply of water to the city, along with the field operations and management staff; the system established for compliance by employees regarding maintenance, the complaints system and the financially system make the whole O&M system.

Billing System; This is the system developed for cost recovery either bank based billing, through cash in municipality office, online services or any other.

Consumers; These are the most important part of the system, as the complete system is dependent on their requirements and feedback. For an efficient system the requirement must be calculated and feedback sought after supply.

2.4.2 International Standards for Water Requirement

There is much discussion on what should be the standard for water requirement per capita per day. Different standards have been derived over the years and are followed around the globe. According to World Health Organization (2010), a person needs 50 to 100 liters of water per day to fulfill his requirements including personal hygiene, drinking and cooking. A study by US Geological Survey in 2015, showed that a female may use 273 l/d, a male may use 164 l/d, a child may use 161 l/d and a retired person may use 401 l/d (Mohandas,2013). In emergency situations, WHO declares basic hygiene and foods needs can be taken care of in 20 l/day, however, laundry and bathing will require additional water.

Table 2-1 shows the most basic requirements of water needed for use excluding the quantity of water needed for growing food as discussed by WHO (Gleik 2014):

Table 2-1: Basic water requirements for human needs
Source: (Gleick, 2014)

Purpose	Recommended Commitment (Liters/day)
Drinking Water	5
Food Preparation	10
Bathing	15
Sanitation	20

2.5 Integrated Urban Water Management

Water scarcity has resulted in numerous conflicts between different sectors over water rights. In urban areas, the competition with and between industry and agriculture sector is increasing with the passage of time due to expansion of cities as well as political influence. As the domestic and industrial demand of water is estimated to double by the year 2050 (Watkins, 2006), the resultant competition among peri-urban, rural and urban areas will most probably intensify (Eliasson, 2015). When a water basin is shared by more than one country, the scenario of water demand and supply becomes even more challenging. Two in every five individuals are projected to be living in such trans-boundary basins that cover approximately 15% of the total land surface of the world (H. Munia, 2016). Cities located in trans-boundary basins rely on urban water infrastructure for their demand of water; the institutions responsible for management of water are unresponsive and inadequate which has resulted in a compromised system of water resources and endangers public health (Feldman, 2017).

2.6 Conventional urban water management

The aim of the urban water management is to ensure uninterrupted access to water and sanitation infrastructure and its subsequent services to the habitants of the community. It is also responsible for managing wastewater, rainwater, runoff pollution, and storm water drainage, while governing different waterborne diseases, mitigating droughts, floods, and landslides, and precluding degradation of this resource. Although the conventional strategies for urban water-management have not been able to cater to the existing needs, the demand for water is mostly likely to increase in the near future (Van der Bruggen, Borghgraef, & Vinckier, 2010; Wong & Brown, 2009). The conventional practices adopted for urban water management are outdated in the light of present day challenges which include climate change, urban growth and other such issues. The practice of managing different elements of the conventional urban water system in isolation has resulted in an unstable urban 'metabolism'. As a consequence, the urban planning processes have been separated from urban water issues (Bakker, 2010; Organization, Supply, & Programme, 2015).

In the past, sanitation, storm water drainage, clean water supply, wastewater treatment, and solid waste management were planned and implemented as separate amenities. Different authorities supervise the subsectors of water at city level which are guided by distinctive guidelines and legislations. The issue with the conventional urban water-management model is that it has not been able to differentiate between several water qualities so that they could be identified for use by different sectors. This has resulted in diverting high-quality water to haphazard urban water needs (Corcoran, 2010).

Furthermore, this problem is also seen in basin-level management as well because they habitually neglect to recognize the cross-scale interdependencies in wastewater, storm water freshwater, and flood control. In the conventional urban water management system, water is obtained from different upstream sources and is then distributed in different urban regions, where it is used and polluted, then channeled back downstream in an untreated form (Kummu, Ward, de Moel, & Varis, 2010).

2.7 Integrated Urban Water Management

Integrated urban water management (IUWM) cannot not be perceived as a quick fix for all the issues related to isolated urban water management instead, it helps in reframing the association of water with other resources in a city in addition to re-conceptualizing the methods that can be adopted for overseeing these resources (Bahri, 2012). In short, IUWM can be summarized as follows:

- This system comprises of all the sources of water in an urban setting, like; blue water (groundwater, desalinated water, transferred water, surface water), reclaimed water, brown, yellow, green water (rainwater), black, storm water, and grey water (wastewater), in addition to virtual water (Ziemke-Dickens, Droogan, Anderson, & Harmon, 2010).
- This system helps in matching the quality of different water sources (storm water, surface water, reclaimed water, wastewater, and groundwater) with the type of quality of water needed for several types of uses (Bahri, 2012).
- Consideration of water distribution, storage, recycling, treatment, and disposal as a cyclic process rather than discrete activities, in addition to planning the entire infrastructure as per requirements (Pikaar et al., 2014).

- Plans for exploitation, conservation, and protection of different water resources as well as their source (Pikaar et al., 2014).
- This system also helps in seeking and recognizing all the formal and informal institutions that administer water in different cities (Zarghami, Abrishamchi, & Ardakanian, 2008); and
- IUWM also focuses on balancing the social equity, economic efficiency, as well as the environmental sustainability. (Zarghami et al., 2008).

Table 2-2: Comparison between past and present Urban Water Management
Source: (Bahri, 2012)

Past Urban Water Management	Future IUWM
Old rainfall records are used for devising water and wastewater systems.	Wastewater systems and water supply depend on numerous sources of data as well as techniques that can accommodate greater level of variability and uncertainty
Water is channeled is such a way that it follows in a one-way direction from supply and is directed for single use followed by treatment and disposal.	Water is channeled is such a way that it can be reclaimed and reused several times, flowing from a higher quality to lower quality
Storm-water is transported swiftly from urban areas.	Storm-water is garnered as a source of water and retained for supporting watercourses, aquifers, and foliage
Human waste is treated and then disposed off	Human waste is used as a resource after being processed, and utilized as a fertilizer
Linear approaches are deployed for discrete systems for collection, treatment, utilization, and getting rid of water.	Regenerative and restorative methods are employed which offer integrated schemes for providing energy, water, and resource recovery associated with land-use design, community health and regulations.

This system determines the infrastructure by calculating the volume of water that is needed or produced by the end-users. The supply-side of the water is treated for use as per potable standards; and all the wastewater is gathered for treatment.	This system devises an infrastructure that is in accordance with the characteristics of water produced or required for the end-users in appropriate quantity as well as quality, in addition to level of reliability
This system consists of gray infrastructure which comprises of metal, concrete, or plastic	This system consists of green infrastructure and make use of vegetation and soil in addition to metal, concrete, and plastic
All the systems for collection and treatment are centralized	All the systems for collection and treatment can be decentralized
Main focus of utilities is accounting and tracking the costs incurred	Utilities assess all the benefits resulting from technology choices, investment and focuses on value creation
Business-as-usual toolkit is employed as a standard	An expanded toolkit is used which consists of multiple options like low-tech, high-tech, as well as natural systems
Institutions and protocols discourage innovation.	Institutions and protocols encourage innovative ideas
Collaboration is perceived as public relations. Public and other agencies are only involved when consent of prearranged solution is needed.	Collaboration is perceived as engagement. Public and other agencies are actively involved so that effective solutions could be sought

2.8 Water Supply Systems around the Globe

2.8.1 Water Supply System in Developing Cities

Urban Water Supply in Banglore & Karnakata, India

According to an analysis of water supply situation in cities of India based on 2011 Census following information was brought to surface by IIHS Paper; As per reports of Census 2011 regarding distribution of households, the principal source of supply for drinking water was tap water which was accessed by 70% of the total population, out of which, only 62% were able to access treated tap water. This leaves approximately 40% of all the urban households that do not have any access to public water supply and consequently depends on other sources for supply of water. Moreover, not all households that have access to public supply have access to it within the premise. Only 49% of households have access to piped water supply within their premises (Ravikumar, Mehmood, & Somashekar, 2013).

KUWSDB and BWSSB are mainly in charge of water supply management to the urban population of 27 different neighborhoods or districts in Karnataka as well as Bangalore respectively. Current withdrawal by Bangalore for water supply is approximately 582 MLD but has the potential to produce 724 MLD. It should be noted that the distance covered by the source of water from the city can be of great significance because the distance plays a major role in the cost incurred by the supplied water. Higher transportation costs are incurred due to long distances and also results in loss of clean water due to leakages and other such issue (Ravikumar et al., 2013).

Per capita availability of supplied water was reduced to 45 liters per day in 1931 which was previously 86 liters per day only 31 years earlier. This was due to increase in population of the city. Due to investments in the Akravathi were made which helped in improving the per capita availability and climbed up to 75 liters per capita per day in 2004 (Nagendra & Ostrom, 2014). The target per capita supply of water has still not been achieved which is 150 liters per day and is attributed to the loss of 'unaccounted for water'. The water demand of the city, at present, is 840 MLD which simply implies that the Supply of water falls short by approximately 258 MLD (Ranganathan, Kamath, & Baindur, 2009).

The GWSSB project proposed for meeting the water demand is estimated to cost approximately 410 Crore INR. Reports have shown that BWSSB bears around Rs.34.25/Kiloliter for supplying water to Bangalore. Subsidized rates are paid by domestic users in the city for consumption of water supplied by BWSSB. However, the tariffs that are charged by the KUWSDB are much lower for domestic consumption. (Ranganathan et al., 2009). The Minimum Uniform rates of water that are charged outside the city are as follows:

- Rs.2/kiloliter in regard to Town Municipal Councils as well as Town Panchayats
- Rs.2.50/kiloliter in regard to City Municipal Councils
- Rs.3/kiloliter in regard to organizations other than Bangalore (Hegde & Chandra, 2012).

This case study implies that the main problem is related to management of demand and supply of water to the population in addition to earning adequately so that it could be reinvested. Hence, privatizing the water supply system ought to be taken into account if such an initiative can meet the estimated demand of water and incurs minimal costs (Hegde & Chandra, 2012).

Urban Water Supply in Mekelle City, Ethopia

Water is the lifeblood of the world and is considered as a national resource of utmost importance. Water scarcity affects the entire community, so anything that disturbs the provision and supply of water tends to jeopardize the very survival of humanity (Van Koppen, Moriarty, & Boelee, 2006). Water supply is indispensable in both urban and rural areas. Therefore, the accessibility to adequate clean water, to produce food for both rural and urban population, is one of the many aspects of the role that is played by water for fulfilling the fundamental requirements and contributing to the overall development (Organization, 2004).

In Mekelle city, water is supplied to residents through public taps and pipelines, pumped in from reservoirs, and collected from any available sources. According to Asgedom (2014), it is assessed that around 51-60% of families have access to tap; other families obtain water through any sources available. In the same reference it is revealed that because of inadequate sanitation and access to sources of potable water each year, residents of the city were suffering from different diseases such as diarrhea (Oyedotun, 2017).

According to Saleamlak (2013), the main issues related to water supply in Mekelle city are non-revenue water and water loss. 4,456 m^3/day water losses were reported in 2008 in the distribution system. In Mekelle city, water supply coverage often vibrates between 41% up to 51% (Araya, 2013). The main supply of water for Mekelle city is primarily from piping connection coming from groundwater at Aynalem well field. This source is augmented by other sources like untreated water from wells, by buying from water vendors and kiosks, and shallow boreholes. According to, Mr. Nega, head of Tigray Water Resource Bureau speech on the second quarter regional parliament forum (2010), the daily water demand by the city community is estimated to be 42,000 m^3, which is 1,260,000 m^3 per month. As per the annual report of Mekelle Water Supply Service office (2009/10), there are 17 boreholes of water supply sources for the city (for not less than 54,073 households, multiple non-government as well as governmental administrations; industry and service companies) with a total average yield of 329,330 m^3 per month, which is 3,951,954 m^3/year. This shows there is a considerable gap in production in the form of 900,670 m^3 per month. Even though most water related investigations undertaken in the city show the existence of serious potable water shortages and frequent water service interruption, no investigation is carried out so far in the reasons as well as challenges of water supply in the city (Lapworth et al., 2017).

According to Asgedom (2014), an average family size of the households is 5.41 and the calculated average daily water consumption of households per day is 60 liters. Based on secondary data from the Water Supply Service Office of the city, the current condition related to the water sources, distributions, reservoirs, productions, and pipeline networks in the study city are presented below.

The existing water supply system of Mekelle city encompasses pipeline works including transmission mainlines, which are connected to each borehole, collecting water from the sources directly to the artificial storage that is reservoirs. The water supply service office, in its 2010 annual report, stated that the present major water supply source of Mekele city is groundwater from 17 boreholes. The supplied water is lost due to many reasons (Lema & Beyene, 2012).

Mekelle, like most major towns in Ethiopia, obtain almost all its domestic water supply from groundwater. The available groundwater sources from where the city is collecting for the domestic and productive consumption is becoming depleted from time to time. This problem is aggravated by the rapid rate of population growth; rapid expansion of the city coupled with other avoidable problems such as electric power failure resulted in the existing water supply to be inadequate. Even though, the Water Supply Service Office is drilling additional boreholes from year to year, there are also wells which are becoming non-functional. The water catchment sites are bare and deforested. This hinders groundwater recharging from rainfall percolation. Besides, the produced water does not effectively reached to end users due to water leakage, frequent electric power failure, lack of expertise of employees of the office, inefficiency of management and other related issues (Araya, 2013).

The study showed that the water supply coverage of Mekelle city is often close to 40%. But, because of the aforementioned reasons water supply coverage of the city in 2009/10 was less than 30%. Even though, total water production of the year increased, the unsatisfied water demand of household for domestic activities raised to 72%. This is mainly due to water demand increment. Above all the unequal water distribution in the city made it a burning issue. Due to the aforementioned root causes, the gap between demand and production is found to increase from with each passing year (Asgedom, 2014).

2.8.2 Water Supply System in Developed Cities

London, England

London has a population of approximately 7,100,000 inhabitants and has a density of an estimated 4,480 inhabitants/km^2. Use of water is reported to be around 140 lit /day/capita according to data collected in 1991 (Walker, 2014). London does not have a metering system for the water demand for domestic use. Approximately 82% of the total households of the country do not have connections with any metering system. Water prices are administered by the government based on the value of the property values and are then are topped by a fixed charge. Thus, the system does not reflect the actual demand of the water in the city (Bithas, 2008).

Until 1974, the prices of water supply were kept quite low but within a span of five years, an increase of more than 97% was seen in the water pricing system (Bithas, 2008). In 1989, extended privatization was seen in the country which led to continued rise in water charges. At present, pressure is being exerted on the authorities to reduce the charges being paid by the domestic users for water consumption (Liu et al., 2017).

The water pricing system in London does not take into account opportunity, environmental, and user/scarcity costs. The reason for this is that the opportunity costs are insignificant due to numerous water resources. The same holds true of user/scarcity costs. Even though there are some environmental costs incurred by the water supply system but due to the advancement of the environmental management system, severe and adverse ecological effects are easily avoided. Consequently, the principal reason of the wasteful use of water is the absence of and effective metering system (Laski et al., 1935; Bolton, 1988; Hassan, 1998).

Athens, Greece

Athens has a population of about 3,100,000 inhabitants (Lasaridi, Rovolis, & Abeliotis, 2006). The water distribution network of the city is approximately 7,000,000 m in length. The water consumption of domestic sector is 98–115 lit/day/capita (Koutsoyiannis et al., 2003). The water supply system of the city is highly dependent on remote water resources as the city is prone to droughts and lacks the basic necessities in terms of water resources (Iglesias, Garrote, Cancelliere, Cubillo, & Wilhite, 2009).

The Greek state (investment costs) is responsible for financing the water supply system but a public fund has been established for sharing the burden of operational costs of the water supply system. The pricing system introduced in the city aims at covering most of the operational cost incurred. At the same time, other costs like opportunity, environmental, and user/scarcity costs have not been considered even though they are quite noticeable. This implies that the water prices being paid by the local people only reflect the average operational costs incurred for provision of water. Consequently, the water prices are significantly lagging behind the complete cost of water supply in the city. Prices are premeditated in aggregating the block rates and have been planned in such a way that it helps in promoting sufficient provision and social equity for households having low-income. Regular metering is done for indoor use of water in 95% of the households (Iglesias et al., 2009).

The main problem with the water supply system of the city is its lack of sustainable water supply system which is an important factor but the effective use of the water supply system does not encourage sustainability in the city at present. Undeniably, efficiency cannot prevail due to the fact that major costs of water are completely ignored, as a result, the actual use of water overcomes the optimal one (Iglesias et al., 2009).

2.8.3 Water Supply Situation in Cities of Pakistan

Water Supply Situation in Lahore

Lahore, with a population of 11 million (Ebrahim, 2018), requires 20 LPCD according to standards set by WHO. These standards also advocate for the access to clean water for basic everyday uses as 20 LPCD, optimal access 100-200 LPCD and intermediate access 50 LPCD. Reports have shown that several methods like, hand pumps, tube-wells, and motor pumps are used for extracting approximately 160 million liters of ground water in the city which is then supplied to the residents through water tankers, filtration plants and different water supply schemes. More ground water is extracted and supplied for industrial use and recreational activities (Imran, 2016).

According to a report by WWF (2013) water demand has increased from 180 liters per capita per day in 1967 to 274 lpcd in 2013. There are around 484 tubewells installed by WASA in different areas and about 2.2 million cubic meters per day is supplied through a network of 7,700 km laid water supply network. WASA is serving piped water to 78% of households in its jurisdiction. Outside WASA area 50% households are getting piped water supply, however, the rest get water from hand-pumps, public water posts and through ground water pumping.

The ground water supplied to residents of the city is not in compliance with the best practices adopted by the rest of the world. Main source of water supply, around the globe, is surface water which includes canals, streams, rivers, and artificial as well as natural lakes. Although Lahore has multiple surface water sources but lack of government policies regarding water supply and its extraction has prompted different water supply organizations like Public Health Engineering Department, Water and Sanitation Agency, Local Administration, different town municipal organizations as well as Community Development Department to access ground without any sort of constraint (Imran, 2016), not to mention the number of tube-wells that were around 20,000 in the 1960s but now have crossed one million mark (Ebrahim, 2018).

All the available reservoirs are exceedingly contaminated due to the poor condition of domestic sewerage system in addition to the unsuitable methods adopted for disposal of industrial wastewater. Moreover, huge stretches of paved zones of roads, streets, and buildings plays a vital part in slowing down the recharge process of ground water (Imran, 2016).

WWF-Pakistan (World Wide Fund for Nature) has reported that the water table in Lahore is depleting at an alarming rate of 2.5- 3.0 feet annually. The level of water table is lower than 130 feet in central region of Lahore and is below 147 feet in the Gulberg area. By 225, these levels are predicted to recede lower than 230 feet in major parts of the city in case no steps are taken for conserving the groundwater with current trends prevailing in the city (Ebrahim, 2018).

Water Supply Situation in Karachi

Data provided by Karachi Water and Sewerage Board (KWSB) implies that 1,100 MGD is required by Karachi for its increasing population which has reached the 15 million mark. The city is only supplied 450 to 480 MGD water. The difference between the demand and supply is more than 50%. Another problem apart from this shortfall is dominance of illegal groups that run hydrants that are supplying water to residents of Karachi at high rates thus, making significant profits (Ebrahim, 2018).

The citizens hold KWSB responsible, the organization which is entrusted with the task of production as well as distribution of potable water to residents. KWSB is also responsible for management of the sewerage system which is also disrupted and hinders the supply of water.

Ground water is being supplied to the residents as opposed to surface water, a practice widely adopted in Lahore. A study led by NASA has confirmed that 50-55 Million Acre Feet (MAF) water is pumped out while recharging of the aquifer is stagnant at 40-45 MAF. As a result, the aquifer is being drained at a faster pace than it can be refilled (Ebrahim, 2018).

Water Supply Situation in Peshawar & Quetta

An insight into Pakistan's water crisis by Mahsud (2018) states the water shortage situation of Pakistan to be severe in nature. According to WAPDA, Peshawar requires 250 million gallons but is receiving 126 million gallons. Similarly, Quetta needs 45 million gallons but is receiving 28 million gallons. Peshawar is being supplied water from tube wells and Pishtakhara water supply scheme (Mahsud, 2018). Quetta is facing acute water shortage and the groundwater level is depleting fast at 0.884 meter annually as tube wells are abundantly being used for water supply (Bungulzai, 2018).

2.9 Water Pricing

There are a number of methods that can be adopted for promotion of equity and improved efficiency as well as sustainability in the water supply sector. The technique of water pricing is one the simplest method for achieving equity and improved efficiency as well as sustainability in the water supply sector but it is the most challenging system to be implemented politically. This is due to the fact that a typical command and control method adopted by most of the countries for water management results in significant involvement of the government as a detailed hands-on measurement and monitoring system is required (Ruijs, Zimmermann, & van den Berg, 2008).

Although there is a misconception that increasing pricing for provision of a service decreases equity, it has been proved incorrect by various studies and has established that equity is improved due to rise in pricing for a service provision. Additionally, higher pricing of water helps in extending services to the regions that do not have the service and are forced to procure water from the vendors offering it at very high prices. More remarkably, it can be deduced form various studies that implementation of a price policy plays a major role in maintaining the sustainability of the water supply system and its resources (Hilaire et al., 2008)

2.10 Effects of Water Pricing

The three accepted impacts of price policy are; increasing the supply, reduction in demand, and effective reallocation of the asset. These impacts are coupled with three additional effects which are not related to pricing policy, which includes better managerial efficiency, enhanced equity, and upgraded sustainability of the asset. Furthermore, if the resources of water are efficiently managed and all the elements of the management system are integrated; the legal, money matters, and ecological aspects would complement each other, increased pricing will eventually lead to enhanced efficiency, equity and sustainability of the asset (Sibly, 2006).

Table 2-3: Facts about Pricing Policy for Water Consumption
Source: (Sibly, 2006)

Well-known and lesser known impacts of Pricing Policy	
a)	***Greater price diminishes demand***
(i)	Alternatives become inexpensive
(ii)	Conservation and preservation becomes reasonably priced
(iii)	Changes in consumption choices
b)	***Increased prices upsurges supply***
(i)	Marginal ventures become reasonably priced
(ii)	Offers economic incentives to diminish water wastage
c)	***Increased price assists re-allocation between different sectors***

(i)	From agricultural to domestic and business
(ii)	From off-stream to in-stream usages
d)	***Increased prices enhances managerial effectiveness due to increased profits***
(i)	Enhances maintenance
(ii)	Enhances staff training and education
(iii)	Makes modern monitoring methods reasonably priced
(iv)	Makes modern supervision methods affordable
e)	***Increased prices leads to sustainability***
(i)	Decreases demands on the asset base
(ii)	Decreases pollution loads because of recycling of industrial water
f)	***Increased prices diminishes the per unit cost of water to poor people***
(i)	Expands coverage of poor peri-urban as well as urban populations as surplus water is accessible for expanding the supply system
(ii)	Decreases dependence of the poor on water vendors

2.11 Full cost pricing of water

The main issue that the water supply sector is facing is that of low pricing and tariffs which does not compensate the full cost of water supply; this problems leads to further issues and inadequacies in the water supply sector. The World Water Commission supports the introduction of full-cost pricing system of water services (Commission, 2000):

> *"Commission members agreed that the single most immediate and important measure that we can recommend is the systematic adoption of full-cost pricing of water services (Commission, 2000)"*

Apart from value and cost, tariff is perceived as the third most significant parameter required for successful employment of water pricing policy. Furthermore, the concepts of costs, price and values are often confused while discussing the water pricing system. For a better policy analysis, these three concepts are described as follows (Sibly, 2006).

Table 2-4: Concepts of Water Economics
Source: (Sibly, 2006)

Concepts of Water Economics	
Cost	Costs of finances and ecological externalities, Opportunity costs, capital costs, O&M costs
Value	Indirect benefits, remunerations to end-users, and benefits from returned flows
Price	The amount of payment set by the government for ensuring equity, cost recovery, and sustainability. This price charged from the public might or might not take account of subsidies.

Figure 2-1 shows how these concepts are associated with each other.

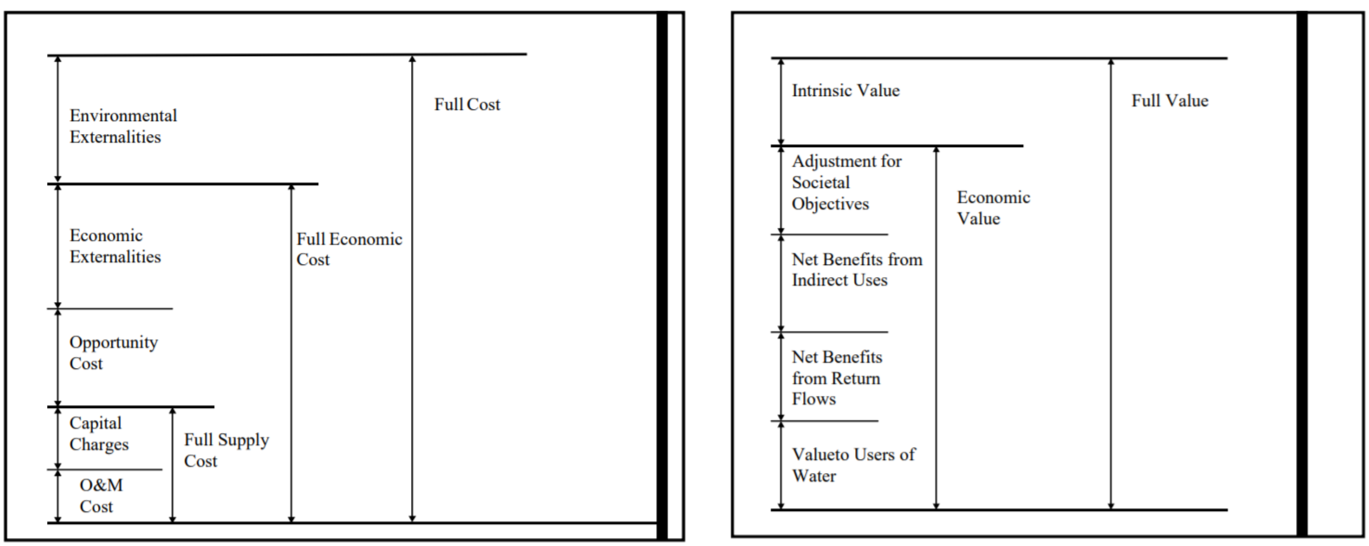


Figure 2-1: Universal Principles for Value and Cost of Water
Source: (Young, 2010)

2.12 Water Pricing Guidelines in OECD countries

The UPP (User Pays Principle) and PPP (Polluter Pays Principle) are the two most popular concepts that are widely accepted and practiced in the OECD states. The UPP was implemented so that the opportunity costs of capital, maintenance, operation, and ecological impacts could be covered by the end-users. The private sector in the OECD countries is now actively involved in providing water supply as the government is now mostly playing the role of a ‘regulator’ of water supply instead of the role of ‘provider’. Most of these nations have, nonetheless, opted for ‘concession’ instead of complete privatization strategy for development of an efficient water supply system. Although there are some countries that have fully privatized their water supply system including management and asset ownership; Czech Republic and England and Wales are the most prominent examples of full privatization. Moreover, investor-owned water supply system has been introduced in the US; in addition to in Hungary, Spain, France, Portugal, and Poland (Parris, 2011).

2.13 Pricing Procedures in ADB Member Countries

ADB has conducted two surveys (in 1993 and 1997) focusing on the water utilities in 38 big cities of Asia. These studies were conducted at two intervals having a five-year gap. The studies showed that during this time, production of water rose by 14% and the per capita consumption of water declined from 182 to 159 l/c/d, this resulted in an 88% upsurge of the tariff. The surveys also showed that the unaccounted-for-water did not changed and maintained the 35% mark of the total production of water; during this time the coverage of the population by the water supply service increased from 75% to 79%. The studies further demonstrated the significant variations of per capita water consumption in various cities. Apia, Western Samoa, had the highest per capita consumption of water having 475 l/c/d while Dhaka, Bangladesh, was found to have the lowest per capita consumption of water having 43 l/c/d. Interestingly, Delhi 257 has l/c/d, Taipei has 282 l/c/d, and Bangkok has 217 l/c/d, thus defying the general assumption that Asian countries cannot afford more than 200 l/c/d. The heavy per capita consumption values of water demonstrates the absence of metering as well as low tariffs in these Asian (Vairavamoorthy, Gorantiwar, & Mohan, 2007).

The survey carried out by ADB in 1997 showed that only 50% had complete metering of water production as well as consumption. In addition to this, 80% of commercial sector, 97% of industrial sector, 82% of the domestic users, and 88% of institutional sector was metered. It should be noted that the utilities did not provide 100% coverage to its respective cities at the time of survey. Only 15 utilities were providing 100% coverage, and cities like Cebu in Philippines had 23% coverage only. As far as the domestic sector is concerned, 32 out of the 50 utilities were using meters for determining payment; while 7 utilities were using flat rates, not to mention the 10 utilities that were using a combination of flat rates with metering system. Similarly, in the industrial zone; out of 50, 2 cities were using flat rates while 35 utilities were using a metering method and the remaining 12 were using a combination of the two methods (Mirza, 2003).

PSP, that is, private sector participation has seen a rise in the Asian cities and has taken numerous different forms like, build, operate, and transfer; management contracts; contracts for services; operating concessions; leasing contracts; and full privatization. The study also showed that 27 of the 50 cities did not have any PSP but 11 of the utilities had production contracts; 8 had were working with the distribution and leak repair contracts; 14 utilities had employed bill collection and meter reading contracts; while only 4 utilities had employed management contracts (Mirza, 2003).

Formerly, water was provided to the users free of charge due to the fact that it is regarded as the basic requisite, not to mention its abundance in the past. But now the trends have changed drastically as multiple sectors need water for their various operations. Regulating it so that all the sectors and communities could have access to this resource is the most suitable method. Pricing method for water ensures that the most valued consumers can have access to it. An appropriately structured tariff can help in meeting all the political, economic, social and ecological goals associated with water supply and demand (Tardieu & Préfol, 2002).

2.14 Sustainable use of water with increased water rates

Definition given by Agenda 21's for sustainability comprises of social development, ecological protection and economic development. As mentioned earlier, water pricing system can develop economic effectiveness and enhance the overall social equity and environmental enhancement. This shows that implementation of a water pricing system can help in addressing all three concerns of Agenda 21's associated with sustainable use of the resource. An assessment of water pricing in two cities shows the sustainability of water supply and its resources. The Waterloo in Canada utilizes the summer rates that echo higher demand of water in summer season which helps in conserving the water available in the summer. Likewise, in Metro Manila, the consumers experiences the low cost for water irrespective of the time of the year (Vörösmarty et al., 2010).

2.15 Water Situation in Pakistan

With the ever increasing demand and meager resources, government of Pakistan needs to come up with a solution for the effective management of all the available sources of water. The volume of water that is available to its end-users at any given time highly depends on the storage capacity of that country in the form of different reservoirs. Studies have shown that desalination is an artificial procedure of transfiguring saline water into a usable form and is employed by many countries where water resources are scarce. In Pakistan, this process has been implemented by the Pakistan Navy and has succeeding in developing a few plants for conducting desalination (Rao, 2010).

The agricultural sector is the backbone of the Pakistani economy and has a geographical area of approximately 196 million acres. About 77.1 million acres of land in the country is appropriate for agricultural use. In addition to this, of 54.5 million acres (nearly 71%) of the overall agricultural land is used for cultivation through irrigation or/and rain. This leaves 22.6 million acres uncultivated which makes up about 29% of the overall land suitable for agricultural use. This land can also become productive if the supply system for water is improved. This implies that almost one-third of the total agricultural potential of the country is still untapped due to non-development of the water supply system and related infrastructure in addition to its poor management (S. A. Raza, Ali, & Mehboob, 2012).

Since Pakistan's economy is basically agrarian, the irrigation sector takes up about 97% of the overall available quantity and adds approximately 25% to the national GDP. This implies that only 3% of potable water is available for domestic and industrial use in the country (Qureshi, 2011). The overall needs of Pakistan related to water as well as its accessibility are as follows:

- Available water - 125.56 MAF
- Required water - 164.48 MAF
- Shortage - 38.92 MAF (31%) (Qureshi, 2011).

Drinkable water is unavailable in most parts of Baluchistan, Sind, and southern Punjab. That is why; the population of these provinces and some other regions of the country highly depend on rain water that is gathered in manmade and natural ponds. The unavailability of drinkable water has also compounded in bigger cities of the like Rawalpindi/Islamabad, Faisalabad, Karachi, and Lahore (Qureshi, 2011). The water requirements of different sectors in Pakistan are as follows:

- Irrigation 159.54 MAF
- Domestic Sector Uses 3.82 MAF
- Industrial Use 1.1 MAF
- Likely to increase to 12.1 MAF by 2025

Increasing population will result in increasing demand of water which will result in shortage of water in the country in the future. Since 1951 (Ministry of Planning and Development, 2005), per capita availability of water is diminishing as demonstrated here:

Table 2-5: Population vs. Available water
Source: (Munir & Davidson, 2017)

Year	Population (in Millions)	Water Availability (in Cubic Meter)
1951	34	5260
1961	46	3950
1971	65	2700
1981	84	2100
1991	115	1600
2000	148	1200
2001	172	1078
2013	207	850
2025	221	659

A 1000 m^3 per capita availability of water is the limit set by the United Nations that is why, according to international standards, in the year 1991, Pakistan was at 1600 m^3 per capita availability of water and was termed as 'a water scarce country'. This number has gone down to 1000 m^3 per capita and the country is now in the list of water-stressed nations (Pakistan Statistical Book, 2007). Since sustainable means of water supply and consumption have not been widely adopted in the country, the water shortage will increase in years to come. This shows that a solution to the problem should be given top priority (Briscoe, Qamar, Contijoch, Amir, & Blackmore, 2006).

2.16 Description of Case Study

2.16.1 Selection of Case Study Area

The study area that was chosen for this research was Islamabad which is the capital of Pakistan. It has a population of about 2 million that is scattered over the area of 906 km^2 having an urban population of approximately 1,009,832 people. The overall Islamabad-Rawalpindi metropolitan region is categorized as the third biggest metropolitan in the country and has a population that exceeds the four million mark (Statistics, 2017).

It should be noted that the importance of the city and its need for a sustainable water supply system is further augmented due to its role as the political center of the country which is managed by the Islamabad Metropolitan Corporation and supported by CDA (S. I. Raza, 2012).

The master plan of Islamabad was prepared by Constantinos Apostolou Doxiadis in 1960s and replaced Karachi as the new capital of Pakistan. The master plan of the city has divided it in eight different zones, which includes; educational sectors, diplomatic enclave, commercial areas, administrative zone, industrial sectors, residential areas, and rural and green areas. Shakarparian Park and Margalla Hills National Park are the two most popular parks of the city (CDA, 2016).

The city has been divided in different sectors that are lettered from A to I. All the sectors are then further divided into four sub-sectors. Sectors from A to C have not been fully developed yet while D series is divided into seven different sectors namely; D-11 to D-17 and only have one developed sector, that is, D-12. Similarly, E series range from E-7 to E-17 and is home to numerous diplomatic personnel as well as foreigners. CDA has proposed a park in E-14, similar to Fatima Jinnah Park while E-8 and -9 comprises of National Defence University, Air University and Bahria University (Butt, Waqas, Iqbal, Muhammad, & Lodhi, 2012).

G (G-5 to G-17) and F (F-5 to F-17) sectors are the highest developed sectors of Islamabad with the exception of some under-developed sectors in these two series. F-9 sector has been developed as the Fatima Jinnah Park. Some important landmarks such as, Serena Hotel and Jinnah Convention Centre (G-5), Karachi Company shopping (G-9) and Pakistan Institute of Medical Sciences (G-8) are located in G sector.

The H series comprises of H-8 to H-17 sectors and are divided in healthcare and educational institutes. The I series comprises of I-8 to I-18 and is predominantly an industrial zone except for I-8 which has been developed as a residential zone (Mahsud).

Additionally, Zone 3 encompasses Margalla Hills National Park, Rawal Lake and Margalla Hills. Zone 4 and 5 are comprised of rural areas and Islamabad Park with the Soan River flowing in the city through Zone 5 ("The Idea of Islamabad," 2016). As the capital of Pakistan, the city has attracted scores of people from all regions of the country and has made it one of the most urbanized cities of Pakistan (S. A. Raza et al., 2012).

The focus areas for carrying out structured interviews were the residential sector area. Information collected from secondary data shows that MCI provides water supply to sectors areas only. Therefore, the target project area has been confined to selected residential sectors in I, F & G Series for carrying out the opinion.

The reason of selection of Islamabad was that, as the case study area actually related to the fact that Islamabad has been identified as a water-stressed city. Therefore, an opinion survey from the residents regarding water supply situation in terms of supply versus demand has been generated. Furthermore, sector-area in Zone-1 (figure 2-2) of Islamabad was selected because MCI provides water supply in these two zones for residential requirements. Residential areas in Zone 3, 4 & 5 are not provided water through MCI. Especially in the case of societies in Zone 5, provision of water supply is the responsibility of the Developer. Similarly, the sectors having predominantly Private Housing establishments, in the Sector Series were also not included in this study. Also, Sectors Series H and E were included in the study area as these have predominantly Education and Industrial Land Use.

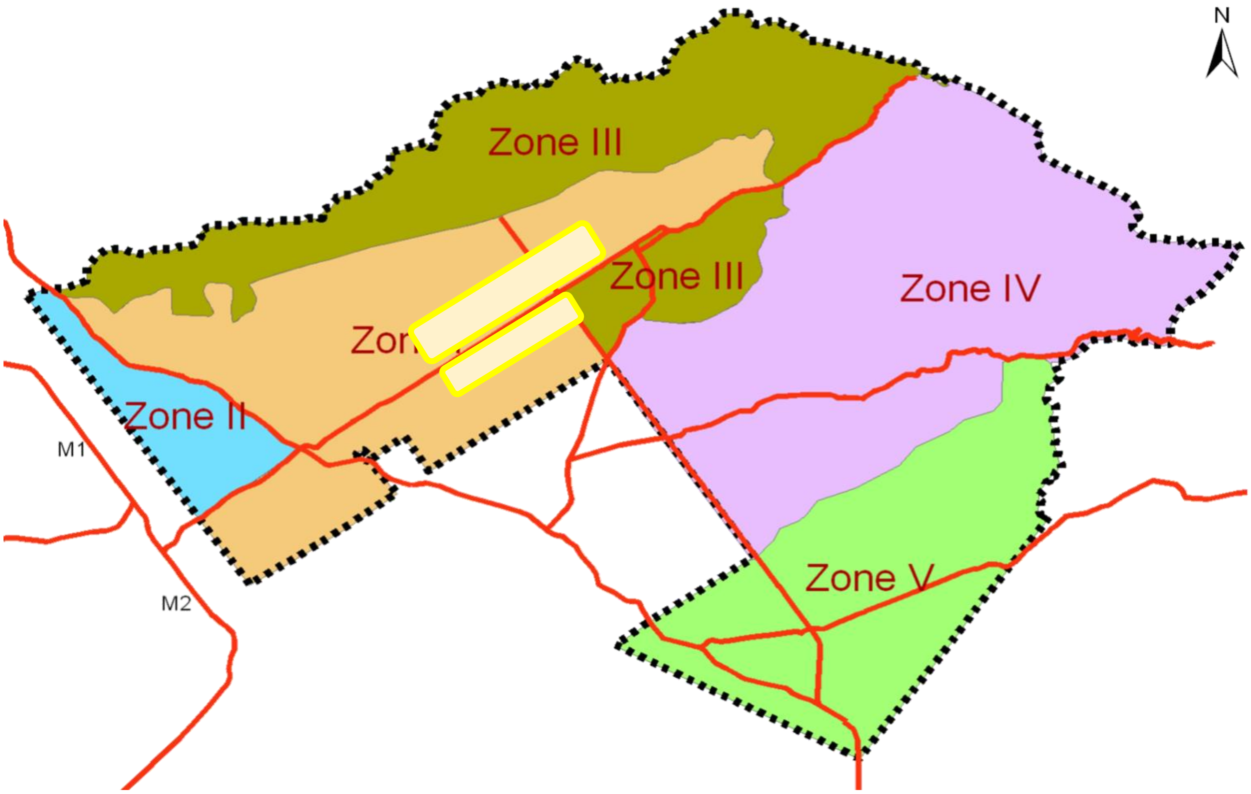


Figure 2-2: Master Plan of Islamabad marked with selected segments of study area
Source:(Mahsud)

2.16.2 Water Supply System of Islamabad

Reports have shown that the domestic water supply for the end-users in Islamabad solely relies on groundwater and surface assets. The designed storage capacity of the existing water supply resources is approximately 107 MGD and the main source of water supply for the study area is Simly dam. Groundwater is accessed from a number of tube wells installed in the National Park area. In addition to this, spring water is also used by diverting it from springs situated at Saidpur, Shahdra-hills and Nurpur stream (Aziz, 2005).

Continuous conditions of drought prevalent in Pakistan due to La' Nino has ensued a diminished inflow to the Simly dam; as a result, the recharge to the groundwater has also declined considerably. An over-exploitation of groundwater due to reduced inflow in the Simly dam has also resulted in so that shortfall in water could be fulfilled. In addition to this issue, the total number of tube-wells in the study area has also declined as a result of drop in the water table in the twin cities. The decline of the water table is attributed to the drought conditions in addition to rapidly increasing demand as well as over-exploitation of the available resources. As a consequence, the inhabitants of Islamabad are setting up small-scale tube wells for fulfilling their water demand (Aziz, 2005).

Reduced inflow of water to the Simly dam has reduced the withdrawal of water for the supply to the residents of Islamabad. At present, approximately 58 MGD of water is being produced against the demand of around 120 MGD. Due to the shortfall in water availability, rationing in water supply is being practiced in almost every sector except F-6 and G-6 due to non-availability of storage tanks at the household level. This is true to some extent because the government employees occupy most of the houses in these sectors. Following valuable information was collected regarding present production and consumption from available water resources in the city (Ahmad, 2011).

2.16.3 Water Supply and Demand in Islamabad

At present, approximately 58.00 MGD water from various ground and surface sources is supplied by the MCI/CDA to the residents of Islamabad after proper treatment and disinfection in accordance with the WHO standards/guidelines against the total demand of 120 MGD. The surface sources of water are Simly Dam, Khan Pur Dam and ground source of water is tube wells (188 Numbers) (Ahmad, 2011).

Table 2-6: Water sources in Islamabad
Source: (Ahmad, 2011)

S. No.	Source	Design Capacity (MDG)	Production Capacity (MGD)	Present Production (MGD)	Area Served
1.	Simly Dam	42.00	42.00	24.00	E-7, Faisal Mosque, F 5, F-6, F-7, F-8, G-5, G-6, G-7, G-8 & from Simly to Quaid-e-AzamUniversity
2.	Korang	04.00	02.40	1.20	Some parts of Q.A.U, Bhara Kahu & connected area under ICT control.
3.	Saidpur	00.80	00.80	0.70	Some portion of F-6/1
4.	Noorpur	00.70	00.70	0.50	Pak Secretariat & local abadies (Noorpur Shahan to Pak Secretariat).
5.	Shahdara	01.60	01.60	1.20	QAU & G-5 (Diplomatic Enclave)
6.	Tube Wells (H&I Series)	09.00	09.00	7.81	G-9, G-10, H&I Series, Model Villages, Tube well also augment Simly and Khan Pur Zones
7.	Others	26.00	21.00	3.01	
8.	Augmentation Poona Faqiran	12.00	08.00	3.20	I-9, I-10 and I.I.U H-10
9.	Khanpur Dam	16.50	16.50	07.00	F-10, F-11, G-9/2, G-10/3 Flats G-10 & G-11

This shows a huge gap in supply and demand, as 48% of the demand is reported to fulfilled, however, 52% of the demand is not fulfilled. This finding from the secondary data presents an alrming finding on the gravity of situation regarding the water situation in the Islamabad.

A graphical presentation of the above data is presented in the following. Simly dam is the major source of water supply to Islamabad as it provides 49% of the required water supply. It is followed by MCI operated tube wells, providing 16% of the demand. Khanpur dam fulfills 14% of the required water supply, then augmentation scheme poona faqiran (tube wells based) provides 7%

of the demand, this is followed by natural streams providing nominal share like Korang, Shahdara, Noorpor, Saidpur and others.

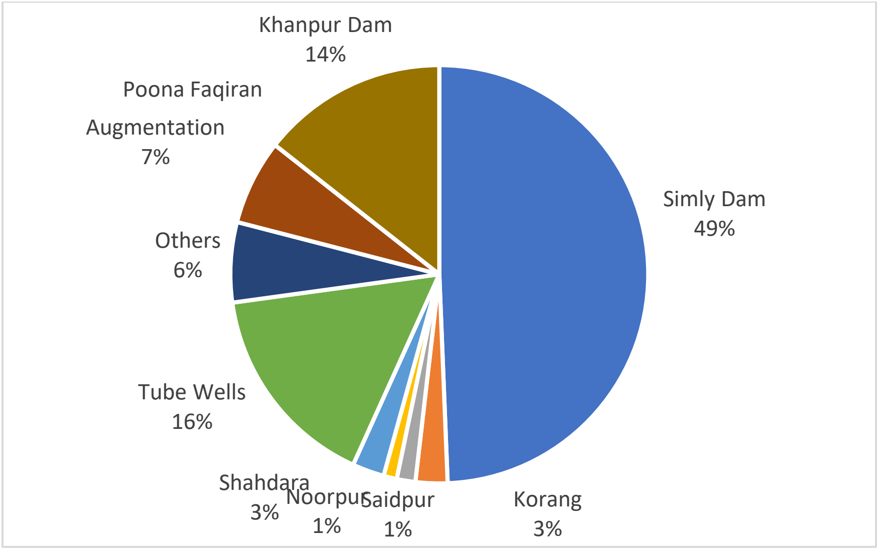


Figure 2-3: Water Supply Sources of Islamabad
Source:(MCI)

Summing it up reveals that 77% of the water demanded is supplied by surface water sources including dams and streams. However, a huge share 23% of the supply if provided by underground water sources depending entirely on tube wells. This is a considerable situation as drawing water from underground sources is not a sustainable option as opposed in the literature earlier. It decreased the water table over time, as the same is reported to have been reduced over the years. Currently the water table of Islamabad has been reduced to below 250 feet underground, as shared by MCI.

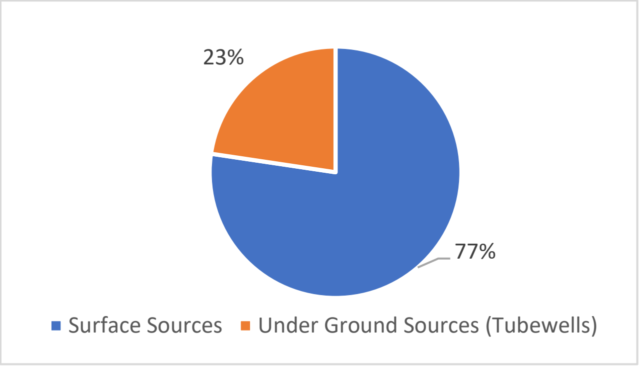


Figure 2-3: Type of Water Supply Sources of Islamabad
Source:(MCI)

3 RESEARCH METHODOLOGY

3.1 Research Design

The current research was a combination of both descriptive and exploratory research. Descriptive part of the study included defining water-stress, scarcity and sustainability along with relevant literature on the subject. Exploratory part of the research comprised of opinion survey of the public regarding the current issues related to water availability and their willingness to pay if any improvement to the existing situation is offered.

This study was conducted as a Mixed Method Research because qualitative as well as quantitative data was collected for assessment and analysis of the existing conditions of availability of water; and its quality was analyzed in selected sectors of Islamabad. This method was adopted so that triangulation of collected data could become possible and quality of the research would not be compromised due to any bias. Mixed Method Research Design was adopted which covered both qualitative and quantitative research, by collecting empirical data directly from the concerned authorities and perception surveys from the end-users. This multi-dimensional design strategy involves a variety of approaches including questionnaire survey technique and in-depth interviews. Another reason for adopting the Mixed Research Method was that this research design improves the reliability and consistency of findings of the study as it employs quantitative as well as qualitative techniques of data collection (Johnson & Turner, 2003).

3.2 Indicators

Table 1 shows the indicators that were considered for current study. In order to determine water-stress, scarcity and sustainability in the study area, an opinion survey of the public was conducted based on the identified indicators which focused on the current issues related to water availability and their willingness to pay if any improvement to the existing situation is offered.

Table 3-1: Table of Indicators

Concepts	Indicators	Dimensions	Reference
PUBLIC OPINION SURVEY			
Water supply	Source	• MCI Piped Supply (Duration) • Private Water Tank • Boring • MCI Water Tank (Monthly cost)	(Abedin et al., 2014; Marlow et al., 2013)
	Fetching water source	• Electric pump	
	Aspects requiring improvement	• Volume/Quantity • Billing system • Pressure • Service quality • Rate • Maintenance • Reliability	
Water shortage	Frequency	• Daily • Weekly • Once a month	(Mekonnen & Hoekstra, 2016; Oyedotun, 2017; Postel, 2014)
	Duration	• 1-2 Hours • 3-4 Hours • 5-6 Hours • 7-8 Hours • More than 12 Hours	
Water consumption	No. of tanks per day		(Postel, 2014)
	Size of water tank		
Water availability	Enough for daily demand	• Yes • No	(Smith & Lant, 2010; Tomory, 2015)
Issues	Operational issues	• Leaking Taps • Leaking Supply Pipes • Leaking Storage Tanks	(Van Koppen et al., 2006; Wong & Brown, 2009)
	Other issues	•	
Operation & Maintenance System	Availability	• Yes • No	(U. WWAP, 2014; Ziemke-Dickens et al., 2010)
	Response time	• 1 day • 2-3 days • 4-5 days • 1 week	
	Charges		
Drinking Water	Source	• Piped Water • Bottled Water • Boring/Well Water • Water from Community Filter Plant • Home Filter on Piped Water • Home Filter on Boring Water	(Archer et al., 2010; Eliasson, 2015; Feldman, 2017)
	Consumption	• Liters	

	Monthly cost	• Rs. Per Liters	
Water Tariff	Current water tariff	• Too high • Normal • Too low	(Ghaffour et al., 2013; Lapworth et al., 2017; Marlow et al., 2013)
	Billing system	• Bank • Internet • Office	
Future Interventions	Increased payments Ownership	• Willing • Not willing	(Marlow et al., 2013; Saleamlak, 2013)
Complaints	Mode	• Online • Community office • Phone call • MCI Office	(Black, 2016; Ravikumar et al., 2013)
	Response time for shortage complaint	• 1 day • 2-3 days • 4-5 days • 1 week	
Consumer satisfaction level	Water supply	• Quantity • Cost • Pressure • Schedule • Quality • Treatment/Purification of Water Supply • Continuity of Water Supply in summers • Continuity of Water Supply in winters • Response to complaints • Management of Water Supply by concerned authority	(Abedin et al., 2014; Pedro-Monzonís et al., 2015; Ravikumar et al., 2013)
SEMI-STRUCTURED INTERVIEW			
Water supply	Source	• Dam • Well • Pumping Station	(Abedin et al., 2014; Falkenmark et al., 2007; Liu et al., 2017; Pearce et al., 2013; Zarghami et al., 2008)
	Responsible Authority	• Capital Development Authority • Metropolitan Corporation Islamabad • Islamabad Capital Territory	
	Water supply method	• Water Tanks • Direct access to houses	
	Allocation of water	• Sector-to-Sector • According to needs	

	Method of water supply	• Scheduled • Non scheduled	
	Duration of water supply	• 2 hours • 4 hours • 8 hours • 12 hours • 24 hours	
	Responsibility allocation for water supply in different areas of the city		
	Measures needed for handling supply	• CDA • MCI	
	Future expansion plans		
Storage Capacity	Storage Capacity of each source	▪ Per cubic meter volume	(Pearce et al., 2013)
	Gaps in storage capacity of water supply source		
Water Demand	Overall Water demand	▪ Cubic meter volume	(Asgedom, 2014; Saleamlak, 2013)
	Basic Criteria for demand calculation		
	Gap in water supply	▪ Supply is less than demand ▪ Supply is more than demand	
	Need to increase water source	▪ Yes ▪ No	
Physical water supply infrastructure	Opinion regarding present conditions	▪ Construction quality ▪ Pressure level ▪ Leaks or defects ▪ Contamination possibility	(Schewe et al., 2014)
	Measures needed for improvement	▪ Pressure level ▪ Leaks or defects ▪ Contamination possibility	
Operation & Maintenance System	Condition of existing components (storage tanks, supply pipes etc.)	▪ Very good ▪ Good ▪ Average ▪ Satisfactory ▪ Poor	(Bithas, 2008)

	Operational issues	▪ Leakage ▪ System Breakdown ▪ Pressure Issues	
	Enough resources for managing existing infrastructure	▪ Yes ▪ No	
Billing	Criteria for charging Method of charging Rate per cubic liter Recovery made through current pricing system	▪ Monthly ▪ Quarterly ▪ Annually	(Asgedom, 2014; Saleamlak, 2013)
Finance Management	Tariff Structure	▪ Tariff fixed for different zones	(Araya, 2013; Eliasson, 2015)
	Percentage of tariff recovered Percentage covered by recovery as compared to expenditure	▪ Monthly ▪ Annually	
Expenses borne by MCI	System provision System maintenance	▪ Monthly ▪ Annually	(Lema & Beyene, 2012; Pearce et al., 2013)
Water tanker based water supply	Problems Regulating organizations	▪ Pressure level ▪ Leaks or defects ▪ Contamination possibility	(Barlow & Clarke, 2017)

As all the selected sectors of Islamabad do not have the same type of characteristics, therefore, the characteristics that were primarily related to water availability and scarcity were determined with the help of indicators. The main reason for adoption of these particular indicators was their relevance to the study area. The selected indicators were used for collection of primary data through questionnaire for public opinion survey and structured interviews with officials of different government organizations involved in water management and focused on the current issues related to water availability.

3.3 Research Tools Formulation

Data for this study was collected from the following two sources:

1. Secondary sources of data
2. Primary sources of data

3.3.1 Collection of Secondary Data

Secondary data relating to the supply and demand gap issues was collected from a number of different secondary sources. The same has been filtered for relevance and added in the literature review chapter. Moreover, other relevant studies highlighting any issues relating to supply and demand gaps in the capital have also been included. Collection of the secondary data from well-renowned literature was the first step of this study as it helped in fully comprehending the existing situation of water scarcity globally as well as locally. This was coupled with studying the sustainable pattern of water usage and storage that can be adopted for the study area. Following are the secondary sources that were accessed for data collection:

1. Reports/ Journal articles/Other published material
2. Online data channels and news feeds
3. GIS Maps of Islamabad
4. Master plan of Islamabad

Peer reviewed journal articles, government reports, research papers published internationally and nationally were studied for understanding the global context of water scarcity and different means for mitigation of this situation. Different reports provided by CDA and MCI were accessed for understanding the current situation of availability of water in the study area. In-depth review of literature also played a major part in understanding different means that can be employed for achievement of research objectives. Additionally, indicators were also identified through collection of secondary data which helped in developing of questionnaire for assessing the current issues related to water availability and willingness of the local people to pay if any improvement to the existing situation is offered.

Furthermore, maps of the city generated through GIS were also analyzed for understanding the current situation of the city which made it easy to select certain sectors of the city for field survey based on their geographical location and context with respect to water availability. Master plan of Islamabad was also assessed for fully comprehending the land use pattern and social setup of the city as these elements play a significant role in usage of water.

3.3.2 Collection of Primary Data

Collection of Primary data is one of the most important tasks in any study to represent the true essence of results targeted to be achieved. The collection of primary data was divided into two separate parts. First part comprised of structured interviews with officials of relevant government organizations and the second part focused on collection of data through opinion/perception survey of the residents of the selected sectors of the city.

Although collection and analysis of secondary data played a major role in understanding the current situation of the study area in terms of water availability to the masses, the primary data covered a significant part of this study. The following techniques of data collection were employed for collection of primary data:

1. Public Opinion Survey
2. Structured interviews

3.3.3 Sampling

Sampling Technique

For Public Opinion Survey; Sector areas where MCI supplied water was available were selected at random. A random sampling technique was adopted for these areas for drawing out the sample for door-to-door survey.

3.3.4 Sample Size

As the Sector areas where MCI supplied water were available were selected for public opinion survey, sample size was determined by using Slovin's formula (Ellen, 2012) which is as follows:

$$n = \frac{N}{1 + Ne^2}$$

Where; n = sample size

N = population size

e = margin of error

Sample size: 205

Confidence level for public opinion survey was 8% which helped in acquiring accurate and conclusive results for the research. The population sample for the public opinion survey was selected at random in order to avoid any kind of bias. The public opinion survey helped in deriving results that played an important part in identifying the existing situation of water scarcity in the city, concerns of the residents regarding the current situation and their willingness to pay if any improvement to the existing situation is offered.

3.3.5 Questionnaire Design

As a systematic method of data collection, questionnaire survey technique was used to solicit the opinions of the target population. A purposeful questionnaire for collection of required data was developed which had both close- and open-ended questions, whereby, in opinion survey a 5 point Likert scale was also used.

3.3.6 Field Survey

Field survey was conducted at different Sector areas where MCI supplied water was available were selected. The main purpose of the public opinion survey was to obtain the perception of the residents regarding current situation of availability of water in their respective neighborhoods. Apart from current issues related to water availability; willingness of the local people to pay if any improvement to the existing situation is offered was also determined through questionnaire survey.

3.3.7 Satisfaction Index

The index od satisafcation was employed for assessing the level of satisfaction of respondents regarding different aspects of current situation of water supply in their homes. Figure 4-22 illustrates the results after calculation of satisfaction level with the help of Index of Satisfaction which was developed in 1972 by Yeh (S. H. Yeh, 1972; S. H. K. Yeh, 1975). Three diferent level of satisfaction are considered which are; satisfied, acceptable and dissatisfied. Different index score are given to each level of satisfaction which is shown in table 4-1. The reason for employing this index was that it has already been used in many studies, and has successfully demonstrated the levels of dissatisfaction or satisfaction in numerous researches around the world (Abdu, Hashim, Samah, & Salim, 2014). The formula for calculation of index of satisfaction is as follows:

YIS = Satisfies cases (X1) – Dissatisfied cases (X2)/Total cases (X)

YIS = X1-X2/X (Abdu et al., 2014)

Furthermore, table 4-1 illustrates a fundamental crieterion for giving meaning to the valuse obtained by empplying the index. A negative value signifies dissatisfaction; as the negative number goes up, the level of dissatisfaction will also be higher. Likewise, a positive value after employing the index signifies statisfaction accourding to YIS (Abdu et al., 2014).

Table 3-2: Range for YIS (Source: (Abdu et al., 2014)

YIS	Level of Satisfaction
Less than 0.2	Very Low
0.20 – 0.39	Low
0.40 – 0.59	Medium
0.60 – 0.79	High
0.80 and above	Very High

3.3.8 Structured Interviews

The overall outcome of the research is often influenced by structured interviews conducted for assessing the existing conditions of a study area. A number of professionals associated with different government organizations were approached for conducting the structured interviews for determining the current issues related to water availability in the study area. Questions regarding different elements and factors involved in the provision of clean water and reasons that played a major part in increasing water scarcity were asked from the professionals.

Also, sustainable means of water storage and water conservation were also discussed during the structured interviews which led to proposition of recommendations for implementation of sustainable means of water storage.

3.4 Data Compilation, Analysis & Thesis Writing

Collected data was analyzed by using Microsoft Office and Statistical Package for the Social Sciences (SPSS). SPSS software was used to perform statistical analysis of the data collected. Descriptive Statistics was conducted for analyzing the results derived from the collected data.

3.4.1 Quantitative Analysis

3.4.1.1 Descriptive Analysis

Descriptive analysis was conducted for results of public opinion survey which helped in deriving meaningful results for the raw form of data which was then used for evaluating the existing situation of water scarcity in the study area. In order to do this, the primary data was scrutinized by employing SPSS which helped in deriving results in the form of descriptive statistics.

3.4.2 Qualitative Analysis

3.4.2.1 Content Analysis

Content analysis was also conducted for this study through review of selected literature related to availability of water and its scarcity, both, globally and locally. In addition to this, results of structured were also analyzed through content analysis as the structured interviews were mainly focused on different elements and factors involved in the provision of clean water and reasons that played a major part in increasing water scarcity in the study area. The content analysis helped in determining the factors that were important for conservation and sustainable storage of water in the study area.

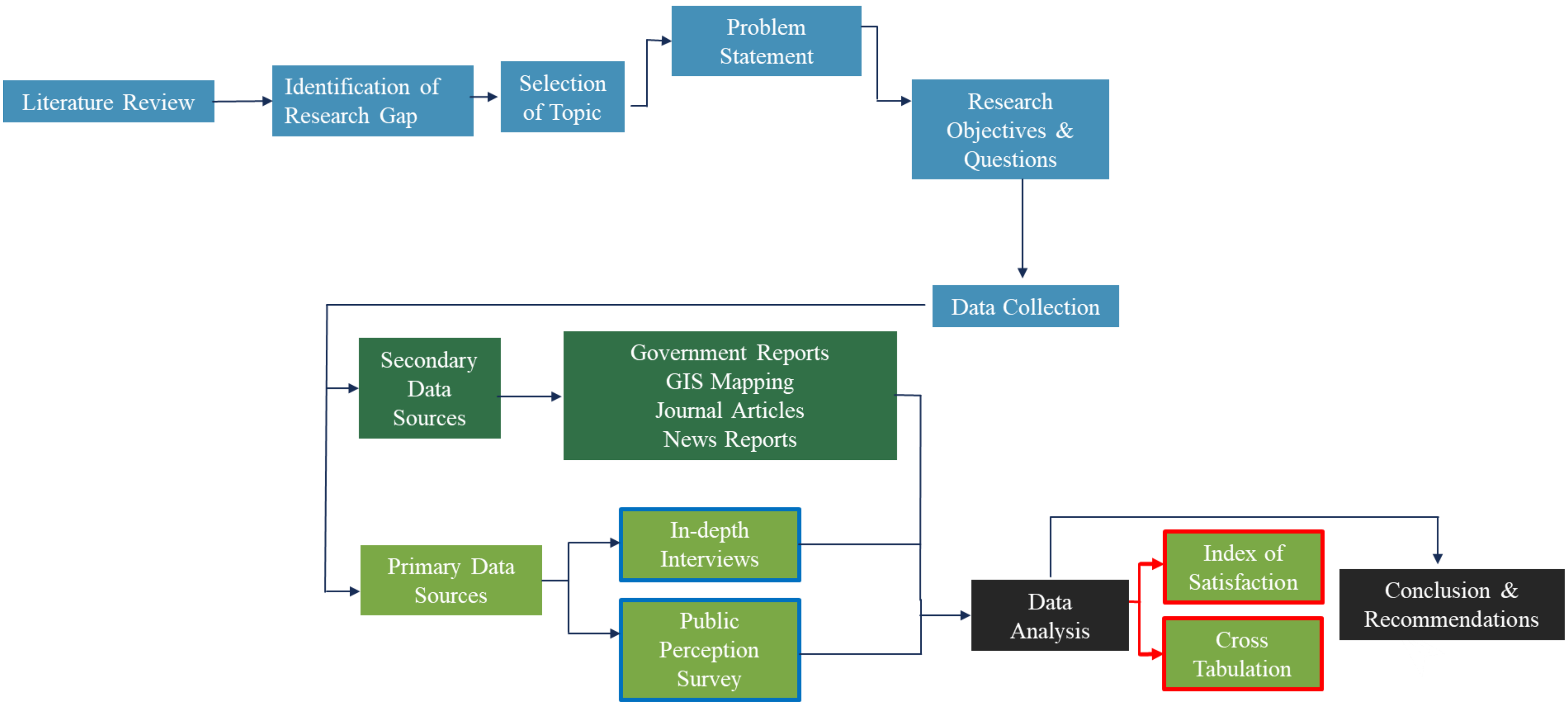
3.5 Strategic Recommendations

After careful assessment and evaluation of the derived results, recommendations were given which were mainly based on the best practices adopted internationally and the results attained through scrutiny of structured interviews and responses obtained through public opinion survey.

3.6 Major Outputs

Chief outputs of this research can be summarized as follows:

1. Assessment of existing situation of water supply in Islamabad
2. Identification of parameters/factors for sustainable water supply
3. Perception of residents of Islamabad towards interventions in water supply system
4. Identification of pertaining to efficient water supply system
5. Recommendation of strategies for sustainable water supply system



Fogure 3-1: Framework for Research

4 RESULTS & DISCUSSION

4.1 Background of Study Area

The study area that was chosen for this research was Islamabad which is the capital of Pakistan. It has a population of about 2 million that is scattered over the area of 906 km^2 and have an urban population of approximately 1,009,832 people (Statistics, 2017). The selected segments for carrying out the perception survey were the residential sectors in I, F & G Series which included, F-6, F-7, F-8, F-10, F-11, I-8, I-9, I-10, G-6, G-7, G-8, G-9, G-10, G-11.

Furthermore, sectors area in Zone-I of Islamabad was selected because MCI provides water supply in these two zones for residential requirements. Residential areas in Zone 3, 4 & 5 are not provided water through MCI. Since the selected sectors were predominantly residential, different sizes and types of houses were present in these sectors which were another reason for selecting these sectors for collecting primary data in the form of perception survey.

Sectors Series H and E were not included in the study area as these have predominantly Education and Industrial Land Use.

Figure 4-1 shows the Master Plan of Islamabad highlighting all the zones. Zone-I has been highlighted as the identified project area zone. The next Exhibit No. shows the identified sectors within Sector E, F & G Series, whereby, government accommodation is provided and MCI/ICT is providing water supply. The sectors areas predominantly offering private residents are identified separately with color, where water supply is being provided by the developer through privately operated tube wells (Ahmad, 2011).

4.2 Current Water Supply System – Interviews with MCI & CDA

The capital city of Islamabad is administratively functioning through two state-organization, the Capital Development Authority (CDA) and Municipal Corporation, Islamabad (MCI). Both these state agencies have distinctly allocated areas of operation and civic roles, while they run the city together. Following is an account of both with organizational charts and responsibilities.

4.2.1 Capital Development Authority

As figure 4-1 shows CDA is led by a Chairman along with a Board of Directors. The main civic functions are performed under the respective Members for Administration, Planning & Design, Engineering, Estate, Environment and Finance. Each Member office is fully supported with technical and non-technical officers and working staff. The roles and responsibilities for performing civic duties and responsibilities while exercising legislative powers is well laid-out.

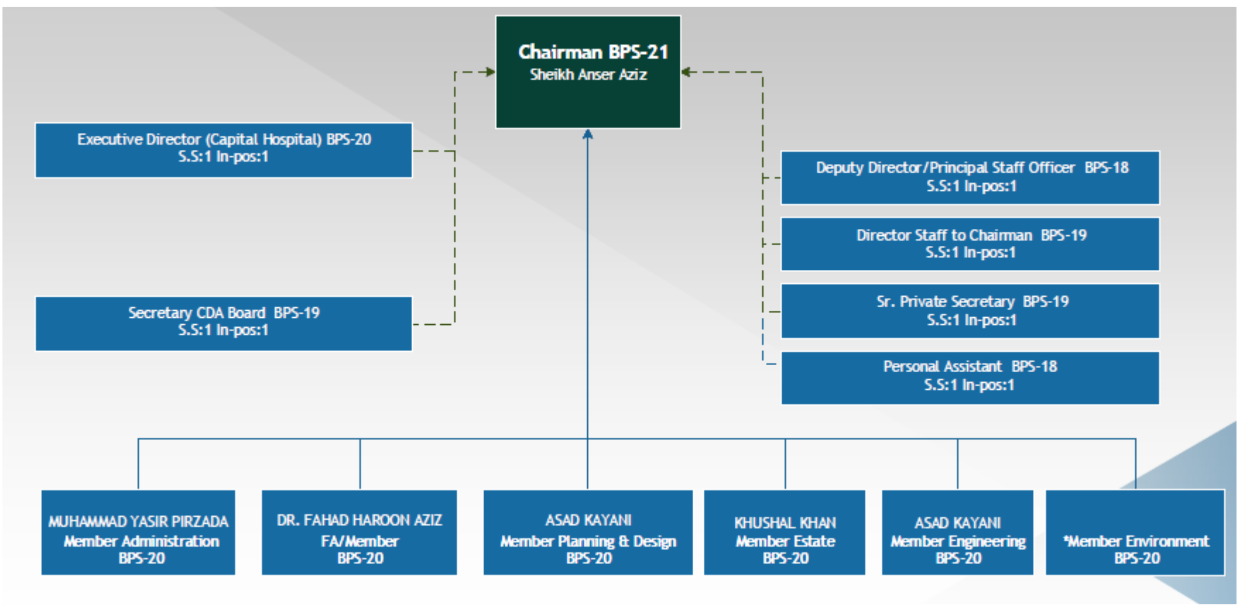


Figure 4-1: Framework of CDA

For the purpose of this study the following offices were contacted for collection of information through structured interviews;

1. Director Urban Planning

2. Director water and sanitation

4.2.2 Municipal Corporation Islamabad

The Municipal Corporation Islamabad is primarily entrusted with tasks of municipal nature and responsibility. As figure 4-2 shows the Mayor of Islamabad heads the all Directorates of civic management.

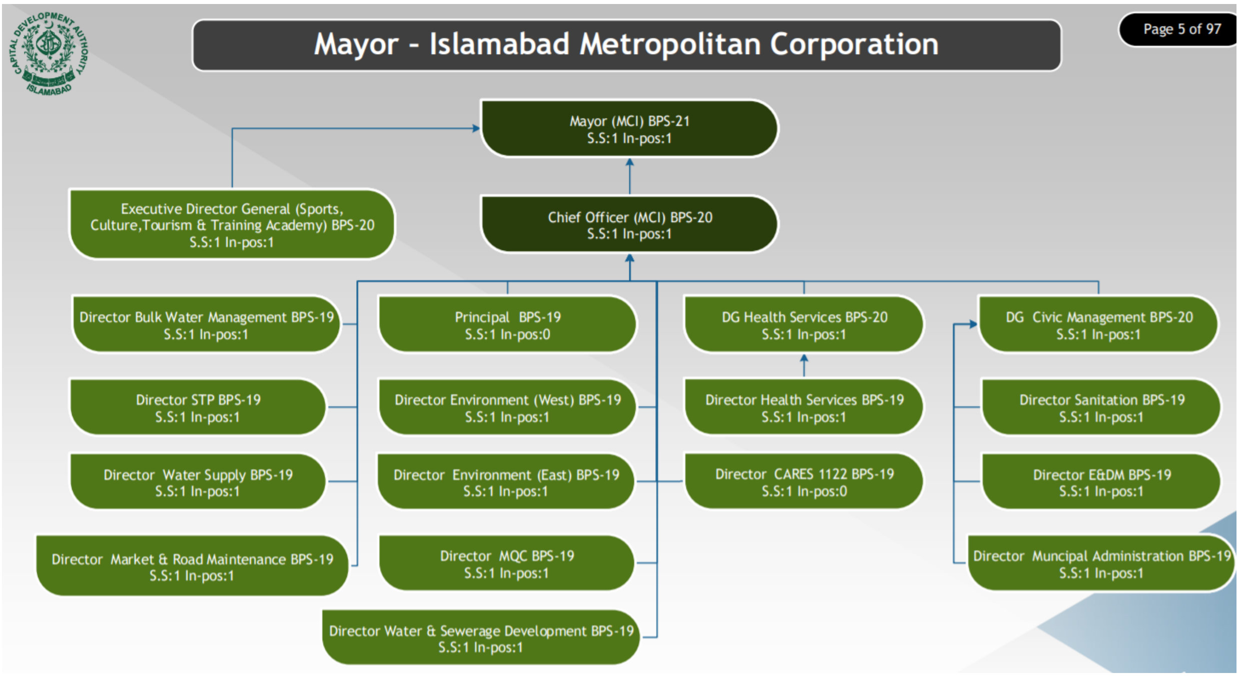


Figure 4-2: Framework of MCI

For this purpose, the following directorates were contacted for collection of information;

1. Directorate of Bulk Water Management
2. Directorate of Water Supply
3. Directorate of Water & Sewerage Development

4.3 Discussions on information collected from MCI

In order to study the objectives of the research, structured interviews were required to be conducted from the managers of the metropolitan dealing with water supply system. The structured interviews from officials of Municipal Corporation Islamabad revealed the following information.

4.3.1 Current Water Supply System of Islamabad

The water supply system of Islamabad is comprised of surface and underground water sources, supplemented by reservoirs and pumping stations, delivering the supply through a system laid out from the early years of the city development, expanded as per requirements. Currently following are the major sources along with the area of service;

1. **Simly Dam**

   Simly Dam is the largest reservoir providing the water supply to major areas of the capital. It has a design and production capacity of 42 MGD. However, the present production is 24 MGD. Simly Filtration Plant was constructed in 1970 to ensure supply of filtered water to the capital. Its area of coverage is the G-Series sectors from Sector G-5 to Sector G-9, F-Series Sectors from Sector F-5 to Sector F-8, Sector E-7 and parts of Blue Area. Simly Dam also provides water to Quaid-e-Azam University as shown in figure 4-3.

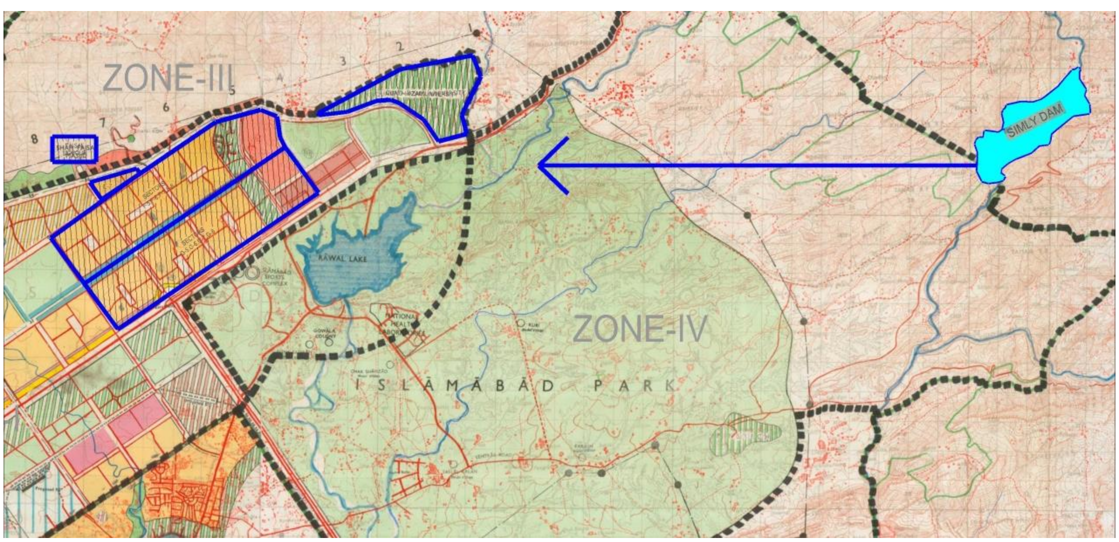


Figure 4-3: Map of Islamabad showing Simly dam and its areas of service

   The water supply from Simly Dam is based on total gravity flow, however, the pressure has to be stepped down before distribution owing to major level differences. Storage tanks take the supply from Simly Dam to storage tanks i.e., 01 storage tank in Sector F-5 Storage capacity 7 MG, 03 storage tanks in Sector E-6 storage capacity 5 MG and 01 storage tank in Margalla National Forest storage capacity 1 MG. Water is then supplied through laid out water supply network to the coverage areas.

2. Khanpur Dam

Khanpur Dam is the second largest surface water source for the capital. It has a design and production capacity of 16.50 MGD. However, the present production is 07MGD. Khanpur storage reservoir was developed in the 1980s. In year 2000, under Water Supply Augmentation Scheme, filtration plant for Khanpur Dam was developed at Sanjani. Currently water from Khanpur Dam is brought to Sanjani Water Treatment Plant. Based on gravity flow it is then directed to Shah Allah Dita 5 MGD Reservoir. From here it is taken to reservoirs in Sector E-10 worth 07 MGD and 05 MGD capacity. Only 07 MGD reservoir is functional at present. The other is non-functional due to maintenance works requirements.

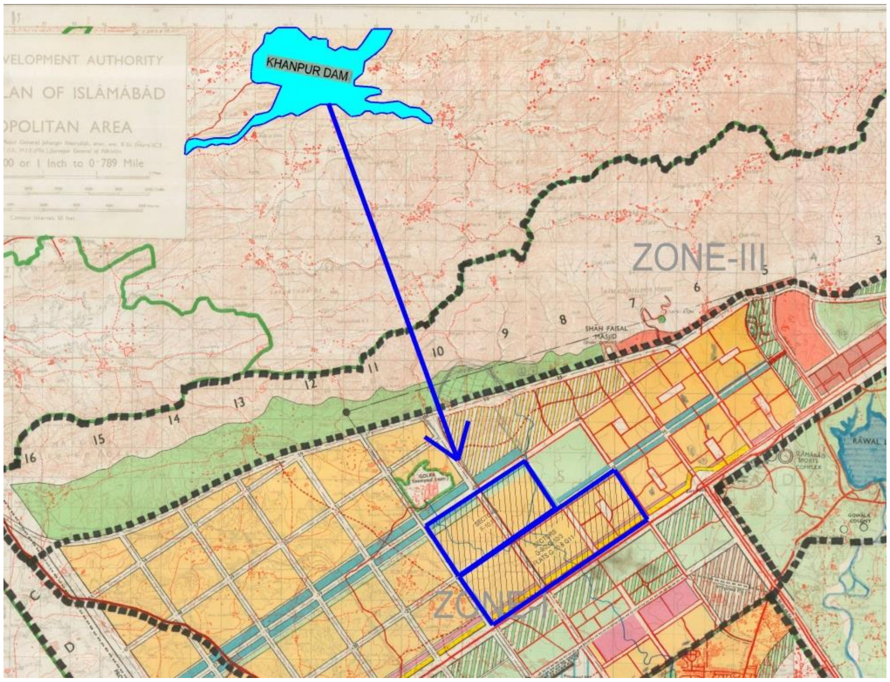


Figure 4-4: Map of Islamabad showing Khanpur dam and its areas of service

Khanpur Dam along with localized tube wells provides water in Sectors G9, G-10, G-11 along with Sectors F-10 & F-11. Sector D-12 is also based on this piped supply network as shown in figure 4-4.

3. **Ground Water Tube Wells**

Around 193 Tube Wells are installed in the capital at numerous locations. The H & I Series Sectors are dependent entirely on tube well water supply. These include Sector H-8, H-9, H-10, I-8, I-9 & I-10. Also, Model Village Humak, Shahzad Town & Rawal Town are based on Tube Wells as shown in figure 4-5.

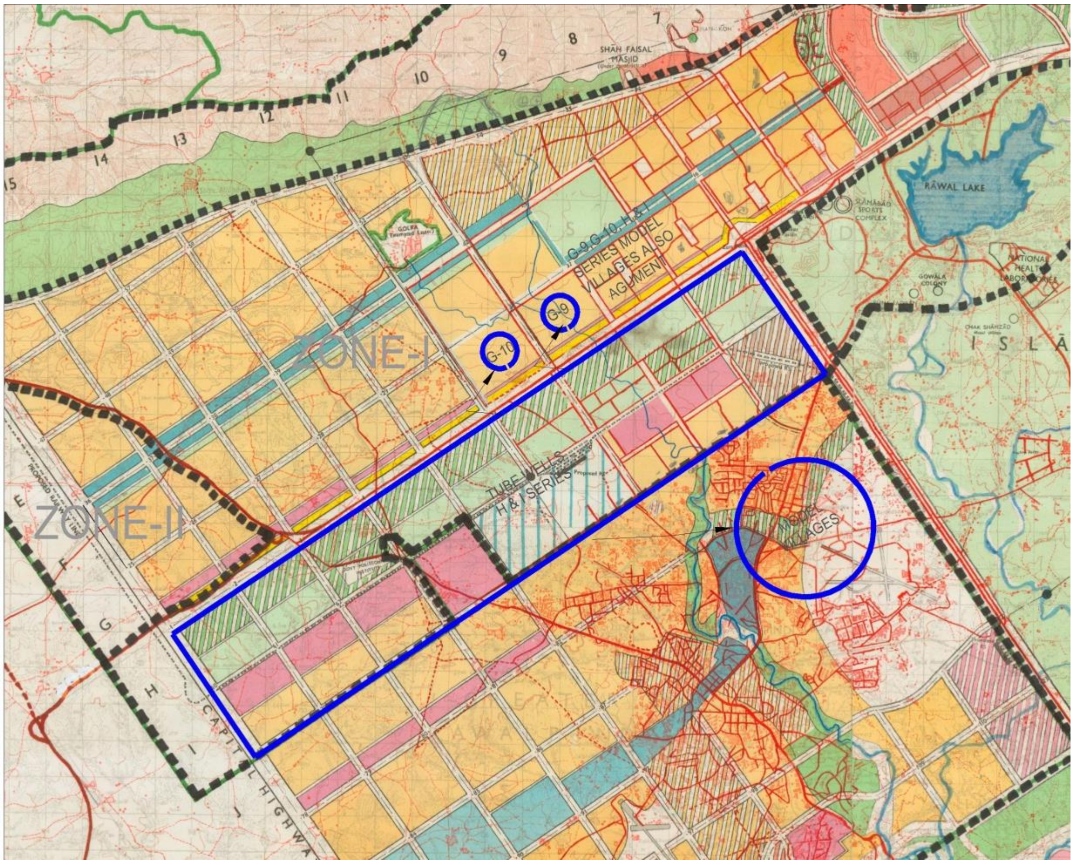


Figure 4-5: Map of Islamabad showing ground water tube wells and its areas of service

4. Korang Stream

Korang Stream has a capacity of 4 MGD at its peak point; however, around 2.4 MGD can be treated and distributed. Currently, only 1.2 MGD is distributed to some parts of Quaid-e-Azam University, Bhara Kahu area and other connected areas under the ICT Administration as shown in figure 4-6.

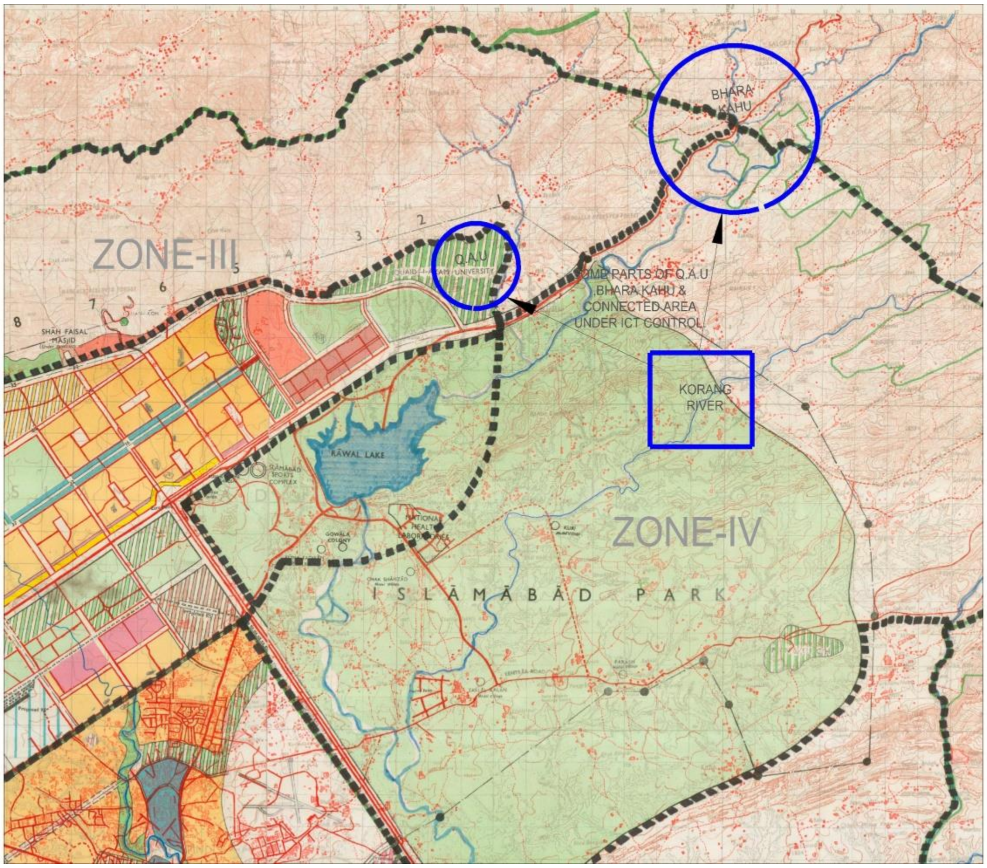


Figure 4-6: Map of Islamabad showing Korang River and its areas of service

5. **Saidpur Stream**

Saidpur stream falling in the Islamabad National Forest area provides 0.8 MGD water and its source point atop Saidpur Village. 1 MGD tank constructed in vicinity provides treated and stored water to Saidpur Village and some parts of Sector F-6 as shown in figure 4-7.

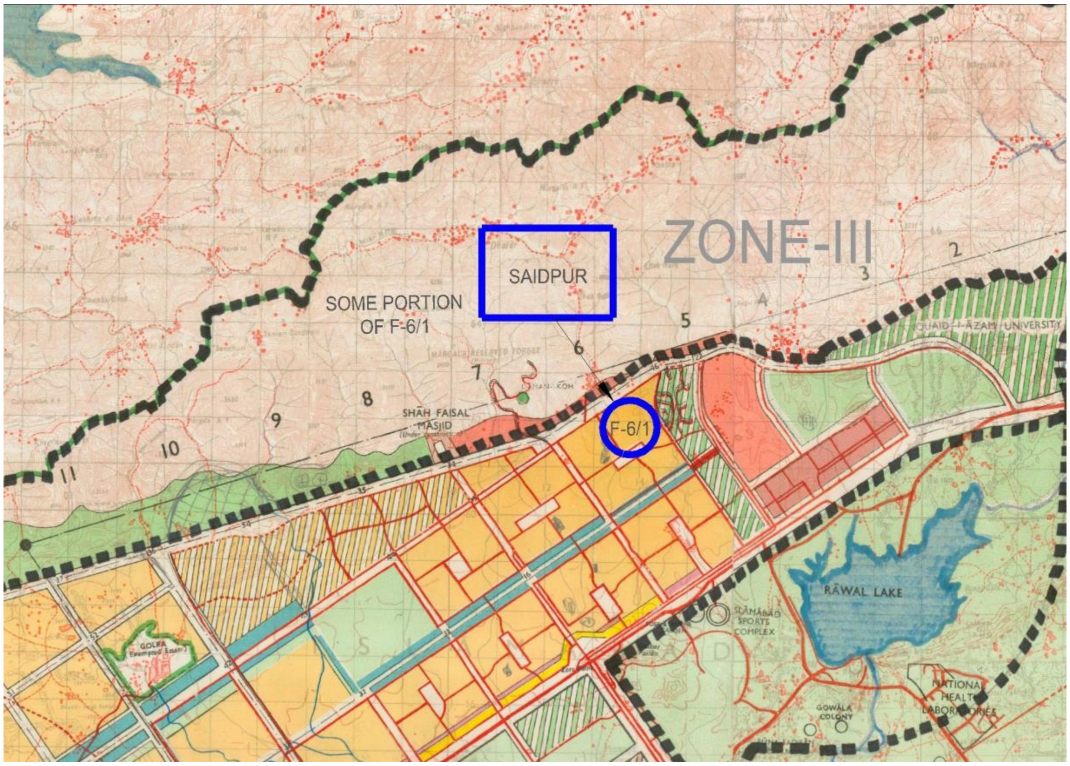


Figure 4-7: Map of Islamabad showing Saidpur Stream and its area of service

6. Noorpur Stream

Noorpur Stream has a capacity and production of 0.7 MGD. It supplies 0.5 MGD water to Noorpur Shahan local abadies and Pak Secretariat. The lines in these are areas are old and damaged. Water Filtration plants are installed for purification of water as shown in figure 4-8.

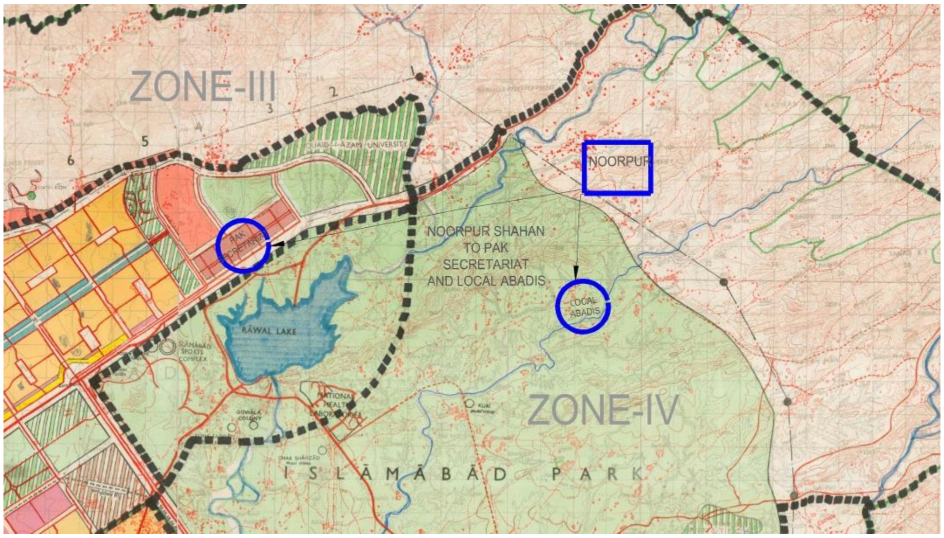


Figure 4-8: Map of Islamabad showing Noorpur Stream and its area of service

7. Shahdara Stream

Shahdara stream has a production capacity of 1.6 MGD; however, 1.2 MGD water is distributed to Diplomatic Enclave Sector G-5 and some parts of Quaid-e-Azam University as shown in figure 4-9.

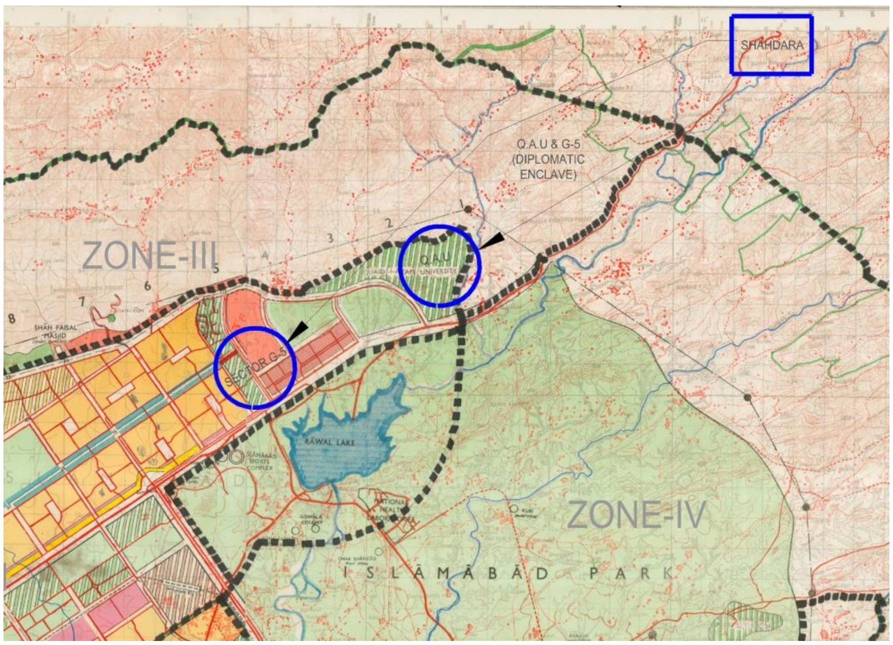


Figure 4-9: Map of Islamabad showing Shahdara Stream and its area of service

8. Augmentation Poona Faqiran

The Poona Faqiran augmentation scheme based on ground water tube well sources has a design capacity of 12 MGD. Around 8 MGD is produced and barely 3.2 MGD is supplied to different areas of Sector I and Sector H. The losses are due to line losses due to damaged lines and illegal connections as shown in figure 4-10.

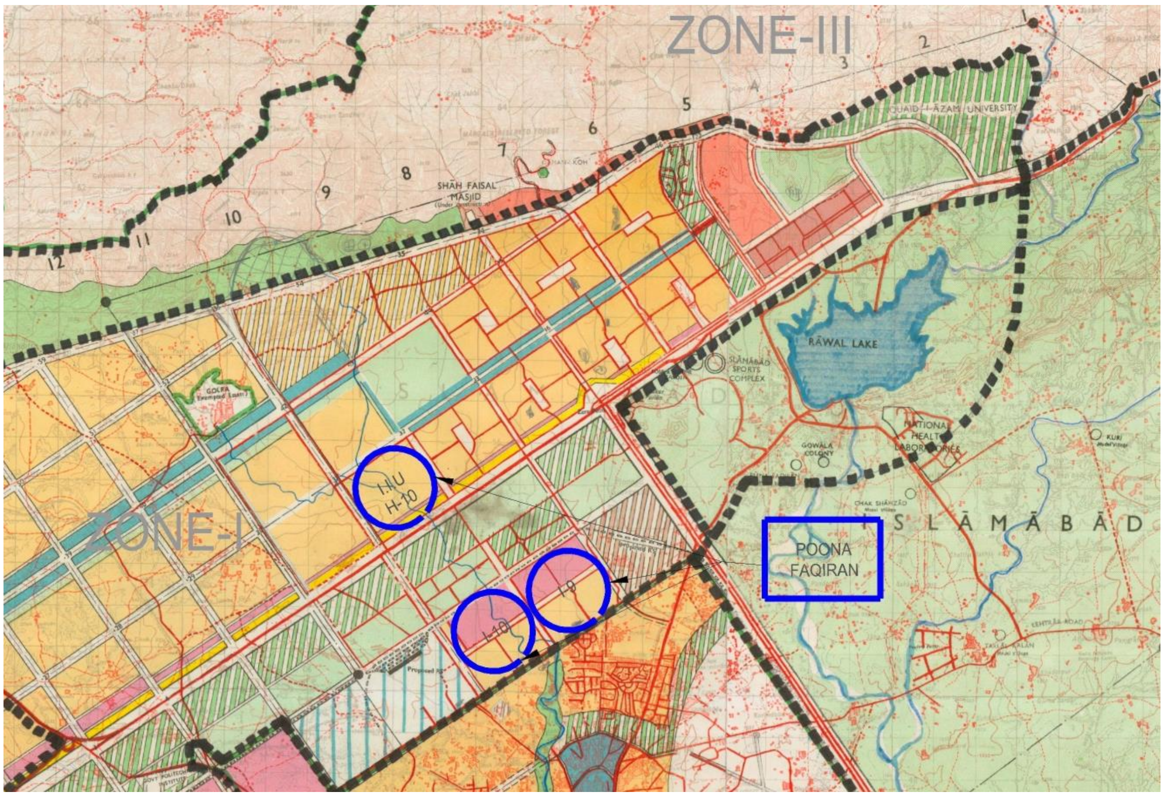


Figure 4-10: Map of Islamabad showing Poona Faqiran and its area of service

4.3.2 Water Supply and Demand Gap in Islamabad

At present, approximately 58.00 MGD water from various ground and surface sources is supplied by the MCI / CDA to the residents of Islamabad after proper treatment and disinfection in accordance with the WHO standards/guidelines against the total demand of 120 MGD. The surface sources of water are Simly Dam, Khan Pur Dam and ground source of water is tube wells (193 Numbers).

The water demand is calculated at peak hour demand by MCI and comes out to be 150 Gallons per capita per day.

Table 4-1: Water Supply and Demand Gap in Islamabad

S.NO.	**SOURCE**	**DESIGN CAPACITY (MGD)**	**PRODUCTION CAPACITY (MGD)**	**PRESENT PRODUCTION (MGD)**	**AREA SERVED**
1.	Simly Dam	42.00	42.00	24.00	E-7, Faisal Mosque, F 5, F-6, F-7, F-8, G-5, G-6, G-7,G-8 & from Simly to Quaid-e-Azam University
2.	Korang	04.00	02.40	1.20	SOME PARTS OF Q.A.U, BHARA KAHU & CONNECTED AREA UNDER ICT CONTROL.
3.	Saidpur	00.80	00.80	0.70	SOME PORTION OF F-6/1
4.	Noorpur	00.70	00.70	0.50	PAK SECRETARIAT & LOCAL ABADIES (NOORPUR SHAHAN TO PAK SECRETARIAT).
5.	Shahdara	01.60	01.60	1.20	QAU & G-5 (DIPLOMATIC ENCLAVE)
6.	Tube Wells (H&I Series)	09.00	09.00	7.81	G-9, G-10, H&I SERIES, MODEL VILLAGES, TUBE WELL ALSO AUGMENT SIMLY AND KHAN PUR ZONES
7.	Others	26.00	21.00	3.01	

8.	Augmentation Poona Faqiran	12.00	08.00	3.20	I-9, I-10 and I.I.U H-10
9.	Khanpur Dam	16.50	16.50	07.00	F-10, F-11, G-9/2, G-10/3 Flats G-10 & G-11
	TOTAL	112.70	102.00	48.62	

According to the city water supply managers at MCI, a tentative shortage of 50% exists with regard to the water supplied to the capital. The same was agreed by all wings of MCI. Also it is highlighted that the existing sources of water are not sufficient to fulfill the current water demand. The storage reservoirs are designed as balancing tanks to store water and distribute with constant pressure head.

4.3.3 Percentage share distribution of sources to Islamabad

Following chart demonstrates the percentage distribution of water from different sources to areas of Islamabad and Rawalpindi. Water resources at Simly Dam are entirely devoted to Islamabad with Tube Wells and Pumping Stations following the lead. Khanpur Dam provides 33% of its sources to Islamabad. Rawal Dam does not provide water to Islamabad.

Table 4-2: Percentage distribution of water from different sources to Islamabad and Rawalpindi

Description	Islamabad	Rawalpindi
Simly Dam	100%	
Khan Pur Dam	33%	28.80%
Rawal Dam	Presently Nil	
Tube Wells	50%	
Pumping Stations	50%	

Coverage by Piped Water Supply

MCI is entrusted with the responsibility of water supply to the capital. According to MCI, approximately 90% of the urban area of Islamabad is covered by piped water supply. This includes urban areas falling in Zone-1, Diplomatic Enclave and National Forest Area.

Distribution of water supply is based on population and available water production. The areas/zones of water supply are formed depending upon the source from where water is supplied.

Satisfaction of Municipality Officers

The officers who participated in the interview session reported that the overall water supply system in un-metered and ill-maintained. The system was laid in 1963 and augmented with growing population until 2000. The water lines are outlived. Filter media are required to be replaced along with back washing system.

4.3.4 Water Losses

Of the available system supply, 40-50% water is lost to system wastage including illegal connections. Of this, nearly 30% is system wastage and 20% is lost to illegal connections. System wastage is mainly due to disturbed and leaking lines, reservoir and other issues. Of the laid system, nearly 15-20% lines are damaged. Water leakage and pressure are major contributor to the water loses suffered during distribution.

4.3.5 Expenses Borne on System

MCI could not tell the amount of expenses borne by on system provision. However, according to their rough estimates, the expenses borne on supply system maintenance are 6-8 times more than recovery. Therefore, the recovery made through current pricing system is merely 1/6th or 1/8th of the expenses borne.

4.3.6 Current Pricing System

Current billing system is divided into two categories for water provision to domestic users based on whether the type of residence is a property of the government or Privately-owned. The government provided residents pay monthly charges of up to 150 Rs for category A to category I houses. The Privately-owned residents pay quarterly charges of up to Rs. 400 per month. The commercially supplied water has different rates in different areas. Some supply to commercial and industrial areas is metered as well. Following table represent the rates shared by MCI. These rates were fixed in year 2000 and have not been revised afterwards.

Sr. No.	*Description*	*Rate Per Month*
1	***Government Owned Residences***	
	Category A	Rs. 48
	Category B	Rs. 48
	Category C	Rs. 48
	Category D	Rs. 62
	Category E	Rs. 84
	Category F	Rs. 110
	Category G	Rs. 140
	Category H	Rs. 162
	Category I	Rs. 188
2	**Private Residences**	
	Less than 250 Sq. Yards	Rs. 96
	251 to 499 Sq. Yards	Rs. 114
	500 to 999 Sq. Yards	Rs. 140
	1000 to 1199 Sq. Yards	Rs. 188
	1200 to 1499 Sq. Yards	Rs. 254
	1500 to 1999 Sq. Yards	Rs. 316
	2000 and above Sq. Yards	Rs. 378
3	**Model Villages**	Rs. 96

In case of Water Tanker Supply, the half water tanker for domestic use is supplied at Rs. 300 and full at Rs. 600. Commercial areas access water tanker supply at Rs. 1000. These areas are applicable regardless of the areas of the metropolitan as these are fixed rates by the government.

4.3.7 Future Projects

To meet present as well as future requirement of water, a sustainable project, "Conduction of water from Indus River system for Rawalpindi & Islamabad" has been conceived. According to the MCI officials, the project is contested at different forums. The PC-I of the project approved in 2005 at a cost of Rs. 27.000 Million. The PC-II was prepared in 2006 at cost of Rs. 37.000 Billion, the CDWP deferred it in 2008 for revision and inclusion of land acquisition & detailed design. The CCI has approved water share from the provinces in Feb 2016. The PC-II of the project is under preparation by the concerned Bulk Water Management Directorate CDA in line direction of the ECNEC regarding design and land acquisition with costs involved.

Funds worth Rs. 500.00 Million have been earmarked for the project in PSDP 2018-19. The project has been planned for 655 MGD water by the 2050 in three phases. In phase-I, 200 MGD water will be conducted/supplied for the twin cities (i.e., 100 MGD each for Islamabad and Rawalpindi).

4.4 Problems & Issues faced by MCI

Metropolitan Corporation Islamabad is a new civic body established after Local Govt Act 2015. No proper budget is allocated for MCI. The system is in transition phase. Availability of budgets, long procedures for approvals and lack of adequate professional staff are some of the problems faced by the organization.

Lack of maintenance, due to lack of funds is an impeding problem owing to leakages and illegal connections. Illegal connections are a major problem in Katchi abides, where irrespective of government supply, illegal connections are drawn. The Irony here is political shelter of illegal connections.

The system and procedures both are remote and not smartly enabled. The use of technological advancements is non-existent.

4.5 Suggestions by MCI

Water Supply related officers and skilled staff equipped with modern techniques and required resources are required to be posted to maintain system properly and improve it to meet future water supply requirement as well as quality of water as per WHO standards.

4.6 Results of Perception Survey

The household-based survey was carried out using questionnaire as a tool for collection of primary data as discussed in the previous section. Following is a detailed account of the data received.

4.6.1 Demographic Profile

Type of Family

Of the total sample, the basic information that was retrieved showed that 59% of the families which responded to the survey were living in a joint-family system and 41% of the respondents were living as nucleus families as shown in figure 4-11.

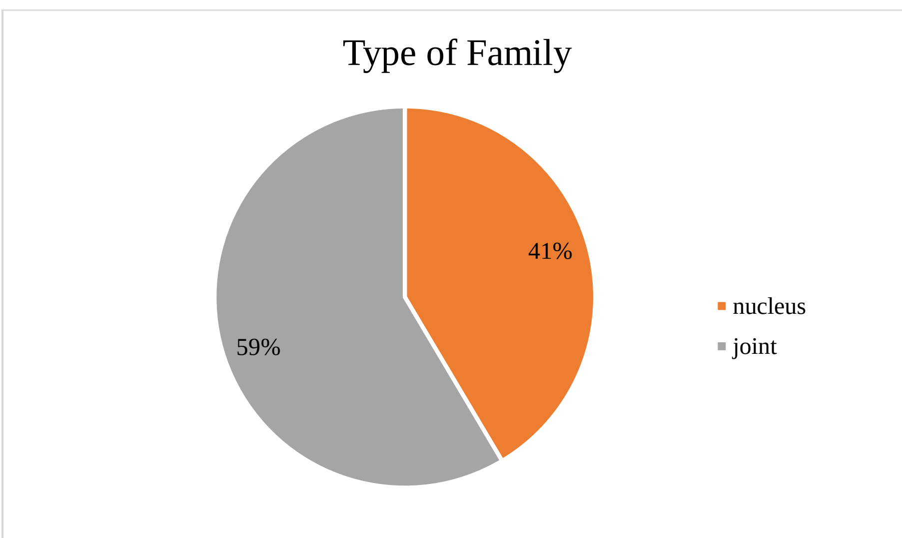


Figure 4-11: Type of family
Source: Field Survey

Number of Household Members

The number of Household members was also inquired from the residents of target area. Majority of the households i.e. 48% have 5-6 members, followed by 16% for both 3-4 and 7-8 members of the family as shown in figure 4-12.

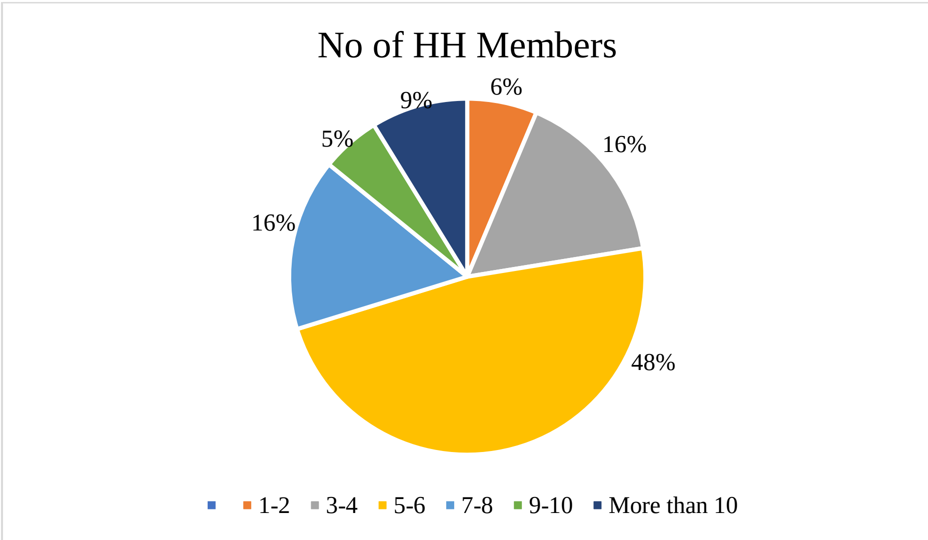


Figure 4-12: Number of Household Members
Source: Field Survey

According to Census Bureau of Pakistan, results of Population Census 2017 for Islamabad District shows a population of 2,001,579 having 335,408 households ("District and Tehsil Level Population Summary with Region Breakup," 2017). From this data, the household size is estimated to be 6 persons per household. The same majority has been observed in household survey, as depicted by figure 4-12.

Housing Ownership

As regards to housing ownership, 49% of the houses surveyed are owned by the residents. This is followed 29% houses on rental residence. 22% of the remaining houses were government provided, semi-government or government hired for government servants as shown in figure 4-13.

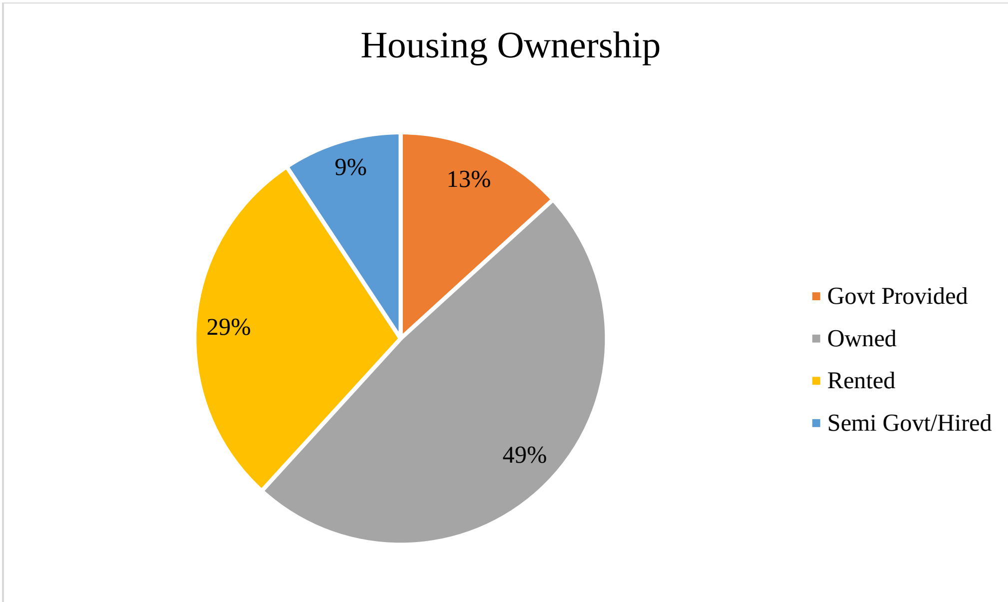


Figure 4-13: House ownership
Source: Field Survey

Monthly Average Income

To develop an understanding of the socio-economic conditions of the respondents their monthly average income was also observed which is shown in figure 4-14. 5% of the respondents shared their income level to be within 25,000 rupees per month. A majority of 38% respondents shared their income to be between 25,001-50,000 rupees per month. It is followed by 24% having income ranging from 50,001-75,000 rupees per month. Similar percentage of 12% respondents has income ranges between 75,001-100,000 and 100,001-150,000. While only 9% responded to have monthly income above 150,000 rupees per month.

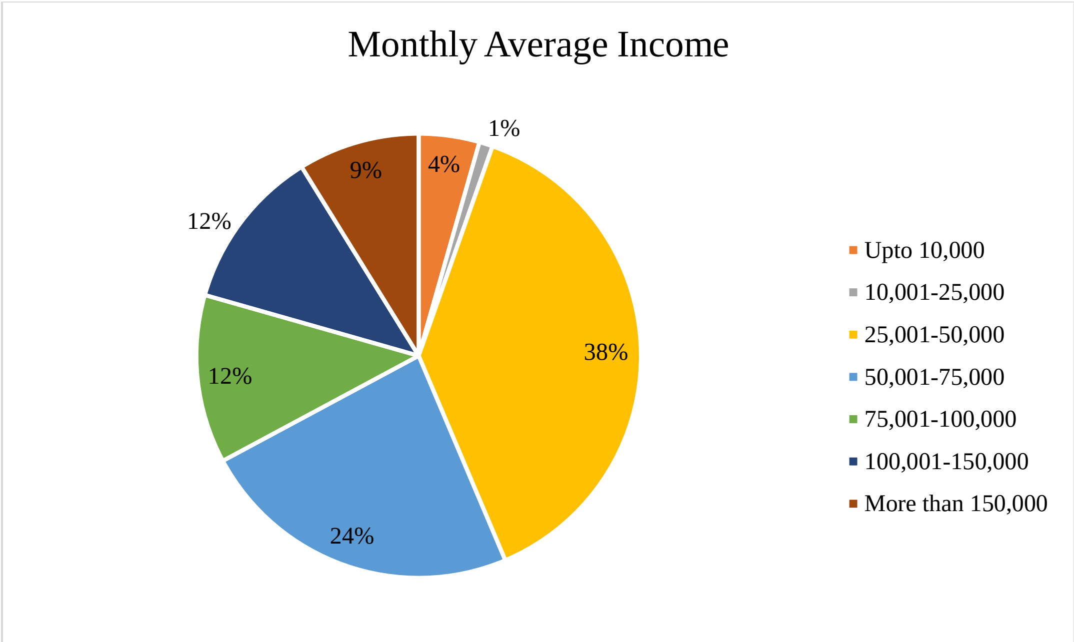


Figure 4-14: Monthly average income
Source: Filed survey

4.6.2 Water Expense

Average Water Expense per Month

29% of the respondents shared their average monthly water expense/bill is to up to Rs. 200 per month only as shown in figure 4-15. 20% have bills within Rs. 200-400 per month. 27% respondents shared their monthly bill to be falling within Rs. 400-600 per month. Remaining 24% reported to have monthly water bills of up to Rs. 1000 per month.

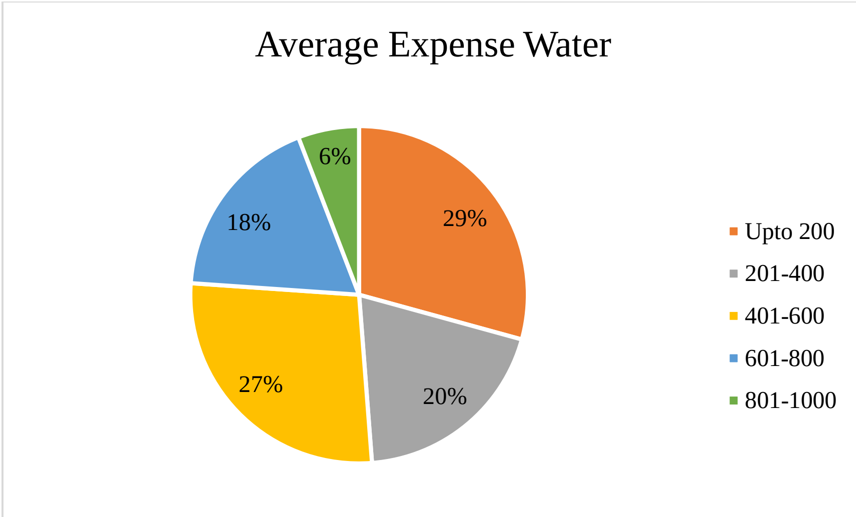


Figure 4-15: Average expense on water
Source: Field survey

Monthly Cost on Drinking Water

When asked about the monthly cost incurred on drinking water, the overall response was somewhat mixed as illustrated in figure 4-16; but the most prominent brackets were Rs. 200, Rs. 1500 and Rs. 5000. 24% of the total respondents paid Rs. 200 per month for drinking water while 21% of the respondents said that they paid Rs. 5000 every month for clean drinking water and 14% said they paid Rs. 1500 for accessing clean drinking water every month. 10% of the respondents paid Rs. 3600 while an equal number of respondents said they paid Rs. 6000 per month for clean drinking water. Such a high amount of capital being paid for drinking water every month can be attributed to the joint family system prevailing in the sample chosen for this survey. While anything between Rs. 200 and Rs. 1500 seems suitable amount to be paid for drinking water every month, the respondents who paid above Rs. 3000 complained of lack of provision of clean drinking water by their respective source of water supply.

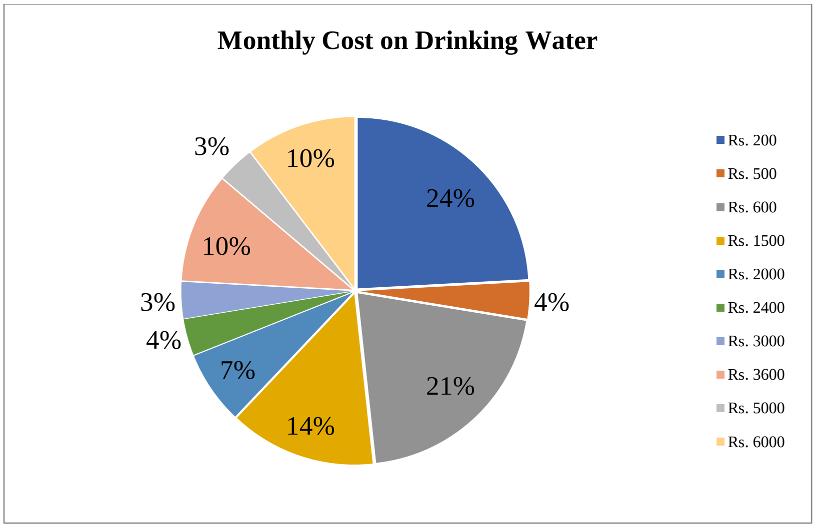


Figure 4-16: Monthly Cost on Drinking Water
Source: Field survey

4.6.3 Water Supply

Source of Water Supply

A huge majority of 83% residents reported their main source of water supply to be through laid government (MCI) provided piped water supply system as shown in figure 4-17. 13% reported to be depending upon boring as main source of water supply. Only 4% reported to rely on MCI or private water supply tankers.

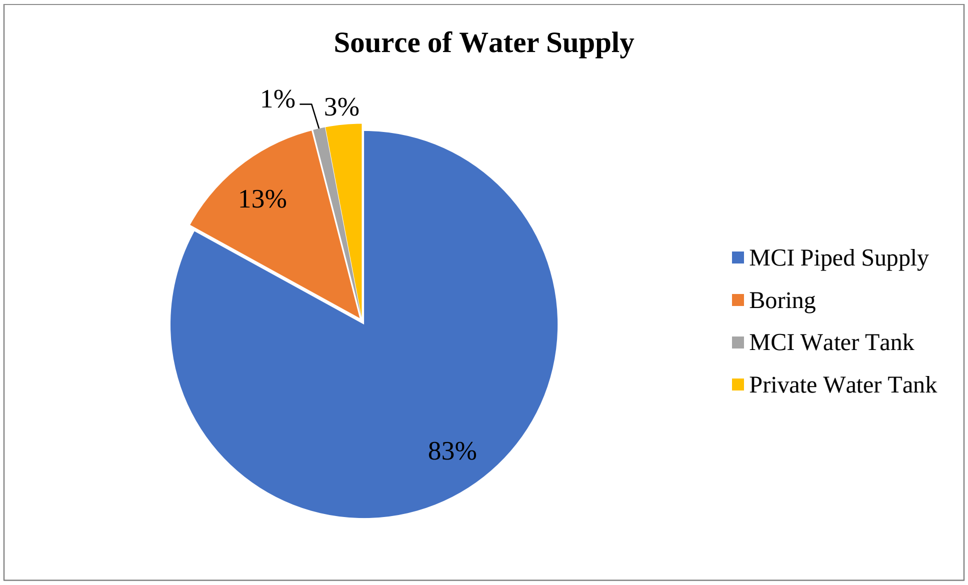


Figure 4-17: Source of water supply

Source: Field survey

Continuity of Supplied Water

The results of collected data show that majority of the households received water supply for 2 to 4 hours daily and only 15% of the households received water supply for 8 hours. Figure 4-18 shows only a negligible number of households received water supply for 12 to 24 hours daily. These stats illustrate the situation of potable water supply in Islamabad. Since the residential sectors that received water supply from MCI were selected for data collection. These results show that the governmental organizations are unable to cater to the needs of the residents in terms of provision of potable water.

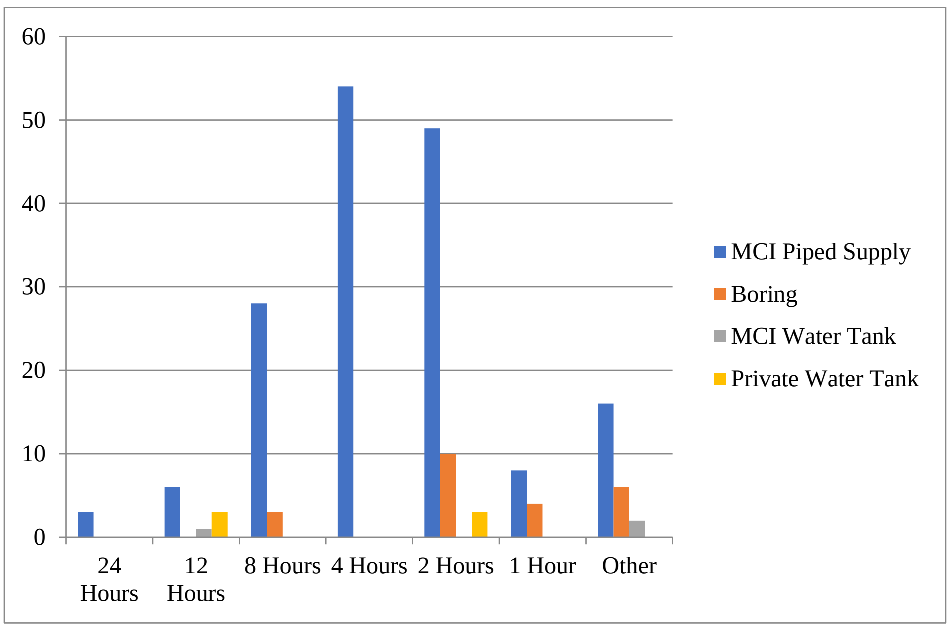


Figure 4-18: Availability of Water Supply
Source: Field Survey

Sufficiency of available water

Figure 4-19 shows results of data collected regarding sufficiency of available water. Almost one-third (30%) of the total respondents stated that the available water was sufficient while 26% of the participants of the perception survey termed the current water supply as partially sufficient. While a negligible number of respondents (5%) indicated that the available water supply was highly sufficient, 22% of the total respondents said the available water supply was not at all sufficient and 17% of the respondents said that the available water supply was somewhat sufficient. These results show that steps need to be taken to remedy the issue of clean water supply in the selected segments of study area.

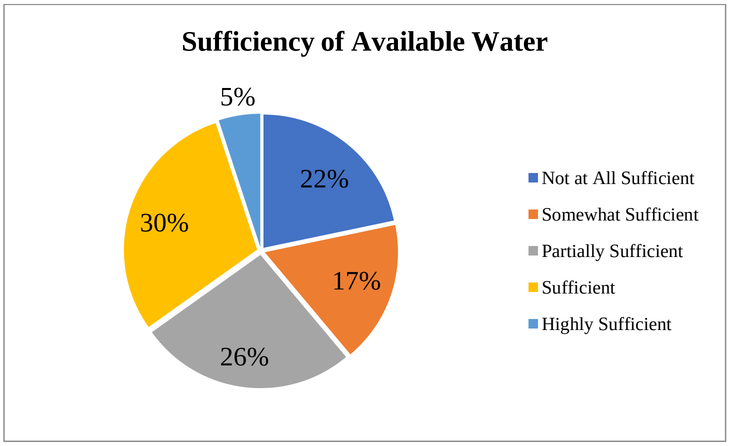


Figure 4-19: Sufficiency of available water
Source: Field survey

4.6.4 Water Shortage

Frequency of Water Shortage

A huge majority of the respondents stated that they faced shortage of water on a daily basis as shown in figure 4-20. Out of these, a substantial number of respondents were those who received water supply from MCI. While 21% of the respondents indicated that they faced shortage of water once a week, the respondents facing this issue mostly received water from MCI. This, again, shows that the water supplied by MCI is not sufficient to cater to the needs of the respondents and steps need to be taken for adopting sustainable means of water conservation and storage.

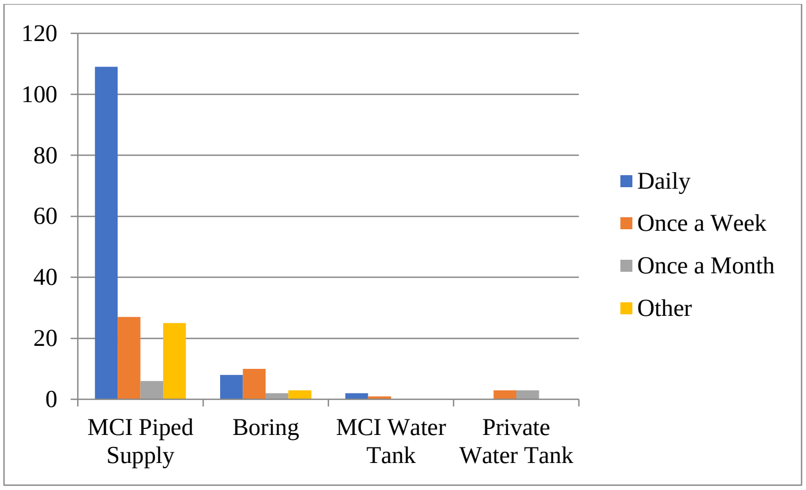


Figure 4-20: Frequency of Water Shortage
Source: Field survey

The respondents were also asked about the duration of the shortage of water supply that they were facing currently. The results show that one-third of the total respondents faced water shortage for 12 hours or more as shown in figure 4-21. Additionally, 27% of the respondents faced water shortage for 3 to 4 hours while 22% of the total respondents complained of water shortage for up to two hours. These statistics illustrate the gravity of water shortage in the study area.

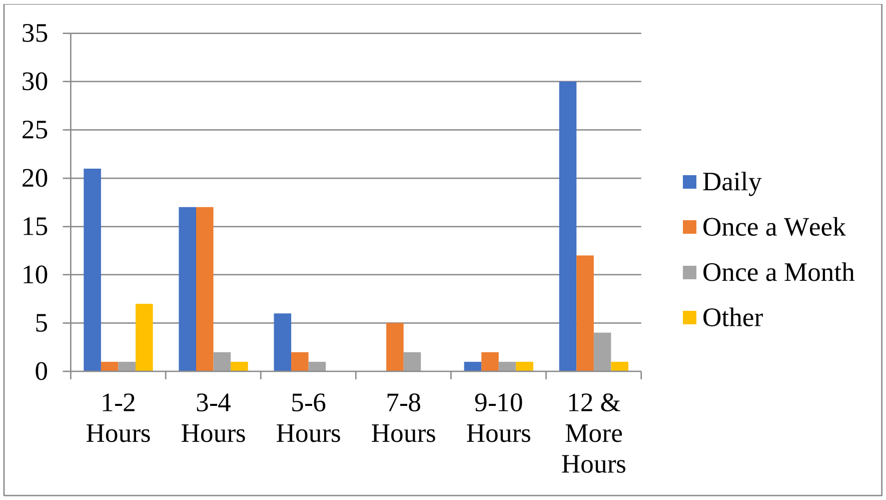


Figure 4-21: Duration of water shortage
Source: Field survey

4.6.5 Water Supply Charges

When asked about their point of view regarding charges they were paying for the water supplied to their homes, 72% of the total respondents stated that the current charges were normal and were not very high according to them as shown in figure 4-22. This shows that the respondents of the perception survey were willing to pay for accessing potable and clean water.

A negligible number of respondents claimed that the charges were too high but then again, 15% of the respondents termed the current charges as too low. The mixed response from almost one-fourth of the respondents can be attributed to the fact that their perception about the current charges of water supply can be due to their family system. In a joint-family system, the charges of water supply get divided but this is not the case in a nucleus family. But since most of the respondents termed the current charges as normal, this shows their willingness to pay for better supply of water in future.

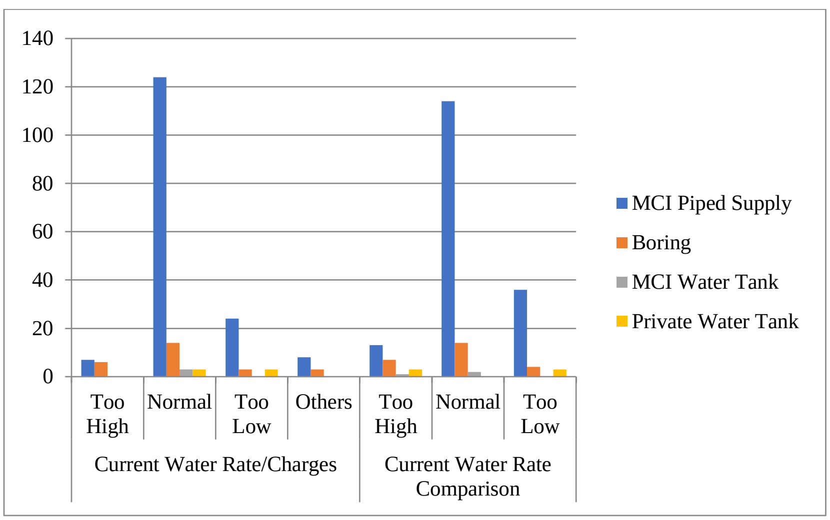


Figure 4-22: Water Supply Charges
Source: Field survey

4.6.6 System Related Problems

Different issues like leaking taps, supply lines and storage tanks were pointed out by the respondents during the perception survey. Out of all of these issues, leaking supply pipe lines was the most common issue faced by the respondents as shown in figure 4-23. More than three-fourths of the respondents indicated this issue and majority of these respondents was of the residents being supplied water through piped lines by MCI. Leaking taps was another common issue but only 16% of the participants of the survey were facing this problem. This problem was most common in water supplied through piped lines laid down by MCI and Boring done by the residents.

These results show that the most common problem faced by the residents was leakage of pipelines. This can be attributed to the fact that these lines were laid by MCI a long time ago, as indicated in the literature review. The factor of leakage has also played a major part in wastage of potable water and can be termed as one of the reasons of water shortage in the study area.

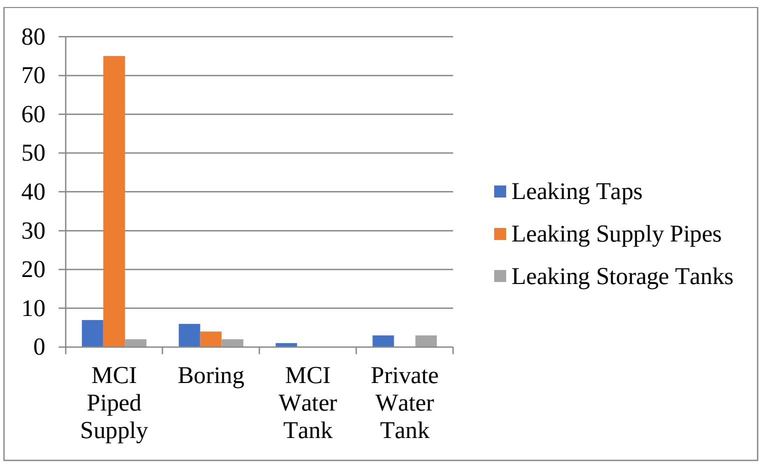


Figure 4-23: System Related Problems
Source: Field survey

4.6.7 Maintenance Services at house level offered by the municipality

Figure 4-24 shows the percentage of respondents that received maintenance service form their respective sources of water supply. Since respondents of the survey were using sources like private water tanks, MCI piped lines, boring and water tanks provided by MCI; results show that none of the sources were providing any substantial maintenance services. This factor points to the level of service being provided by these sources. Most of the respondents have no means of lodging a complaint in case they face an issue like leakage, quality of water, low pressure of water, or any other issue related to water supply and its quantity.

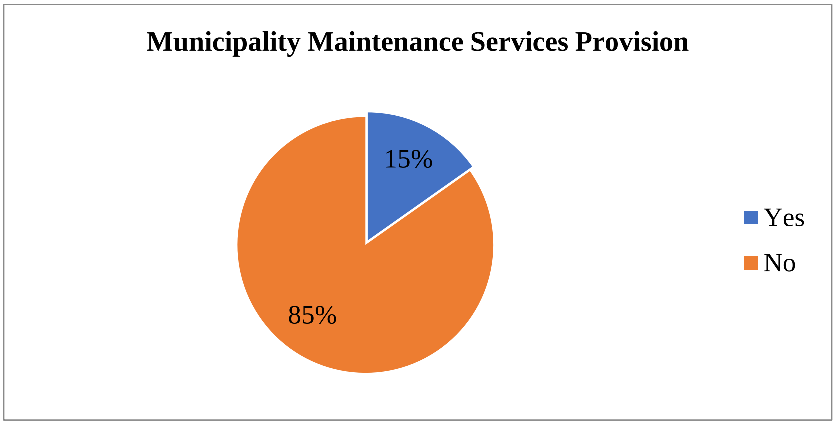


Figure 4-24: Maintenance services at house level offered by the municipality
Source: Field survey

Mode of Launching Complaints

When asked about the mode of launching complaints regarding different issues related to water supply, 42% of the total respondents said they accessed the community office while equal percentage of respondents stated that they launched their complaints through phone calls as shown in Figure 4-25. Only 7% of the total respondents used the online service of their respective water suppliers which shows that the sources of water supply are not up-to-date and majority of the people have to go to the office or call them for launching their complaints. This also indicates that they have to call multiple times or visit the community office more than one for getting an update regarding their launched complaints.

If an online system for launching complaints is put in place for launching complaints, it would become easier for the people to launch their complaints and get an update about them instead of calling their community office again and again as some of the respondents stated that it sometimes take more than 24 hours to resolve the issue related to water supply.

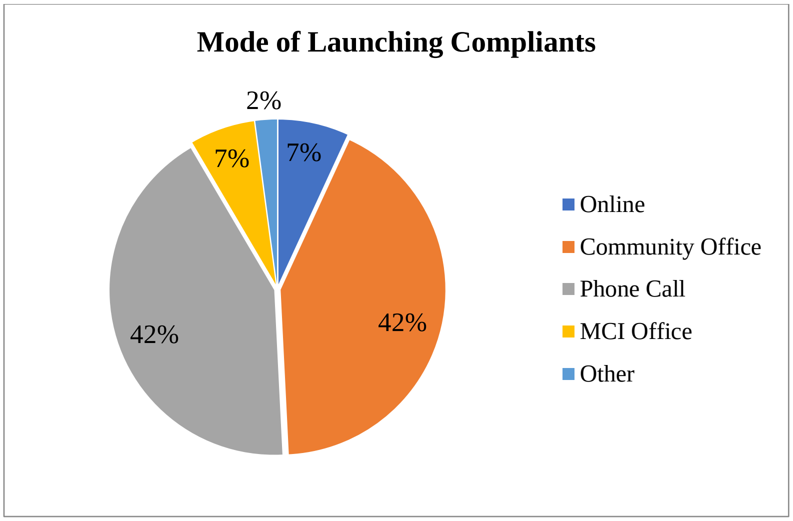


Figure 4-25: Mode of Launching Complaints
Source: Field survey

Response time for resolving the issues

Since most of the complaints were launched through community office or phone calls, the respondents were asked how long it did take for the water suppliers to resolve the issue. 30% of the total respondents said that it took 24 hours at least to resolve the issue. Many of the respondents said that they have to call several times before any action is taken by their respective water supplying agency and finds it very inconvenient as water is the most basic commodity that is needed in everyday life. Almost one-fourth, that is, 24% of the total respondents said that after launching the complaint, their issues are resolved within an hour and were quite satisfied with the time taken by their respective water supplying agency for resolving the issues related to water supply. Still, 6% of the respondents said that it took 48 hours; and an equal number of respondents said it took 20 hours or more for their issue related to water supply to be resolved, as shown in figure 4-26.

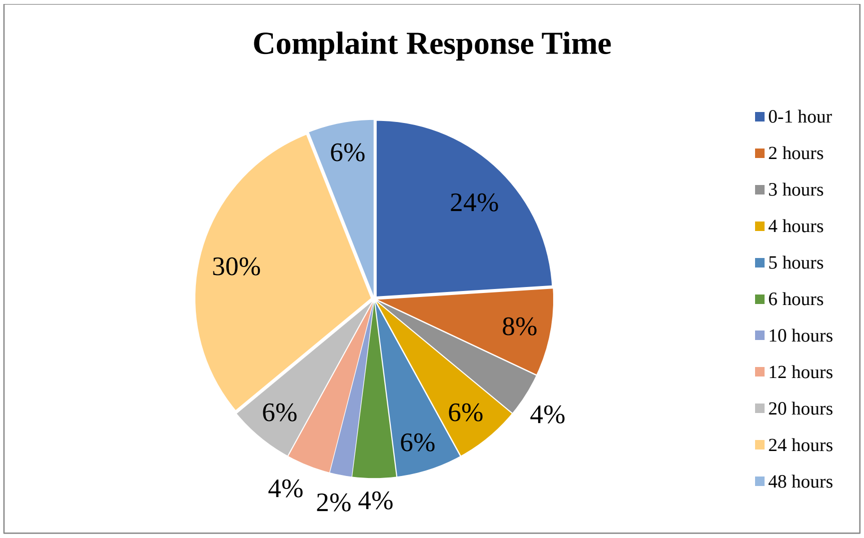


Figure 4-26: Response time for resolving the issues
Source: Field survey

When the response time was broken down to assess which of the water supplying sources were taking the most time for resolving the issues, it was discovered that while complaints launched by respondents using water supply from boring had their issues resolved within two hours. Water supplied by MCI pipelines, on the other hand, took 24 hours in majority of the cases but in some cases the issue was resolved by the MCI piped suppliers within 1-2 hours, although in some cases it took 48 hours to resolve the issue as shown in figure 4-27. These results show that the piped service provided by MCI is not up to the mark and needs to be improved, not only in terms of resolution of complaints, but also with respect to provision of quality and quantity of water. These two aspects have been discussed earlier.

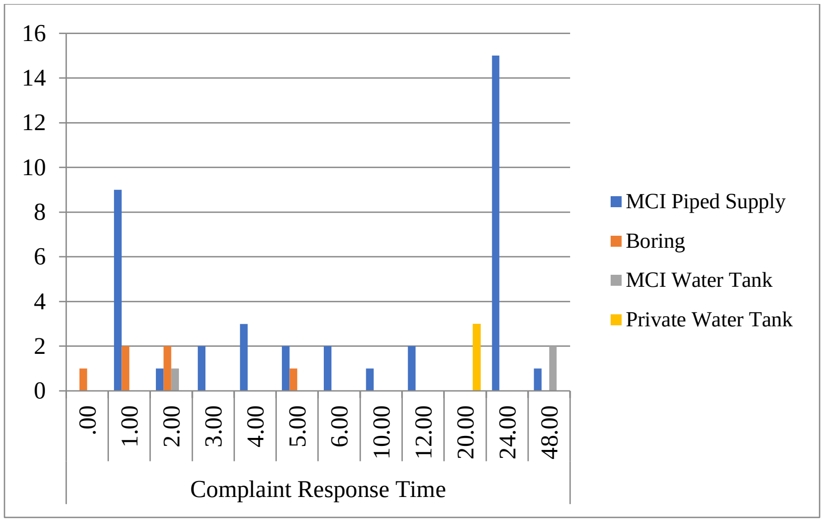


Figure 4-27: Response time for resolving the issues
Source: Field survey

4.6.8 Interventions for improving the water supply in future

A number of different issues related to water supply system were pointed out by the respondents in the selected segments of the study area but the most persistent problems, according to the respondents, were water pressure and its volume as shown in figure 4-28. 40% of the respondents regarded low water pressure as the main issue that need to be resolved while 30% of the total respondents said that volume of quantity of available water should be increased in future.

Another noteworthy issue indicated by the respondents was that of quality of water as some of the respondents stated that they have to use bottled water for drinking and cooking as quality of supplied water is not up to the mark.

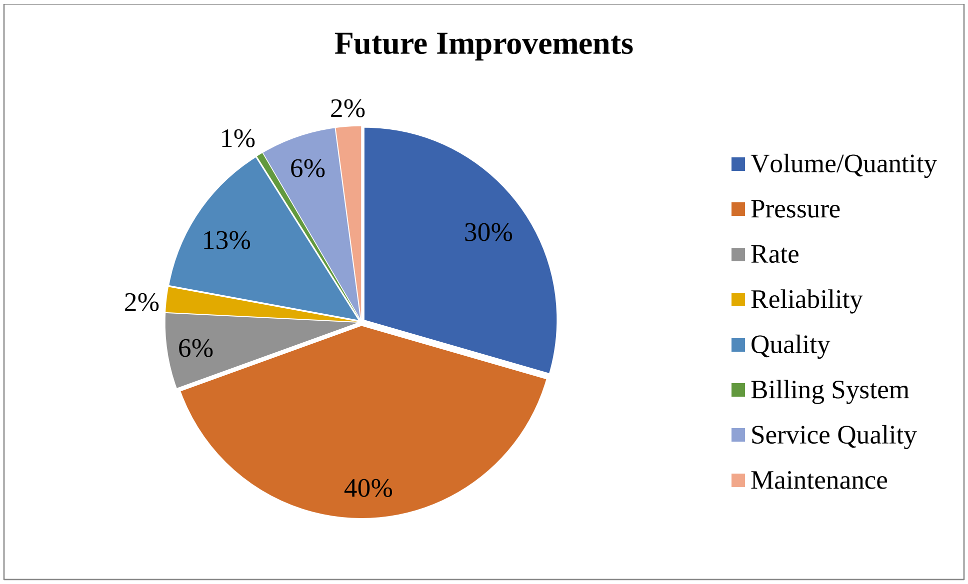


Figure 4-28: Future improvements
Source: Field survey

4.6.9 Willingness to pay for improved water supply

Figure 4-29 demonstrates the responses of the participants of the perception survey when they are asked if they would be willing to pay for improving the quality of service provided to them by MCI. 65% of the total respondents agreed to this while 35% of the respondents were not willing to pay.

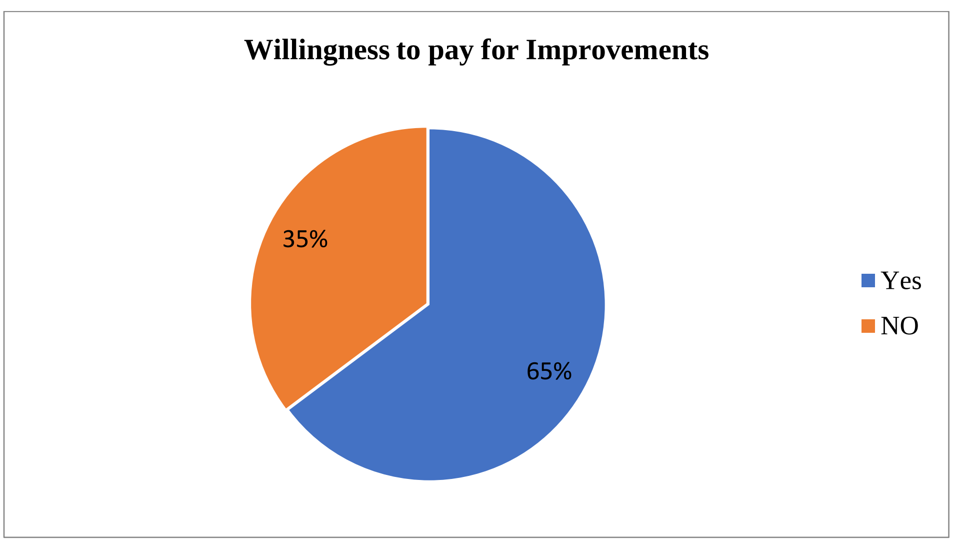


Figure 4-29: Willingness to pay for improved water supply
Source: Field survey

The results also show that majority of the respondents were willing to pay up to Rs. 600 if the water supply is improved as shown in figure 4-30. Majority of the people were willing to pay for improved service provision, this can be attributed to the extreme shortage of water in some of the segments of the study area.

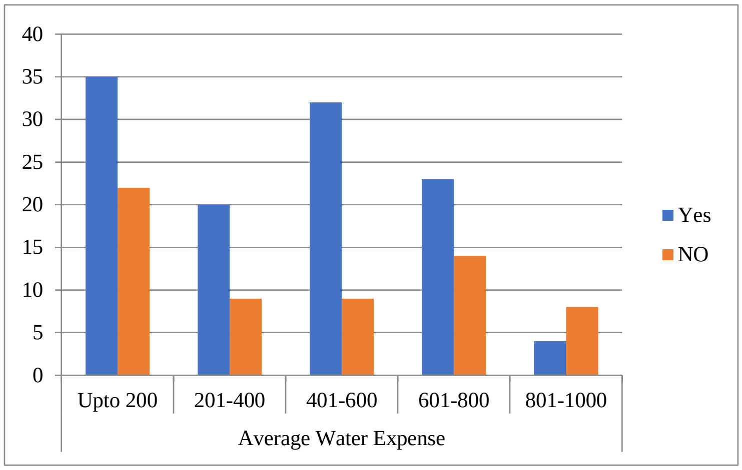


Figure 4-30: Willingness to pay for Improvements
Source: Field survey

4.6.10 Satisfaction Index

After employing the index of satisfaction in the current study, it was deduced that the respondents were highly dissatisfied with respect to quality of water, its pressure, its treatment, schedule, and its continuity in summers and winters, response time taken for resolving issues and overall management, as shown in figure 4-31. It should be noted that while the respondents were highly dissatisfied regarding most of the elements of the water supply, they showed low level of satisfaction with respect to cost incurred by the water suppliers for provision of the service.

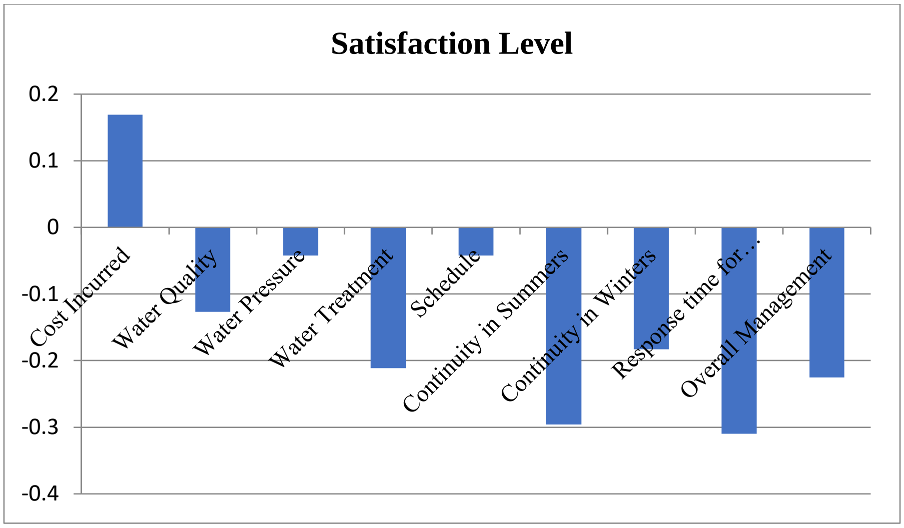


Figure 4-31: Index of Satisfaction
Source: Field survey

Shortage of water can be associated with issues like its pressure, and its continuity in summers and winters, but treatment of water and its quality can be improved by the responsible authorities. This is important due to the fact that poor quality of water has prompted the respondents to access bottled water for drinking purposes which incurs additional cost and increases the chances of wastage of water in an already water-stressed region. In addition to this, if problems of leaking pipes and taps are resolved, the wastage of water will be reduced consequently and will help in increasing the satisfaction level of residents.

5 Conclusion & Recommendations

5.1 Conclusion

At present, approximately 58.00 MGD water from various ground and surface sources is supplied by MCI to the residents of Islamabad after proper treatment and disinfection in accordance with the WHO standards/guidelines against the total demand of 120 MGD. Water resources at Simly Dam are entirely devoted to Islamabad with Tube Wells (193 Numbers) and Pumping Stations following the lead. Khanpur Dam provides one third of its sources to Islamabad. Rawal Dam does not provide water to Islamabad. There is a huge gap of 62 MGD between the water demand and supply in Islamabad. In fact, the shortage exceeds the water supplied to the city by the Municipal Corporation Islamabad. The issues observed at source reveal gaps in production capacity and production being carried out. Above this, the water supplied further faces one third in losses to leakage and illegal connections, making the overall supply even more strained.

According to MCI, approximately 90% of the urban area of Islamabad is covered by piped water supply. This includes urban areas falling in Zone-I, Diplomatic Enclave and National Forest Area. They have fixed flat monthly rate of water supply from government houses at Rupees 150-400 depending upon the category (based on officer rank and square feet area) and upto Rs. 1000 from private homes depending upon category of house size. In case of water shortage, water tankers are supplied at subsidized rates in both residential and commercial areas. According to MCI the expenses borne on water supply and maintenance system are estimated to be around 6-8 times more than the recovery generated through the current tariff & billing system.

Metropolitan Corporation Islamabad is a new civic body established after Local Govt Act 2015. No proper budget is allocated for MCI. The system is in transition phase. Availability of budgets, long procedures for approvals and lack of adequate professional staff are serious problems faced by the organization. Lack of maintenance, due to lack of funds is an impeding problem owing to leakages and illegal connections. Illegal connections are a major problem in Katchi abides, where irrespective of government supply, illegal connections are drawn. The Irony here is political shelter of illegal connections. The system and procedures both are remote and not smartly enabled. The use of technological advancements is non-existent.

The Demographic Profile of the target area shows that majority of Joint families reside in capital as compared to nucleus families. The dominant family size is of 5-6 members per household. Of the houses surveyed nearly half are owned by the residents, one-third are on rent and the rest are government or semi-government provided housing. Regarding their income status only five percent had income levels up to twenty-five thousand rupees, around forty percent have incomes up to fifty thousand rupees and one third had monthly income up to seventy thousand rupees, rest were above these income groups.

A huge majority (83%) of the respondents identified the source of water supply to their houses to be MCI provided piped water supply. A considerable 13% have water boring and 4% are entirely dependent on MCI water tankers. This shows that the MCI does have majority of the area covered by piped water supply but still it is not providing piped water supply to all the areas under jurisdiction. Moreover, the continuity of MCI supplied water to this dominant portion of respondents was only for a maximum of two to four hours expressing a shortage of supply. Nearly all the respondents shared that they store water in water tankers using water pumps at the time water is supplied by the municipality which is usually in the early morning hours.

Based on the indicators of sustainability identified and discussed in literature review, the data gathered on water expense showed that upto nearly half of the respondents reported that the water tariff was normal or even lower than their expectations (i.e. Rs. 150-400 monthly). Regarding expense on drinking water nearly one-third depend on filtered water from govt provided filter plants in the municipality while a major two-third reported to be paying from Rs. Fifteen hundred to Rs. Five thousand per month on drinking water. This is a considerable cost as compared to the monthly income reported by the respondents of the target area. When water charges were compared with the source of water supply, the huge majority of respondents who graded them as normal had MCI provided supply. Also, when water rate was compared with other utility bills it was graded as normal by the residents.

Regarding sufficiency of water supply a huge majority declared the water supplied not sufficient, while a minor percent also reported it to be sufficient for their daily needs. When cross-referred with other responses it was revealed that these respondents had large water tanks which they fill at the time of supply using additional motor pumps. Majority (80%) of the respondents reported to be facing water shortage are dependent upon MCI piped water supply source. One third of these respondents face water shortage for 12 hours and more, while rest of the majority respondents face up to 4 hours of water shortage. This also highlights that water shortage is faced by nearly all residents of the municipality, the severity of shortage might vary from one sector to the other.

Regarding System related problems around three-fourth of the respondents having MCI piped water supply reported leakage of taps and pipes. A huge majority of respondents complained regarding provision of maintenance services although almost all of them have piped water supply by the municipality. MCI have dedicated employees in each sector/zone for complaint and maintenance services for the government provided housing. Major ways of communicating complaints are complaining at the community office or making a phone call. One third of the respondents showed satisfaction as the issues are resolved within an hour after launching a complaint, nearly one third have to wait up till 12 hours and around half of them have to wait for even more than 12 hours for solution to maintenance related problems. When this was cross referred with the source of water supply it was revealed that respondents with MCI provided piped water supply had to wait for more than 12 hours while the minority having boreholes get their issues resolved within an hour. It shows that there are serious issues relating to maintenance faced by the residents due to lack of quality services by the MCI.

Regarding the issues faced, respondents identified limited volume of water available and low water pressure as the biggest problems. It is followed by bad quality of water supplied as nearly all the respondents complained that water was not fit for drinking as it had smell and bad taste.

For the purpose of assessing acceptance towards any sustainability steps for future interventions the willingness to pay more was also questioned by the residents. It was revealed that majority of the respondents are willing to pay more if any interventions are carried out. Respondents are willing to pay double the charges they are already paying monthly in case of interventions. This relates to the huge turnout of respondents on grading the current water rate as normal or low.

An Index of Satisfaction has also been drawn based on the responses received using a five-point criterion. It has been revealed that the respondents are satisfied only with the cost incurred on the water supplied by MCI. They are highly dissatisfied with the quality, volume, pressure, treatment, schedule of supply, continuity of supply in both summers and winters, response time to complains and the overall management.

5.2 Recommendations

Based on the inferences drawn from the study, the case studies discussed in literature review and the recommendations and suggestions received both by the city managers and dwellers following is a set of recommendations drawn. The recommendations have been grouped based on the indicators of sustainability drawn earlier in the study and the results received by the indicators-based questions asked in primary survey and structured interviews.

Supply & Demand - Quantifying Demand

The study showed a huge gap in supply and demand, in fact the demand is more than the supply. The data on demand and supply was collected from MCI. This data on demand comes from the previous studies and leaves room for further investigation on what is the current demand in the capital. Also, on what international or national standards have been based for calculation of these demands. Water Demand Management is essential in ensuring sustainable usage of water supply.

Metering & Pricing of Water Supply

An increase in the current tariff can be considered as an option to release the budget constraints faced by MCI. However, as discussed in the literature review case studies of Seville, London and Bangalore show that only increasing flat rate could not sustainably affect the use of water. It must be coupled with metering of water supply. Like as discussed earlier in Athens, Greece metered the water supply being used. The tariff was then charged according to the usage of water supply and this resulted in an efficient usage of water.

Allocation of Budget for Maintenance

Efforts need to be put in place to use the already built dams, Simly and KhanPur to their full potential, as gaps in their actual production capacity and the present production have been observed too. Also, the production capacity at Korang River and Streams mainly Noorpur, Shahdara, Saidpur and Poona Faqiran Augmentation is reduced due to lack of maintenance. MCI must be allocated exclusive budgets for maintenance of these water sources to improve production. The already allocated budget is not sufficient and a major portion of it is used at Rawal Dam maintenance, however, the water is supplied to Rawalpindi City from this source. This burden may also be taken off from MCI and handed over to Rawalpindi Development Authority.

Improving Water Infrastructure

Investing into the existing infrastructure to control leakage and illegal connections will improve supply to the target areas and relieve the stress on municipality administration. Moreover, replacing the worn out pipelines; adding pipelines, storage and connections is also recommended.

Future Project for Water Supply - "Conduction of Water from Indus River System for Rawalpindi & Islamabad"

The project title "Conduction of Water from Indus River System for Rawalpindi & Islamabad" as discussed in the earlier chapter is undergoing discussions and approval stages at different forums. This project, regardless of the expenses, should be given serious discussion to end the water issues faced by the city. The fact that demand exceeds the amount of water supplied to the municipality is alarming and huge effort is needed to cater for this gap. The natural dams that could be built around the city are already built and are being used.

Realization of this project will also generate opportunity for the municipality to apply ban on use of tube wells for water supply both officially and privately. This will then provide roam for ground water recharge within the municipality and raise the water table reported to be gone down to 350 feet at places.

Privatization of Water Supply

Privatization of water supply has also been an option in developed countries like in London.

However, it was done without metering, therefore charges fixed increased many folds over time to balance the expenses borne. In Athens however, with metering and pricing, water demand has been managed efficiently. Privatization of water supply system can be considered as an option; however, the benefits will not be earned by the government.

Rainwater Harvesting

Rainwater harvesting is another sustainable solution for tackling the issue of water scarcity in the study area. Although this system needs appropriate planning and needs to be maintained at all times to ensure efficient operation of the system, this system can help in fulfilling the needs of the industrial sector which will help in catering to the needs of agricultural and domestic needs of the study area. Chlorination, boiling, flocculation and chlorination, solar treatment, filtration and chlorination are some of the most common practices that are being implemented all over the world for sustainable water supply systems.

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Annexure

Annexure A

NUST
NATIONAL UNIVERSITY OF SCIENCES & TECHNOLOGY

National Institute of Transportation (NIT)

The research is being carried out to assess the sustainability of water supply & management of Islamabad. All the data provided will be treated as strictly confidential and for academic purpose only. Please, carefully read the following and mark the appropriate answer. Your kind cooperation, response and time are highly appreciated.

Name of Enumerator: ________________________ Date: ______________________

Name of Respondent: ________________________ Study Sector: _______________

Part I: Household Demographics

1. **Number of Households**
    a. 1
    b. 2
    c. 3
    d. More than 3
2. **Type of Family**
    a. Nucleus
    b. Joint
3. **Number of Household Members**

    ____

Part II: Household Socio-Economic Data

4. **Housing Ownership**
    a. Government Provided
    b. Owned
    c. Rented
    d. Semi-Government/Hired
5. **Number of Storyes**

    ____
6. **Monthly Average Income of Family**

    ____

7. Average Monthly expense on various utility bills

Description	Water	Electricity	Telephone	Sui Gas	Internet
Monthly					
Quarterly					
Annually					

Part III: Water Availability & Demand Data

8. What is the main source of water supply in your house?

a. MCI Piped Supply
b. Boring MCI Water Tank
c. Pvt WaterTank
d. Other: ______________________________

9. In case of boring, why have you opted for it?

____

10. In case of Water Tanker, what cost do you bear monthly in addition to piped supply cost;

____

11. In case of pipeline supply, what is the continuity of supply;

a. 24 hours
b. 12 hours
c. 8 hours
d. 4 hours
e. 2 hours
f. 1 Hour
g. Other:____________________

12. Please mention the timing at which piped water supply is available:

____

13. Is the water available sufficient to fulfill the demand of your household?

a. Not at All
b. Somewhat Sufficient
c. Partially Sufficient
d. Sufficient
e. Highly Sufficient

14. How frequent do you face water shortage?

a. Daily
b. Once a Week
c. Once a Month
d. Other: ________________________

15. How long did the latest Water Shortage Last?

a. 1-2 Hours
b. 3-4 Hours

c. 5-6 Hours
d. 7-8 Hours
e. 8-10 Hours
f. 12 & More Hours

16. Do you use Electric Motor Pumps for fetching Water?

a. Yes
b. No

If Yes, Why: ____

17. Do you consume one water tank a day (Overhead Water Tank at home)

a. Yes
b. No

18. Size of Water Tank?

____________________ ____

19. Do you face any system related problems?

a. Leaking Taps
b. Leaking Supply Pipes
c. Leaking Storage Tanks

20. Do you have any maintenance services at house level offered by the municipality?

a. Yes
b. No

21. What is the response time when a maintenance related complaint is launched? ____

22. Is it offered free of cost, if not then are any charges taken?

____

23. What is the major source of household drinking water

a. Piped Water
b. Bottled Water
c. Boring/Well Water
d. Water from Community Filter Plant
e. Home Filter on Piped Water
f. Home Filter on Boring Water

24. How much drinking water does your family consume in one day (liters)?

____

25. If your family does not drink tap/filter water, what is the monthly cost incurred on drinking water?

____

26. What do you think about the current water rate?

a. Too High
b. Normal
c. Too Low

d. Other: ___________________________

27. Compared with other utility payments such as electricity fee, what do you think about the current water tariff?

a. Too High
b. Normal
c. Too Low
d. Other:____________________________

28. What is the current billing system?

a. Through Bank
b. Paid at Office
c. Paid through Internet
d. Other: ____________________________

29. Which of the following aspects of your water supply needs improvement in the future?

a. Volume/Quantity
b. Pressure
c. Rate
d. Reliability
e. Quality
f. Billing system
g. Service quality
h. Maintenance
i. Other: ____________________________

30. In case of interventions for improved water supply will you be willing to pay more than you are already paying?

a. Yes
b. No

31. What do you think about water availability situation in Pakistan?

____

32. How do you launch complaints related to Water Supply?

a. Online Community Office
b. Phone call
c. MCI Office
d. Other: _____________

33. What is the response time after a shortage/availability related complaint is launched?

____

34. Any issues/problems you would like to share;

____

35. Any suggestions you would like to give;

____

Annexure B

National Institute of Transportation (NIT)

The research is being carried out to on the sustainability of water supply & management of Islamabad. All the data provided will be treated as strictly confidential and for academic purpose only. Please, carefully read the following and mark the appropriate answer. Your kind cooperation, response and time are highly appreciated.

Interview Sheet for Municipal Managers / Operators of Water Supply

Name: ______________________________

Designation: _________________________

Organization: ________________________

1. **What are the main sources of water supply in the Capital (specify numbers please)?**
    a. Simly Dam
    b. Khan Pur Dam
    c. Rawal Dam
    d. Tube Wells
    e. Pumping Stations
    f. Other: ________________________

2. **What is the storage capacity of identified water sources;**
    a. Simly Dam ________________________
    b. Khan Pur Dam ________________________
    c. Rawal Dam ________________________
    d. Tube Wells ________________________
    e. Pumping Stations ________________________
    f. Other, please identify ________________________

3. **How much share of water (in %age) do these sources supply to Islamabad?**

Description	Islamabad	Rawalpindi
Simly Dam		
Khanpur Dam		
Rawal Dam		
Tube Wells		

Pumping Stations
Other

4. **In case of pumping stations being used, how is water supplied to communities?**
    a. Through Water Supply System
    b. Through Water Tankers
    c. Through Community Water Tanks
    d. Directly to Houses
5. **Is water supply system divided in different zones, if yes, on what basis**

____

6. **What percentage of urban area is covered by piped water supply?**

____

7. **Is there any schedule for supplying water in different zones? If yes, please share.**

____

8. **In your knowledge what is the continuity of water supply?**
    a. 24 hours
    b. 12 hours
    c. 8 hours
    d. 4 hours
    e. 2 hours
9. **In your Knowledge, is there any shortage of water, If Yes, Please identify when you experience it?**

____

10. **Who is mainly responsible for municipal water supply in the city?**
    a. Capital Development Authority
    b. Metropolitan Corporation Islamabad
    c. Islamabad Capital Territory
    d. Other, please identify: ______________________________

11. **What is the distribution of responsibilities for water supply in different areas of the city?**

____

12. **Are you satisfied with the overall situation of water supply in the capital?**
    a. Yes
    b. No

If not, Why?

____

13. What is the overall water demand in the city?

____

14. **On what basis is the water demand calculated?**

____

15. What is the increase in water demand per year?

____

16. Do you think that there is a gap in water supply and demand in the capital?

a. Supply is less than demand
b. Supply is more than demand

17. In your opinion do we need to increase sources of water supply to meet demands?

a. Yes
b. No

If Yes, What measures should be taken to handle supply;

____

If No, What measures should be taken increase supply;

____

18. What is your opinion on the physical water supply infrastructure?

____

19. What are the steps/measures we need to adopt to improve the physical infrastructure, if any?

____

20. What is condition of existing water supply system components (storage tanks, supply pipes etc.)?

a. Very Good
b. Good
c. Average
d. Satisfactory
e. Poor

21. In your knowledge, does system face any of the following physical system operational issues?

a. Leakages
b. System Breakdown
c. Pressure Issues
d. Other, please specify: ________________________________

22. Are the resources to manage existing infrastructure enough?

a. Yes
b. No

If yes, reasons:

____

If no, reasons:

____

23. How is water bill charged and at what rate?

Description	Water Bill Charged
Monthly	
Quarterly	
Annually	

24. What are the expenses borne by MCI on system provision?

____

25. What are the expenses borne on system maintenance?

____

26. How much recovery is made through current pricing system?

____

27. What percentage of expense is recovered through billing?

____

28. Do you think the tariff charged is enough?

____

29. Do you think tariff should be increased to sustain system economically?

____

30. What percentage of tariff is recovered on monthly/annual basis?

____

31. How much percentage does recovery cover as compared to expense incurred?

____

32. On what basis do you charge water supply in different zones of Islamabad?

____

33. Do you have enough finances to operate the current arrangements?

____

34. **Do you have financial resources required for improvement of existing water supply system?**

____

35. **What arrangements do you have with other suppliers on supplying water in municipality area (if any)?**

____

36. **Is water tank based water supply regulated under your organization command?**
    a. Yes
    b. No

If yes, what are the tariffs fixed for different zones/areas;

____

37. **Are there any problems regarding water tanker based water supply?**

____

38. **Is there any inventory/data of the physical infrastructure laid down?**

____

39. **Is the system using any modern/smart technologies to identify leakages or blockages?**

____

40. **Are there any future expansion plans for the water supply system? Please explain;**

____

41. **Any problems/issues you would like to highlight?**

____

42. **Any suggestions you would like to give;**

____

43. **Are the existing sources sufficient to fulfill the current water demand?**

____

44. **Are there any gaps in storage and production capacity of the reservoirs/tube/wells, if so why?**

____