12-2021

# Sustainable urban groundwater governance in Faisalabad, Pakistan: challenges and possibilities.

Shahbaz Altaf
*University of Louisville*

# SUSTAINABLE URBAN GROUNDWATER GOVERNANCE IN FAISALABAD, PAKISTAN: CHALLENGES AND POSSIBILITIES

By

Shahbaz Altaf
B.Sc., University of Engineering and Technology, Lahore, 2011
M.Sc., Universiteit Hasselt, Belgium, 2017

A Dissertation
Submitted to the Faculty of the
College of Arts and Sciences of the University of Louisville
in Partial Fulfillment of the Requirements
for the Degree of

Doctor of Philosophy
in Urban and Public Affairs

Department of Urban and Public Affairs
University of Louisville
Louisville, Kentucky

December 2021

SUSTAINABLE URBAN GROUNDWATER GOVERNANCE IN FAISALABAD,

PAKISTAN: CHALLENGES AND POSSIBILITIES

By

Shahbaz Altaf
B.Sc., University of Engineering and Technology, Lahore, 2011
M.Sc., Universiteit Hasselt, Belgium, 2017

A Dissertation Approved on

November 19, 2021

by the following Dissertation Committee:

__________________________________
Dr. Frank Goetzke, Dissertation Chair

__________________________________
Dr. Sumei Zhang

__________________________________
Dr. Daniel DeCaro

__________________________________
Dr. Marco Janssen

__________________________________
Dr. Anas Malik

# DEDICATION

To my loving wife, Patrycja, for her endless support and prayers
during this educational endeavor.

To my precious daughter, Maryam, born in the final year of my doctoral studies,
for making my life more joyful.

# ACKNOWLEDGEMENTS

I want to thank my dissertation committee, Dr. Marco Janssen, Dr. Anas Malik, Dr. Sumei Zhang, Dr. Daniel DeCaro, for their valuable insights and guidance, especially my dissertation chair Frank Goetzke, who believed in me and pushed me hard to achieve this academic milestone. I also want to thank my wife, Patrycja, and colleague Brenton Hereford for reading and proofreading parts of my dissertation.

# ABSTRACT

SUSTAINABLE URBAN GROUNDWATER GOVERNANCE IN FAISALABAD, PAKISTAN: CHALLENGES AND POSSIBILITIES

Shahbaz Altaf

November 19, 2021

Groundwater use is high in developing countries, especially in places where municipal water authorities struggle to meet the water demand of the residents. To analyze interactions between groundwater and piped water, Faisalabad, Pakistan was taken as case study area. Using the Institutional Analysis and Development framework and Elinor Ostrom's design principles as institutional analysis tools, formal and informal institutions governing the piped water and groundwater, including their congruence with the social and ecological factors, were explored. The results showed that scarcity of piped water pushed people towards groundwater and the absence of informal and the weakness of formal governance rules allowed people to access freshwater aquifer without restrictions. As a result, urban groundwater in several parts of the city has depleted, while in others, it is close to depletion.

According to Garrett Hardin, open-access common pool resources like groundwater are vulnerable to unsustainable exploitation unless government regulates or privatizes them. Elinor Ostrom contested this idea and argued that there is a third way to manage the resources held in common; resource users can come together and devise institutions to govern the resource themselves. A one-shot common pool resource experiment was conducted with the household heads in Faisalabad to test if people want to want to come together to govern groundwater. The results of the game showed that participants are willing to moderately cooperate with each other. In addition, an Ordinary Least Squares (OLS) regression model was estimated, which demonstrated that a lack of trust, corruption, impatience, and a decline in egalitarianism increase the rate of groundwater extraction. The residents' choice for the piped water governance mode were also explored, as the majority of the people are free-riding on the piped water and contributing to the creation of public goods dilemma. I employed the discrete choice experiment to elicit public preferences and the conditional logit model to process the choice data. The results showed that people prefer to have a state-owned piped water system. In terms of governance, they prefer impartial governance and, to a lesser extent, prefer to co-produce or get involved in the affairs of the public service provision.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# CHAPTER 1: INTRODUCTION

Water is the most abundant resource in the world, but only 0.62 percent of it is groundwater. Most of it is inaccessible because it is located far deep in the earth's crust or too saline for human consumption. Only a fraction (0.0091 percent) of the total water in the world is present in the lakes, rivers, and freshwater aquifers (Bureau of Reclamation California, 2019). Most populous countries in the world, India, China, and Pakistan, are free-riding on these freshwater aquifers (Seckler et al., 1999). The dependence on groundwater is exceptionally high in the cities because water demand is concentrated in a small area. However, the demand for groundwater is especially high in the urban areas of the developing world, as 1.5 billion urban dwellers rely on aquifers (UNESCO, 2012). The groundwater extraction is either unregulated or stipulated laws are not enforced (Ramachandran, 2008). The local municipal water supply authorities are usually mired in administrative and financial challenges, therefore failing to meet the residents' water demand (Biswas et al., 2017). To meet their partial or complete unmet water demand, citizens use groundwater; typically, it is a cheap and easily accessible alternative water source. The negative consequence of this development is that groundwater reduction is getting more and more pernicious in the urban areas of the Global South (e.g., Klassert et al., 2015; Silva et al., 2020).

## 1.1 Justification of the study

In the previous studies, groundwater withdrawal and municipal water supply systems are analyzed separately (Araral, 2008; Arbúes et al., 2004; Foster, 2020; Seward & Xu, 2019). Thus, there is academic space to explore the connections between these two sources of water. The challenges that groundwater or the municipal water supply systems face can be ecological (e.g., dried up water wells, poor rainfall), social (e.g., political interventions, cheap water pumping technology), and institutional (e.g., lack of social trust, dependence on donor agencies). I want to analyze how municipal water supply and groundwater consumption are related and investigate this relationship from the institutional perspective. According to the United Nations, all the water crises today are a crisis of governance (WWAP, 2003). According to the cross-country analysis of the water governance institutions, the performance of the water resource management depends more on the quality of institutions than the sole focus on the physical, ecological, or economic dimension of the problem (Saleth & Dinar, 2004).

In developing countries, *formal institutions* are generally weak (Kessides, 2005, p.86) and drenched in various types of corruption (e.g., rent-seeking, patronage, bribery, state capture), bureaucratic inefficiencies (Rothstein & Varraich, 2017), and social traps (Rothstein, 2005). In contrast, *informal institutions* are more potent and can play a positive or a negative role. For instance, trust networks based on caste, kinship, or religion reduce uncertainty and help develop trust among the members of the network (Malik, 2017). A higher level of trust leads to a higher degree of cooperation among the group members in social dilemmas. On the negative side, informal institutions might, for example, exclude women from decision-making arenas by restricting their physical mobility or devising discriminatory property rights that leave them with limited access to wealth or other resources (Jütting et al., 2007). Nonetheless, looking at the groundwater withdrawal and depletion problem from the institutional perspective is crucial to understand why groundwater scarcity is a much severe problem in the Global South.

### 1.2 Study Area

To conduct research in the context of developing world, Faisalabad, Pakistan, was selected as a case study area as it faces massive groundwater scarcity and piped water supply challenges. This city is the author's hometown; therefore, familiarity with the geography, people, and institutions are substantial. In Faisalabad, people are part of or grouped in *biraderi*[1] based trust networks (informal instituions). A higher level of communication and contact between the members of the *biraderi* helps garner the environment of trust and reciprocity in society, which in result removes obstacles to cooperation (Malik, 2017, p.245; Rothstein, 2005). Biraderies are active in politics, especially during the elections for provincial and national parliaments. All the members follow the lead of the biraderi head and vote in unison for the candidate of his or her choosing. The leadership of the trust network strives to secure public sector jobs for the members of their biraderi using political connections or personal relationships with the bureaucrats. Once the politicians and government employees whom they have endorsed assume power, biraderi heads start to seek privileged treatment in accessing goods and services for themselves and their group members (Anwar, 2019). This relationship between formal (e.g., bureaucrats) and informal actors (biraderi based trust-networks) creates an informal governance system, that makes the state appear less like a legitimate democratic

[1]The term refers to caste, clan, religion, tribe, or sect.

entity but more like a vehicle for the illegal distribution of goods and services (Malik, 2017). An even bigger problem is that biraderies are not equal in terms of their influence and resources, the key factors that guarantee access to the sought-after goods and services in society (Gazdar, 2007).

## 1.3 Research Design

I followed the journal article format and wrote three papers, presented in the dissertation as Chapter 2, 3, 4. In each chapter, I looked at the different aspects of the problem and provided policy recommendations. In chapter 2, Institutional Analysis and Development (IAD) framework and Elinor Ostrom's design principles to explore social, ecological, and institutional factors affecting the piped water and groundwater governance in Faisalabad. The results of the institutional analysis showed that the water sector in Faisalabad is facing two kinds of social dilemmas, 1) Public Goods dilemma, as citizens do not pay their bills and there is a challenge of illegal connections. Informal governance units comprised of politicians, bureaucrats, and biraderi (clan, caste) based trust-network subvert and undermine the authority of water agency. The cash-strapped water agency then starts to look for subsidies and aid to perform basic operations like water filtration. The dependence on external funds has slowed the institutional maturation process of the water agency. 2) Common Pool Resource dilemma, as groundwater table is declining thanks to the consistent overuse of the aquifer. The absence of informal rules and the weakness of formal groundwater governance allowed people to exploit the freshwater aquifer without any restrictions. As a result, urban groundwater in some parts of the city is depleted, and in others, it is declining. In Faisalabad, the water agency is also formally responsible for the protection of groundwater. Hence, to arrest the groundwater decline and provide quality piped water service, the performance of the water agency must be improved as well.

In the chapter 2, institutional analysis was conducted In chapter 3, a one-shot common pool resource game was played with the household heads in Faisalabad. The goal was to determine if the people would cooperate in the CPR dilemma and devise institutions

to self-govern the aquifer. The game results showed that respondents moderately cooperate, indicating a real potential for the community-based organization to work on groundwater management. In addition, an Ordinary Least Squares (OLS) regression model was estimated to explore which factors affect the level of cooperation in the game. The findings showed that trust, lack of corruption in the water agency, patience, and egalitarianism increase cooperation. In chapter 4, I explored what kind of piped water governance residents of Faisalabad would prefer. I employed the discrete choice experiment to elicit their preferences and later used the conditional logit model to process the choice data. The model results showed that people prefer to have a state-owned piped water system that is impartial and willing to involve consumers in administrative affairs. In chapter 5, a summary of the findings and possible future research directions are presented.

# CHAPTER 2: GROUNDWATER GOVERNANCE IN FAISALABAD, PAKISTAN-AN INSTITUTIONAL ANALYSIS

## 2.1 Introduction

To meet their domestic water needs 2.5 billion people around the world are dependent on groundwater, and approximately 1.5 billion users among them are urban dwellers (UNESCO, 2012; Foster et al., 2010)[2]. The reliance on groundwater is high and continuously increasing in the developing cities, particularly in places where government-led water supply systems have been struggling to fulfill domestic and non-domestic water demands of the residents (Silva et al., 2020; Grönwall & Danert, 2020; Foster et al., 2011; UN-Water, 2009). To satisfy their unmet water demand, people start to rely on groundwater either directly when in-situ private access to the aquifers is a feasible option or indirectly through vendors who pump water from the distant locations (e.g., Biswas et al., 2017; Zozmann et al., 2019). The private in-situ self-supply of groundwater is increasing in South Asia, continental Africa, Southeast Asia, and some parts of Latin America. For example, in 2015, about 369 million people (or 79 percent of the total city population) in urban continental Africa were meeting their drinking and other domestic needs (e.g., bathing, washing dishes) from groundwater. In Lucknow and Delhi, India, 50 percent, and 43 percent of the population, respectively, is involved in uncontrolled private drilling of

[2]There is no systematic and comprehensive data available on global urban groundwater consumption. This estimation is based on the observed trends of aquifer exploitation in the major regions of the world.

groundwater, causing the water table to decline (Ramachandran, 2008). Similarly, according to the urban water consumption data collected by Carrard et al. (2019) from 10 Southeast Asian and Pacific Island cities, 66 percent of urban households are privately extracting groundwater. On the other hand, 100 percent of the resident's rely on groundwater in Natal, Brazil. As a result, the aquifer has started to experience an intrusion of seawater, turning the freshwater brackish due to the excessive lowering of the water table (Foster et al., 2011). The spatial concentration of hundreds of thousands private groundwater pumps in urban areas put extreme pressure on the aquifers, as the rate of groundwater discharge is often higher than the rate of recharge (McDonald et al., 2014). Consequently, aquifers have either completely dried up (e.g., Klassert et al., 2015), or they are experiencing decline in their water tables in global south cities (van Leeuwen et al., 2016).

To explore the dynamics between the performance of municipal water supply systems and the groundwater consumption including the factors that influence them, I have chosen Faisalabad, Pakistan as a case study. It is a city where the local water agency is struggling to cope with the residents' domestic and non-domestic water demand. According to the survey conducted by the Japan International Cooperation Agency with 600 households from all income categories in Faisalabad, on average a typical resident fulfills 75 percent of its domestic water demand (103 liters per day) from groundwater. The local water agency meets only 24 percent (33 liters per day) of the domestic demand (JICA, 2019b, p.A2-38). Approximately 72.6 percent of the households have installed private in-situ motorized pumps on their premises to extract groundwater to compensate for the lack of municipal water (JICA, 2019c, p.B5-13). Similarly, 100 surveys conducted with the commercial and industrial water users in the water agency's service and the non-service areas show that only 8 percent of the respondents were dependent on the municipal water supply, while 18 percent used both municipal water and groundwater, and 59 percent used groundwater (JICA, 2019b, p. A2-44). This massive exploitation of the groundwater is negatively impacting the aquifer lying directly underneath the city. According to the water agency officials, the groundwater table is declining at a rate of ~2 feet per year (Jamal, 2019, p.17). Moreover, the Pakistan Council of Research in Water Resources (PCRWR) found that the freshwater layer of the aquifer in some regions of the city it is already depleted while likely depleted in others (Khan et al., 2016, p.3).

### 2.1.1 Causes of Urban Water Scarcity

The poor performance of public piped water supply systems and the subsequent rise in groundwater consumption in the metropolitan areas of the developing world have been attributed to factors such as population growth and urbanization (Grönwall & Danert, 2020; Kalhor & Emaminejad, 2019). Fifty-five percent of the world population (4.2 billion) is urban, and it is expected to increase up to 68 percent, injecting 2.5 billion more people into the cities by 2050. According to the United Nations' estimation, 91 percent of this growth is taking place in developing nations (UN-DESA, 2018). With the growth of urban population, the demand of water for domestic, commercial, and industrial uses increases as well. Local administrations build more water supply infrastructure but usually find it difficult to keep pace with the rapid rate of urbanization (McDonald et al., 2014). For example, in Erbil, Iraq, a 278 percent increase in urban population between 2004 and 2014 led to a 54 percent decline in the water table (Ibrahim, 2015). Another strand of research focused on climate change suggests that changes in the Earth's natural water cycle have altered the rainfall patterns in the world's river systems. That is the primary reason, some regions of the world are facing surface and groundwater shortage, while others are experiencing flooding (UN-Water, 2021). For instance, in South Korea, a reduction in precipitation, -32 mm/yr in the dry season and -29.6 mm/yr in the wet season and a decline in groundwater level were correlated in 70 percent of the sites monitored in a single year (Lee et al., 2014).

At the turn of the twenty-first century, the UN report *Water for People, Water for Life* claimed that the water crisis the world is facing today is actually a crisis of governance (WWAP, 2003). Thenceforth, debates and discussions on governance issues in water management literature have multiplied. Some scholars are analyzing public, private, and community-based piped water governance models (e.g., Bakker, 2007), while others focus on getting tariffs right, corruption, bureaucratic inefficiencies (e.g., Araral, 2008), or human resource management issues like overstaffing and nebulous or opaque personnel promotion mechanisms (e.g., Tortajada, 2006). In contrast, the scholarship originating from the Bloomington School[3], not only considers the governance/institutional aspects but biophysical conditions and community attributes of the problem as well (Ostrom, 1990). This line of research evaluates whether institutions governing the resource/public goods align with the socio-economic, political, and ecological conditions linked to the policy

[3] It refers to the interdisciplinary research program founded and advanced by Vincent and Elinor Ostrom, most notably through the workshop they established at Indiana University Bloomington. Now the term refers to the entire research agenda of the Ostroms and their associates, which is pursued in various research centers across the globe (e.g., CPR management, polycentricity, public administration, self-governance).

problem. In other words, it seeks to discover context-specific institutional arrangements that might help ensure natural resource sustainability and effective public goods management (Epstein et al., 2015). Overall, the governance scholars contend that for better resource protection and management the creation of robust institutions is far more critical than tackling social or ecological issues alone (Holmberg & Rothstein, 2011; Lu et al., 2014; Ostrom, 2005). For example, there are places where the water is available in abundance, but the people still face drought and scarcity, chiefly due to poor governance (Araral, 2008). On the other hand, some areas were experiencing acute water shortage, but strong institutions were able to provide an adequate amount of clean water to the public (Tortajada, 2006). In addition, when the institutions are weak, uncertainties (e.g., water scarcity) emanating from phenomena such as climate change and urbanization may be exacerbated (Pahl-Wostl et al., 2012).

### 2.1.2 What are Institutions?

Institutions are the instruments through which the formation and execution of governance[4] occurs (Kooiman, 2003). The term *institutions* refer to formal and informal rules, norms, and shared strategies. Formal rules are usually written and encapsulated in constitutions, laws, regulations, and legal systems. Official entities like police, courts, or bureaucrats enforce the formal rules and punish the violators (Ostrom, 2005). On the other hand, informal rules are unwritten, created, communicated, and enforced outside the officially sanctioned channels like social taboos. Unlike *formal institutions* or formal rules,

[4]The term governance can be defined as "the sum total of the institutions and processes by which society orders and conducts its collective or common affairs (Institute of Governance Studies, 2009, p.1), which takes place both inside and outside of formal institutions at multiple levels and scales (Ostrom, 2005, p.215).

breaking informal rules results in subtle, illegal, or hidden sanctions like hostile remarks, ostracism, and loss of friends (Helmke & Levitsky, 2006). In addition, norms are standard behaviors shared by the members of a social group, such as reciprocity. No external punishments or rewards are needed to ensure conformity toward norms because individuals generally unconsciously follow them. Lastly, individuals follow particular strategies at a specific time and place because it pays to do so. Neither norms nor rules can prevent an individual from adopting strategies. A deep understanding of the strategies followed by the people in a community reveals how they coordinate with each other during social interactions (Schlüter & Theesfeld, 2010). I will call informal rules, norms, and shared strategies *informal institutions in this study.*

According to the cross-country analysis of the water governance institutions (formal and informal laws and regulations, policies and administration etc.) on the performance of the water utilities, water resource management is dependent more on the quality of institutions than the independent isolated focus on physical, ecological or economic dimension of the governance (Saleth & Dinar, 2004). However, in developing countries, *formal institutions* are generally weak and exist mainly on paper (Kessides, 2005, p.86). They are drenched in all kinds of corruption (e.g., rent-seeking, patronage, bribery, favoritism), bureaucratic inefficiencies (Rothstein & Varraich, 2017), and social traps (Rothstein, 2005). On the other hand, *informal institutions* are more potent and play a positive or a negative role. For instance, trust networks based on caste, kinship, or religion reduce uncertainty and help develop trust among the members of the network (Malik, 2017). A higher level of trust leads to a higher degree of cooperation among the group members in social dilemmas. On the negative side, informal institutions might, for example, exclude women from decision-making arenas by restricting their physical mobility or devising discriminatory property rights that leave them with limited access to wealth or other resources (Jütting et al., 2007). Nonetheless, informal institutions are flexible enough to play complementary, accommodating, competing, or substitutive roles in relation to formal institutions (O'Donnell, 2006).

### 2.1.3 Common Pool and Public Goods Dilemmas

Water pumped from underground aquifers or accessed through a piped water network is a common pool resource (CPR). The core characteristics of a CPR are, first, it is rival, meaning consumption of one unit of water by an individual makes it unavailable to others. Second, it is non-exclusionary; it is costly and difficult to exclude people from groundwater pumping or connection holders from consuming pipe water. On the other hand, piped water supply infrastructure is a public good. It is non-rival, the use of the infrastructure network by one person does not reduce its availability for others, and non-exclusionary as utilities are legally bound to serve everyone (Flint, 2011). These properties of CPRs and public goods makes them prone to social dilemmas, a situation in which rational short-term self-interests of the individuals leads to long term unsustainable results for the collective (van Soest, 2013). To elaborate, a public goods dilemma occurs when self-interest dictates that an individual let others contribute towards the production, delivery, and maintenance of the public good and then free-ride on their efforts (Dionisio & Gordo, 2006; Olson, 1965). However, if everyone decide not to contribute, the public good would not be produced and everyone will be worse off (Wasko & Teigland, 2004). Similarly, the tragedy of the commons or CPR dilemma arises when an individual receives a direct benefit from the overuse of the commonly held resource but bears only his/her own share of the costs. Hence, refraining from over-exploitation does not guarantee that everyone will comply and avert the tragedy of the commons. So, the resource is fated to go extinct (Hardin, 1968; Ostrom, 1990).

It is harder to solve social dilemmas using non-institutional measures alone, such as building more infrastructure to deal with water scarcity. Notwithstanding, if people are unwilling to pay their bills, there will be no funds to pay for a long run for construction, operations, and maintenance of the infrastructure. By contrast, appropriate institutional arrangements can spur collective action and engender trust among the people and the public officials to solve issues such as non-payment of utility bills or uncontrolled groundwater abstraction. Thus, I have used the Institutional Analysis Development (IAD) framework to explore the dynamics between piped water supply and groundwater abstraction, as well as to examine if the common pool and public goods dilemmas are present in the water sector of Faisalabad. I used the IAD to identify biophysical, socio-economic, political, and institutional factors that enable or hinder collective action and to provide solutions for the social dilemmas. Furthermore, I explored weaknesses in groundwater governance using Ostrom's design principles for sustainable common pool resource governance and the role of institutional power in decision-making and the enforcement of stipulated rules.

## 2.2 Institutional Analysis

Institutional analysis highlights formal and informal institutions that give meaning, legitimacy, and direction to governance in a broader ecological, socio-economic, and institutional context. In this section, the IAD framework and design principles, including the use of these institutional analysis tools, are discussed.

### 2.2.1 Institutional Analysis and Development Framework

The Institutional Analysis and Development (IAD) framework is a systematic approach to organize policy analysis, developed by Nobel laureate Elinor Ostrom and colleagues at Indiana University, Bloomington (Ostrom, 1990, 2010; Ostrom et al., 1994). The framework helps researchers interested in designing, reforming, and evaluating policy interventions break down complex social and environmental issues into more comprehensible and manageable activities (Polski & Ostrom, 1999). The IAD draws attention to the full range of factors and dynamic processes involved in the operation and management of the commons (McGinnis & Hall, 2019, p.14). Villholth & Conti (2017) contend that it is also well equipped to handle complexities inherent in the urban groundwater systems. The graphical representation of the IAD framework (Figure 2.1) shows that at its center lies an action situation. It is a social space where actors (e.g., individuals, households, or organizations) interact, solve problems, dominate one another, or create social dilemmas. The action situations are influenced by external variables grouped into three categories: (a) *biophysical conditions* discuss characteristics of the resource under study and its relationship to the users; (b) *attributes of the community* includes social, economic, political, and cultural attributes of the entities affected by the policy problem; and (c) *rules-in-use* consider the entire body of laws, regulations, rules, norms, and shared understandings among the participants relevant to the problem situation. In the action situation, actors make choices based on their beliefs, incentives, and available information or act to uphold social expectations. The interactions among the actors result in specific outcomes which are evaluated against an agreed upon criterion (e.g., accountability, sustainability, and equity) by the actors doing the evaluations. These outcomes and the evaluations then inform back the entire set of exogenous variables, setting the stage for the next round of action situations (McGinnis & Hall, 2019).

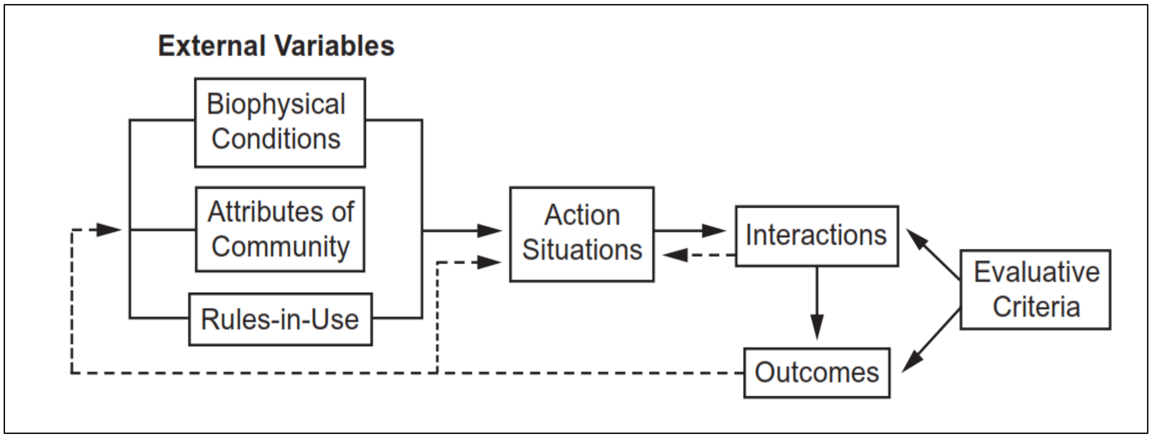



Figure 2.1: The graphical representation of the IAD framework

Source: Ostrom (2011)

### 2.2.2 Ostrom's Design Principles

Ostrom's design principles for sustainable common pool resource governance are: (a) clearly defined boundaries of both the common pool resource and the users; (b) the congruence of the resource's appropriation and provision rules with local conditions; (c) the ability of those affected by the rules to participate in the collective choice arenas; (d) monitoring of the resource condition, appropriation, and provision levels by the individuals who are accountable to the users; (e) punishment of rule violators based on the seriousness of the offense; (f) access to low-cost conflict resolution mechanisms for resource users; (g) external authorities recognize minimal rights of users to organize and create their own institutions; and (h) governance activities are organized in multiple layers of nested enterprises (Ostrom, 1990). All the design principles can be interpreted as outcomes generated by the action situations. They explicitly connect factors from one or more of the three categories of external variables: biophysical conditions, rules-in-use, and community attributes. For instance, in an action situation, if sanctions are not applied consistently, they lose their legitimacy among the people; conversely, if sanctions do not match the severity of the offense, people will start to resent them (McGinnis & Hall, 2019). This observation about sanctions then informs the evaluation of design principle, *graduated sanctions*. The probability of a common pool resource governance to remain effective is high if all the design principles are present. However, it is a probabilistic, not a deterministic rule (Ostrom, 2005; Cox et al., 2010). Therefore, there might be a governance system in which all the design principles are present, but it still might fail to sustainably manage the resource and vice versa.

### 2.2.3 Some Applications of the IAD Framework and Design Principles in the Water Sector

The IAD framework and design principles have been widely used to explore water governance institutions. For example, Stone-Jovicich et al. (2009) employed the IAD framework to examine water scarcity issues in the Australian Outback, where drought conditions are a common occurrence. The findings suggest that non-transparent centralized water resource governance is the primary cause of perennial water shortages. Similarly, Kadirbeyoglu & Özertan, (2015) have used the IAD to explore the impact of water users' satisfaction level on irrigation water sustainability in Sanliurfa, Turkey. The results showed that even though consumers were satisfied with the performance of water user associations and operational rules, especially the low amount of fees imposed on the users, the total funds collected were not enough to maintain the resource and ensure its long-term sustainability. On the other hand, Ross & Martinez-Santos (2010) examined the relevance of Ostrom's design principles for groundwater management in the Murray Darling Basin, Australia, and the Upper Guadiana Basin, Spain. They found that stakeholders struggled to agree on appropriation, monitoring, and sanctioning rules crucial for sustainable groundwater management, including the need for collaboration between water users and the government. Moreover, Lopez-Gunn (2003) utilized the IAD and its design principles to study the role of water user associations in facilitating collective action in the Mancha region of Spain. The outcomes of the study suggest that while solutions like subsidies might help mitigate aquifer overuse in the basin temporarily, this strategy is not suitable for the resource's long-term sustainability. She recommended that trust between water user associations and the state must be improved to devise robust groundwater protection policies.

Additionally, Kamran & Shivakoti (2013) used the IAD framework and design principles to compare the community-led tribal and state-administered spate irrigation system in Punjab, Pakistan. The canals in the spate system get water only after the seasonal rains and floods that make the appropriation and provision of water difficult, including managing the cost of operations and maintenance. The results found that community based tribal administration worked comparatively better than state-controlled governance. In a state-led system, rules were externally enforced and communicated in written English. As a result, farmers were not familiar with the provision, monitoring, and sanctioning rules the government applied to them, and public officials were taking advantage of the low literacy rate among the farmers. Kamran and Shivakoti reported that the officials asked the farmers for bribes under the false charges that they had violated one or more rules, which the farmers were often not even aware of. They stress the farmers that the best solution for them to get out of this trouble and avoid hefty official fines is to bribe them. By contrast, water users in the tribal system held regular meetings, communicated, and codified rules in the local language. They also appointed monitors and punished violators with fines and on occasion social seclusion. The democratic representation in the decision making and enforcement provided incentives for unbiased treatment of all users. In addition, customary rules were highly flexible and well understood by the resource users.

### 2.2.4 Institutional Power

Institutions, due to their particular form and structure, have the power to influence decision-making and subsequent outcomes. They can bring people to do what they normally would not do in their absence and to do what does not always serve their interests (Lukes, 2005). In addition, they have the ability to affect the behaviors, beliefs, and perceptions of the individuals and groups in a society (Lawrence, 2008). It is also critical to note that institutional power is not a property of actions, but rather a capacity, as one can have institutional power without necessarily exercising it (Searle, 2005). The nature and the type of institutional arrangements determine the capacity or distribution of power. For example, in administrative monopolies one person or a single group has all the decision-making and enforcement authority, while in a contrasting institutional arrangement all the agents can have a symmetric distribution of power (Stahl, 2011).

Institutional power can be wielded to manipulate people to pursue narrow self-interests or rectify problems for everyone (Riker, 1980). In reality, Stahl (2011) noted that institutional power frequently masks hidden agendas, personal motives, and deceptive behavior of the people in authority, especially if the institutional structure is so complex that a common citizen is unable to fully comprehend it. The Bloomington School of new institutionalism is often criticized for ignoring the role of power in their institutional analysis tools and governance improvement mechanisms (e.g., Clement, 2010; Whaley, 2018). However, Epstein et al. (2014, p.128) argue that the Bloomington School does not disregard power; in fact, power is, and always has been, part of new institutionalism, although the term power is rarely invoked in their scholarship. For instance, both the IAD framework and design principles can be operationalized to understand and explore the effects of institutional power in formal or informal governance arrangements including the processes used to create and manipulate rules (Epstein et al., 2014).

## 2.3 Methodology

Urban groundwater and piped water systems are composed of technical (e.g., water infrastructure), environmental (e.g., water resources), and social components (e.g., income level) (Anderies et al., 2004; House-Peters & Chang, 2011). They can be studied as complex social-ecological systems in which heterogeneous individuals and groups act based on their diverse value systems and objectives (Pahl-Wostl, 2003). The source of the heterogeneity might be behavioral diversity (e.g., in decision-making or personality), demographic diversity (e.g., race, sex, and age), or diversity in context (e.g., urban, rural) (Sterman, 2006). According to Ostrom (2011) and (Knüppe & Pahl-Wostl, 2011), frameworks provide organized and context-specific assessments that can help researchers structure their thinking and, in turn, render socio-ecological systems more transparent and understandable. In this paper, the IAD framework is used to explore biophysical, social, and institutional factors that give rise to the challenges of piped water scarcity and groundwater depletion, as well as the dynamics between the two. Then, design principles are employed to evaluate the outcomes of the IAD analysis and role of power in the governance activities.

### 2.3.1 Case Study Area

Faisalabad is located in the central region of the Punjab province of Pakistan (Figure 2.2). It is the third-biggest city in the nation, with a population of about 3.2 million. The city has 506,870 households and an average family size of 6.45 people (Pakistan Bureau of Statistics, 2017). Its population is growing at the rate of 2.5 percent per year and is expected to reach 5 million in 2035 (World Population Review, 2020). To accommodate this population, Faisalabad is expanding into peri-urban areas at an explosive rate. In 1995, the city's area was 85 $km^2$; in 2020, it was projected to be 252 $km^2$, an addition of 167 $km^2$ in 25 years (Javed & Qureshi, 2019; Punjab Cities Growth Atlas, 2018). Moreover, the city is a large industrial hub, contributing 15 percent to the national economy. It receives on average 200 mm of rainfall annually and has a hot, desert-like climate. The temperature ranges from 17°C in winter to 50°C in summer (JICA, 2019b).

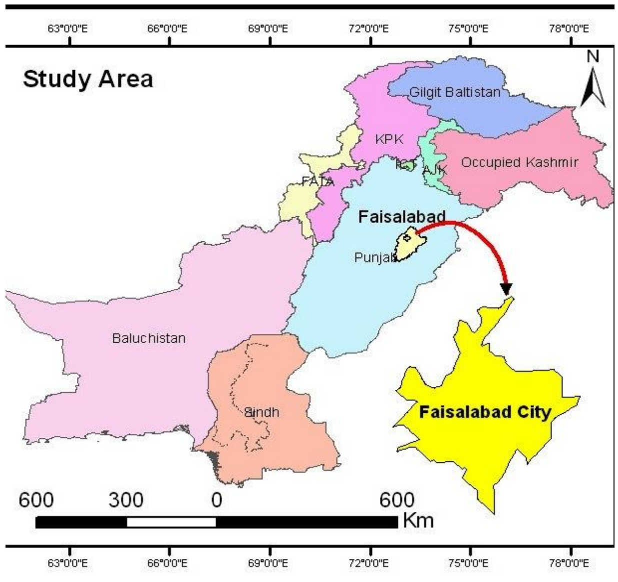



Figure 2.2: Location of the Faisalabad city

Source: Javed & Qureshi, 2019

### 2.3.2 Data Collection

To get a detailed picture of the state-led piped water supply and groundwater management systems in Faisalabad, I have gathered data from multiple sources:

1. I conducted five semi-structured, open-ended interviews with two water agency officials (labeled as Respondent-W1 and Respondent-W2), a local academic (labeled as Respondent-A), the head of a non-profit organization (labeled as Respondent-N), and an employee of the French Development Agency (labeled as Respondent-D) working in the water sector of Faisalabad (Appendix-I).

2. I performed a document analysis. I analyzed five volumes of *Water and Sanitation Master Plan of Faisalabad* of the Japan International Cooperation Agency in 2019, a water supply network map provided by the water agency, laws and policies

enacted by the Punjab Assembly (provincial parliament), and reports and documents provided by the nonprofit organization.

3. I conducted a literature search on water governance in developing countries, the IAD framework, Elinor Ostrom's design principles, and institutional power in water governance using *Google Scholar, Web of Science, University of Louisville's online library,* and *Google search engine*.

### 2.4 Application of the IAD framework

In this section, external variables (biophysical conditions, attributes of the community, and rules in use), action situations, outcomes, and evaluations are presented.

#### 2.4.1 Biophysical Conditions

Faisalabad is situated on the Indus River Basin that stretches from the Himalayas in the north to the Arabian Sea in the south, covering approximately 16 million hectares of land area (Haider, 2000). The native groundwater of the basin is saline due to its marine origin and is therefore unfit for human consumption. The development of the irrigation canals on the Indus River and its tributaries in the late 1800s helped create a freshwater layer on top of the existing saline water (JICA, 2019b, p.A3-1). The residents of Faisalabad are dependent on this freshwater layer which extends beyond the city limits into surrounding peri-urban and rural areas. It stretches in the east to the River Ravi and in the West up to the River Chenab. The Q.B. Link Canal is at its northern boundary, while the southern boundary is not defined by the irrigation department yet (see Appendix-I). The primary sources of groundwater recharge today are irrigation canals (JICA, 2019c, p.B2-12). Rainfall could contribute up to 15 percent to the recharge, but roads, pavements, and buildings do not let rainwater seep into the ground to feed the aquifer. Thus, the actual contribution from rainfall is insignificant (Jamal, 2019). According to an investigation conducted by the Pakistan Council of Research in Water Resources (PCRWR), the average depth of the freshwater layer in the areas immediately adjacent to Faisalabad is ~100 feet. By contrast, it is either close to depletion (40 feet) or already depleted (<40 feet) in several parts of the metropolis (Khan et al., 2016). Additionally, the flow volume of the rivers in Pakistan is predicted to decrease between 30-40 percent in the next 100 years due to climate change, since glaciers in northern areas are melting faster than usual and monsoon rains are becoming less frequent (Kugelman & Hathaway, 2009). Reduction in the flow means diminished availability of groundwater, as rivers are responsible for more than 70 percent of the recharge in the Indus River Basin (Laghari et al., 2012). Therefore, the potential negative effects of climate change are expected to put pressure on the dwindling groundwater resource in Faisalabad.

The Water and Sanitation Agency of Faisalabad[5] is legally responsible for the piped water provision in the city. The municipal water supply system gets 86 percent of water from the underground aquifers and 14 percent from the surface water (JICA, 2019b, p.B2-1). The primary groundwater sources are Chenab Well Field, Jhang Branch Canal, and Rakh Branch Canal. The first two sources are 27 km and 15 km away from the city limits, while the third source is located at the northern edge of the city. The primary source of surface water is the Rakh Branch Canal which passes through the city center (WASA-F, 2020). Owing to excessive pumping, the water table at the Chenab well field dropped ~11

[5] I referred to it as “the water agency” in this study.

m from 1992 to 2007. Afterward, the deterioration in the water uptake capacity by happenstance stabilized the water table. The water table adjacent to the Jhang Branch Canal was declining at rate of 1 m per year as well, but it was stabilized when the rate of discharge was reduced up to 62 percent, again by accident. Similarly, well fields built along the Rakh Branch Canal within the metropolitan boundaries were closed due to excessive pumping and subsequent groundwater decline. Later, these wells were moved upstream, far away from the city (JICA, 2019b, p.B2-4-6). Thus, currently, the overall rate of groundwater discharge by the water agency is equal to the rate of recharge (JICA, 2019b, p.B2-34).

### 2.4.2 Attributes of the Community

The primary actors active in the groundwater and municipal water supply in Faisalabad are the parliament of Punjab, the provincial government of Punjab, donor agencies, the water agency, and water users. The attributes of these actors are discussed in detail below.

*Provincial Parliament and Provincial Government*

The parliament of the Punjab Province have enacted the "Punjab Development of Cities Act–1976" and "Punjab Irrigation & Drainage Act–1997" to manage the surface water and groundwater in urban and rural areas of the province under the guidance of national government. However, in 2010, the 18$^{th}$ amendment to the constitution of Pakistan gave provinces the sole responsibility of water resource governance and provision of water to the general public (Cookman, 2010). Assuming its independent legislative responsibilities, the provincial parliament of Punjab recently enacted the comprehensive

"Punjab Water Act-2019" that deals with surface water, groundwater, and piped water supply systems. The enforcement arm of the government of Punjab is Housing, Urban, and Public Health Department (HUD&PHED), which executes the laws legislated by the parliament. In addition, it can also enact policies, such as "Punjab Urban Water and Sanitation Policy–2007" and "Punjab Drinking Water Policy–2011". These laws and policies give local water authorities autonomy to formulate their own rules. However, HUD&PHED has the power to override local planning, design, and operational rules at any time and propose its own rules instead. In other words, the water agency is not fully autonomous in its governance; it shares decision-making and operational jurisdictions with the provincial government, an arrangement that sometimes creates tension between municipal and provincial administrations.

*The Water Agency*

The Water Agency was established in 1978 under the "Punjab Development of Cities Act-1976" to provide water, sewerage, and drainage services to the residents. According to the formal law, Punjab Water Act-2019, it is the primary and most powerful actor in the water sector of Faisalabad. It is responsible for operational rule-making (tariff setting, monitoring, sanctioning etc.) with respect to piped water provision and groundwater appropriation (WASA-F, 2020). However, in practice, the water agency has limited authority (power) to devise rules without the approval of the provincial government (HUD&PHED). So far, it has not been able to meet the water demand of the citizens. The total water demand for domestic and non-domestic uses in Faisalabad is 170 million gallons per day, but the designed capacity of the water supply system is only 110 million gallons per day (Respondent-W1, 2021). Even in the face of a piped water shortage, the water agency is operating at 64 percent of its production capacity. The total water produced is not 110 million gallons per day but 70.4 million gallons per day (JICA, 2019a, p.A8-3). The diminished water production is caused by the deteriorated water uptake capacity of Chenab well field (43 percent reduction), Jhang Branch Canal (28 percent reduction), and Rakh Branch Canal tube wells (88 percent reduction). In addition, the surface water treatment plants are not fully functional (56.5 percent reduction in output) because they are old and often require shutting down for maintenance (JICA, 2019c, p.B3-7). Furthermore, the 70.4 million gallons of water produced by the water agency does not reach the consumers; 40 percent of it leaks through pipes or is stolen via illegal connections. The actual amount of water in the water supply network is only 42 million gallons per day (or 25 percent of the demand), of which 37.8 million gallons are supplied to households and 4.2 percent to non-domestic users. Overall, the total water shortage is 128 million gallons per day (JICA, 2019b, p. A8-3).

*Donor Agencies*

The most prominent donor agencies currently working in Faisalabad are Japan International Corporation Agency (JICA) and French Development Agency (AFD). JICA worked with the local water agency to develop the *Water and Sanitation Master Plan of Faisalabad* in 2019. It also provides funds and technical supervision to implement the master plan. The core objective of JICA is to build new water supply infrastructure close to the irrigation canals to meet the increasing water demand and in turn shift some burden from the groundwater to the surface water (JICA, 2019a). In addition, the stated mission of the AFD is to improve the duration and pressure of the piped water supply in cooperation with the water agency. It is building water purification plants on the Rakh Branch canal to filter canal water to add it to the municipal piped water supply system. The AFD is in communication with public officials to provide water leakage detection technology to reduce water wastage (AFD, 2019). On the other hand, WaterAid and the United Nations are working at the provincial level to advise policy-making and finance drinking water projects (HUD & PHED, 2021). Khan & Ahmed (2007) examined whether foreign aid was a blessing or a curse for the socio-economic development of Pakistan for the period between 1972-2006. They found no evidence of any positive impact of aid on the social infrastructure development. Instead, they noticed that foreign aid actually promoted aid dependency, which stymied the maturation process of critical local public institutions.

*Water Users*

In Faisalabad, people are part of or grouped in *biraderi*[6] based trust networks, which are sources of social capital. Social capital is "the shared knowledge, understandings, norms, rules, and expectations about patterns of interactions that groups of individuals bring to a recurrent activity" (Ostrom, 2000, p.176). A higher level of communication and contact between the members of the *biraderi* helps garner the environment of trust and reciprocity in society, which, in turn, removes obstacles to cooperation (Malik, 2017, p.245; Rothstein, 2005). Membership in a trust network might mean access to additional employment opportunities, funds when needed, and a larger pool of potential marriage partners (Tilly, 2005). This within group trust and connections is an example of bonding social capital (Pretty, 2003). One major negative impact of bonding social capital might be the development of distrustful attitudes toward the members of other biraderies (Tilly,

[6]The term refers to caste, clan, religion, tribe, or sect.

2005). An even bigger problem is that biraderies are not equal in terms of their influence and resources, the key factor that guarantee access to the sought-after goods and services in society (Gazdar, 2007). Hence, in the absence of bridging social capital, or when the trust between different biraderies is non-existent, inequalities in the communities multiply.

The most influential trust networks in Faisalabad are caste-based biraderies: *Jatt*, *Arian*, *Gujjar*, *Rajput*, and *Sayyed*. They are active in politics, especially during the elections for provincial and national parliaments. All the members follow the lead of the biraderi head and vote in unison for the candidate of his or her choosing. The leadership of the trust network strives to secure public sector jobs for the members of their biraderi using political connections or personal relationships with the bureaucrats. Once the politicians and government employees whom they have endorsed assume power, biraderi heads start to seek privileged treatment in accessing goods and services for themselves and their group members (Anwar, 2019). This relationship between formal (e.g., bureaucrats) and informal actors (biraderi based trust-networks) creates an informal governance system, that makes the state appear less like a legitimate democratic entity but more like a vehicle for the illegal distribution of goods and services. Moreover, these institutional arrangements are such that the law is selectively applied to favor individuals with wealth and powerful connections (Malik, 2017).

Furthermore, mental models, which are "internal representations of external reality that people use to interact with the world around them," provide a mechanism through which an individual can filter and store information (Jones et al., 2011, p.1). These models can be applied to storing the rules governing resources like groundwater. Mental models can give researchers insights into various aspects of human cognition that underpin preferences, behaviors, and actions of individuals. This information is of great value for the practitioners and scholars working to devise actionable policies (Jones et al., 2011). The investigation conducted by Qasim et al. (2018) gave a glimpse into the mental models of the groundwater users in Faisalabad. The study showed a severe lack of information among the public on the condition of the aquifer. The majority (83 percent) believed that humans would never run out of groundwater and that the phenomenon of aquifer depletion is only temporary. Moreover, 63 percent of participants were unaware of terms such as "watershed" and "hydrological cycle" and how they are connected to the water table.

### 2.4.3 Rules-in-Use

There are numerous collective-choice and operational rules developed at the national, provincial, municipal, and community levels pertaining to the management and use of groundwater and piped water supply in Faisalabad (see Table 2.1). Collective-choice rules refer to the constitutive processes through which institutions are constructed (McGinnis, 2011), and at the operational level, formal and/or informal institutions directly affect the behavior of individuals, such as when and how one can access the resource (Banerji, 2013, p.87). The politicians have legislated collective-choice rules such as the Punjab Development of Cities Act-1976, Punjab Irrigation and Drainage Act–1997, and The Punjab Water Act-2019 in the provincial parliament. Meanwhile, the donor agencies, the United Nations, and WaterAid influenced the HUD&PHED to produce policies like the "Punjab Urban Water and Sanitation Policy-2007" and the Punjab Drinking Water Policy-2011. The Changa Pani Program (CPP) was developed by the non-profit organization to help the government close the gap between water supply and demand in the cities. On the other hand, operational rules, The Easement Act-1882 was developed during the British Raj in the sub-continent. The Water Supply Faisalabad Regulations–2015 were written by the bureaucrats of the water agency. In addition, *"Water and Sanitation Committee Organization (WASCO)" is an informal community-led governance system of piped water management, and "Panchayats" are a low-cost conflict resolution mechanism comprised of influential local community members.*

The piped water users and groundwater consumers were not involved in the collective-choice and operational rule-making processes (except for WASCO and Panchayat), even though the "Punjab Water Act-2019", "Punjab Urban Water & Sanitation Policy–2007", and "Punjab Drinking Water Policy-2011" recommend municipal water agencies tto involve local communities in the groundwater/municipal water use decision-making processes. They are advised to help water users organize themselves for the development of infrastructure and resource conservation. However, according to the Societies Registration Act XXI-1860, community-led organizations must be registered before they start any activities (The Urban Unit, 2010). The state does not explicitly challenge any informal entity working to protect water resources or improve municipal water provision. Thus, it is safe to deduce that appropriators are partially free to devise their institutions, and there is a strong possibility that the state will not challenge them.

The Punjab Development of Cities Act-1976 provides legal foundation to the city administration for the creation of the water agency. It also lays out who must be part of decision-making arrangements determining the nature of the water supply system in Faisalabad. The Punjab Irrigation and Drainage Act–1997 makes the Irrigation and

Drainage Department responsible for the protection and monitoring of the groundwater and surface water resources in the province. To access surface water and groundwater resources for the piped water supply, the water agency has formal agreements with the irrigation department which it renews every two years. In addition, the basic philosophy of the CCP is that local communities must have a real financial stake in the production and management of the public utility for it to be successful and function on the principles of sustainability. In several cities of Punjab, including Faisalabad, where public piped water supply systems are not available, an independent state-sponsored water provision system based on the CCP model has been developed in several cities of Punjab including Faisalabad.

The Punjab Water Act-2019 has both collective-choice and operational rules for the piped water and groundwater management. According to its Clause-49, groundwater underneath any urban jurisdiction of the province is public a property. When an individual wants to extract groundwater for commercial or industrial purposes, a permit from the state must be acquired that gives the right of access and withdrawal. By contrast, domestic groundwater extraction does not fall under the ambit of this regulation because the government needs to meet the piped water demand of all the residents in the city first. In place of Punjab Water Act-2019, The Easement Act-1882 gives people unrestricted access to the aquifer when exploited for domestic usage (Clause-7g). This law is based on the archaic notion dating back to Roman law which states that “whoever owns the soil, holds title all the way up to the heavens and down to the depths of hell” (Soofi, 2018). However, landowners are not allowed to sell this groundwater for commercial purposes as per Clause-24(1b) of the Punjab Water Act-2019.

The Punjab Water Act-2019 gives the water agency the responsibility to monitor the condition of the aquifer underneath the city (Clause-49). Similarly, Water Supply Regulations-2015 makes the water agency responsible for monitoring piped water supply and non-domestic groundwater extraction. However, it does not have enough resources (workforce and technology) to monitor the groundwater withdrawal of all the resource users. The graduated sanctions for those who break piped water supply or aquifer use rules are laid out in Water Supply Regulations-2015. For instance, individuals convicted of having illegal piped water connections can be subject to a fine not exceeding three years of a water bill. Moreover, those who have illegal re-connections face one-month imprisonment and a PKR 10,000 fine. Likewise, those who violate the non-domestic groundwater extraction rules are punished based on the severity of their crime. Those who do not pay their bills are disbarred from the groundwater extraction in addition to the fine equivalent to the last three months of their utility bills. If someone withdraws from the aquifer illegally, then the violator must pay a fine equal to the last six months of their utility bills, together with a regularization fee for a new aquifer connection.

Furthermore, the formal groundwater governance activities are organized in multiple interconnected layers in Faisalabad. The water agency is vertically linked to the Housing Urban Development & Public Health Department (HUD&PHED), an executive branch of the Punjab government. It is horizontally linked with the Irrigation and Drainage Department to monitor surface water flows and groundwater levels in the well fields. The downward link is with the local communities via the Citizen Liaison Cell (CLC) created by the water agency in 2013. The goal of the CLC is to create community-based organizations to improve the water supply system in the city. The multiple jurisdictions are supposed to make the governance system more robust, but in Faisalabad, the failure of the water agency has not triggered an appreciable response from the HUD&PHED, irrigation department, or from the local communities. Hence, the city still lacks functioning nested enterprises for effective municipal water supply and groundwater governance.

*Table 2.1: Formal and Informal Institutions Governing Groundwater & Piped Water in Faisalabad*

<table>
<tr><th>Type</th><th>Name</th><th colspan="2">Institutional Level</th></tr>
<tr><td rowspan="8">Formal Rules</td><td>Punjab Development of Cities Act–1976</td><td rowspan="6">Provincial</td><td rowspan="5">Collective-Choice</td></tr>
<tr><td>Punjab Irrigation and Drainage Act–1997</td></tr>
<tr><td>Punjab Urban Water and Sanitation Policy–2007</td></tr>
<tr><td>Punjab Drinking Water Policy–2011</td></tr>
<tr><td>Changa Pani Program</td></tr>
<tr><td>Punjab Water Act-2019</td><td>Collective-Choice/Operational</td></tr>
<tr><td>The Easement Act-1882</td><td>National</td><td rowspan="4">Operational</td></tr>
<tr><td>Water Supply Faisalabad Regulations –2015</td><td>Municipal</td></tr>
<tr><td rowspan="2">Informal Rules</td><td>WASCO</td><td rowspan="2">Community</td></tr>
<tr><td>Panchayat</td></tr>
</table>

### 2.4.4 Action Situations

An action situation is a space where actors interact and jointly produce outcomes that they value differently (McGinnis & Ostrom, 2014, p.2). It enables an analyst to isolate a process of interest to explain regularities in human actions, results and then potentially reform them (Ostrom & Ostrom, 2011). In this study, the focal action situations are appropriation, provision, rule-making, monitoring and sanctioning of the piped water supply and groundwater governance system in Faisalabad including the dynamics between these two water resources. Although the IAD framework can differentiate among three conceptual levels of analysis—operational, collective choice, and constitutional—the current research focuses on the operational level and, to some extent, on collective-choice rules pertinent to action situations.

To understand why a typical resident is unsatisfied with the municipal water agency and dependent on the groundwater, the interactions between the water agency and water users are examined. The water agency produces 70.4 million gallons per day (JICA, 2019b, p. A8-3), but according to the official estimates, the total water demand is 170 million gallons per day (Respondent-W1, 2021). There are ecological, social, and institutional factors that undergird this acute water shortage. The major ecological barrier is the limited sustainable water production capacity of the water agency's groundwater well-fields: ~60 million gallons per day (JICA, 2019c, p. B2-1). Social impediments, high population growth (2.5 percent), and explosive urban expansion (167 percent increase in the past 25 years) contribute to the growth in the water demand[7] as well. The water agency has not been able to keep up with urbanization, as only 60 percent of the city has piped water supply network (JICA, 2019a, p.1). Moreover, in the absence of leakage detection technology, nearly 40 percent of the water produced leaks to the ground (Respondent-D, 2021). Thus, overall, the total water left in the piped water supply network is 42 million gallons per day only.

To access the scarce municipal piped water, a resident invokes his or her biraderi based trust-network. Then the biraderi head or the resident directly interacts with the

[7] The estimation based on average per capita water consumption (137 liters), growth rate, and total population of 3.2 million would increase the water demand up to 2.4 million gallons per day in the next year.

politicians or bureaucrats to acquire a piped water connection. In other situations, people make a collective effort to get piped water infrastructure in their neighborhood or to receive municipal water for at least four hours a day in their households (Zia & Chaudhry, 2019). According to Malik (2017), this connection between informal trust-networks and state officials is an example of type-III or unauthorized collective choice units that “provide rules and determine who gets what, when, and how, at times directly contradicting laws and formal rules” (Malik, 2017, p.65). So, in reality, the water agency which is formally empowered to plan, design, operate, and maintain the piped water supply system does not have full institutional authority. The unauthorized governance units functioning as a patronage system undermine the water agency’s institutional power. In a patronage system, patrons (e.g., politicians and the water agency) give clients (e.g., members of the biraderi) special favors in return for votes or unspecified support at the cost of the common good (Malik, 2017; Rothstein, 2011, p.79). Such a system is inherently corrupt, as patrons monitor, sanction, or provide services to people independently of merit (or need) but rather on personal and political considerations (Rothstein & Varraich, 2017). In Faisalabad, unauthorized informal governance units are also known to protect neighborhoods where illegal connections are commonplace and where consumers do not pay their utility bills (Respondent-D, 2021).

The main issue with the biraderies is that they do not have equal resources and opportunities to influence politicians and bureaucrats (Gazdar, 2007). Consequently, areas inhabited by weak (particularly minority) biraderies, like Warispura, Nasir Town, and Aath Chak, are not connected to the piped water supply system despite living on top or beside the necessary infrastructure (see Appendix-II). Similarly, the duration of the water supply in some areas is less than the officially stated four hours a day, while other sites do not get municipal water at all (JICA, 2019b). It has been observed that when the performance of the public utility is poor, and the public officials are biased or corrupt, people start to feel dissatisfied and lose trust in the utility provider (Rothstein, 2011). In turn, they stop paying their utility bills (Jensena & Chindarkarb, 2017). According to the data collected by JICA from the water agency, only 34.6 percent of domestic, 39.2 percent commercial, and 84.9 percent industrial water users pay their bills. In addition, 26.4 percent domestic, 67.2 percent commercial, and 99.5 percent industrial connections are illegal. The annual losses due to unpaid bills and illegal connections are PRK 410.2 million and PKR 306.8 million respectively (JICA, 2019b, p. A7-19). The water agency is currently recovering PKR 840 million, whereas PKR 2179 million are needed per annum for the annual operations and maintenance of the water supply system (JICA, 2019b, p. A6-2). To make up for the losses water agency is dependent on subsidies from the provincial government and donor agencies (JICA, 2019a).

The failure of the water agency to meet their domestic and non-domestic water demands has pushed residents to search for alternatives. Owing to the availability of cheap groundwater extraction technology and benefits in terms of saved time and money, citizens prefer to exploit the freshwater layer of the aquifer when compared to the tanker water option (Nawaz, 2018; IDP, 2017). Today, 72.6 percent of the households and 77 percent of the commercial and industrial entities in Faisalabad extract groundwater (JICA, 2019c, p. B5-13; JICA, 2019b, p. A2-44). If a resident wants to extract groundwater for domestic purposes, there is no need to get permission from the state because, according to the "Easement Act-1882", groundwater is an open access resource for the rightful landowner

(Soofi, 2018). By contrast, groundwater pumping for non-domestic purposes requires a permit from the local water agency as per Water Supply Faisalabad Regulations-2015 (clause-17b). Moreover, individuals' perceptions of groundwater determine their behavior toward consumption and conservation of the resource. An average resident in Faisalabad considers groundwater a free gift of nature that will never go extinct and thinks that the phenomenon of aquifer decline is only temporary (Jamal, 2019; Qasim et al., 2018). In this situation, the only meaningful constraint against excessive groundwater extraction is the exorbitant cost of electricity in Pakistan that is used to run the pumps. Lastly, as previously discussed, the primary source of aquifer recharge are the local irrigation canals. The water flow in the canals has not changed except for seasonal variations in the last two decades to cause the slowdown in the rate of recharge. The groundwater level monitoring data confirms this assertion as the groundwater table at the outer edges of the city and beyond is stable (FoDP, 2012; IDP, 2021). Hence, the issue of groundwater decline seems solely an urban issue, which indicates that the rate of concentrated groundwater draft in the city is higher than the rate of recharge. However, there are no official estimates of how much groundwater is extracted every day.

The water agency often struggles to punish those who are stealing piped water and connection holders who do not pay their utility bills. The informal governance units use bribery and connections with the powerful to ignore, subvert, and bend the formal rules in their favor. As a result, the water agency loses power to implement or enforce its own laws impartially. Moreover, to an outside observer, the monitoring and sanctioning activities of the water agency might seem uncertain and ad hoc. Regarding groundwater, the exploitation of the freshwater layer for domestic purposes is not regulated. However, when groundwater is extracted for non-domestic purposes without prior permission or when terms of the permit are violated, then consumers will be warned, fined, or arrested as per the Water Supply Rules-2015 (clauses 80-84). In practice, the water agency does not have enough resources, like workforce and technology, to monitor the groundwater withdrawal of hundreds of thousands of resource users. For example, the water agency has not been able to force an estimated 70 percent of non-domestic groundwater consumers, of which 41.2 percent draw water illegally, to pay their bills (JICA, 2019b). It is also extremely difficult to hold any government employee accountable for wrongdoing, like mismanagement of the city's groundwater or unequal treatment of piped water users. Hence, public officials are accountable only on paper.

Additionally, the major conflicts between piped water users and the water agency today are the non-payment of bills and use of illegal connections. Residents do not pay their fixed monthly bills, citing intermittent and uncertain water supply. The water agency does not want to disconnect households and other properties from the piped water network but, rather, regularize them. It is currently trying to resolve this conflict through negotiations involving local leaders. In contrast to the piped water, only non-domestic groundwater users fall under the purview of the water agency. When conflict between the groundwater users and the water agency arises, consumers do not approach official channels, such as the water agency's complaint center, police, or the courts, because these platforms are time-consuming and expensive. Instead, water users make use of the informal makeshift community-led justice system called 'panchayat'. It is a low-cost decision-making arrangement that helps resolve disputes swiftly. However, access to these platforms is unequal, poor, and extremely poor communities find it difficult to form panchayat.

The water agency created the Citizen Liaison Cell (CLC) in 2013, which is a platform to work with the piped water and groundwater users to improve piped water provision and aquifer management. The donor agencies, Japan International Cooperation Agency, and the French Development Agency, who are active in the formulation of local water policy-making, have a negative view of the community involvement. One of them stated that "community involvement does not work in large cities; it might work in the small satellite towns or rural areas where the population is small and the willingness to get involved in the development projects is high" (Respondent-D, 2021). Thus, they do not encourage the water agency to proactively employ the CLC for community engagement, nor involve locals in any decision-making endeavor. Therefore, the work of the CLC is limited to the collection of unpaid bills and creation of WASCO in the Shahbaz Nagar neighborhood. To elaborate, the people in Shahbaz Nagar developed an independent piped water supply system under the component sharing program designed following the Changa Pani Program. Then members of the community jointly created WASCO for the governance of the system (e.g., developing operational rules like setting tariffs) (Respondent-W2, 2020; The Urban Unit, 2010). In addition, there has not been any evidence that people are making any effort or requesting the state to work together to create operational rules for both piped water supply and groundwater use. Gazdar et al. (2013) has argued that the most likely reason for low-and middle-income communities to avoid engagement with each other and the state in Pakistan is that people do not think they are savvy enough to contribute anything to the decision-making process, while some people do not have time to participate in the discussions.

### 2.4.5 Outcomes and Evaluation

The scarcity of piped water triggers the people to put their biraderi-based trust networks into action and create informal governance units (comprised of biraderi heads, politicians, and bureaucrats) to access the resource. Moreover, the work to protect illegal connection holders and customers who do not pay their bills. The subversion of formal regulations by some biraderies and the consequent unequal treatment by public officials leads more piped water users to ignore or disobey the rules. Therefore, a huge number of consumers have stopped paying their utility bills and begun stealing water (see action situations). Now, the majority of the people who have water connections are free-riding on the water supply infrastructure without contributing anything toward its production, operation, and maintenance. This situation is an example of a public goods dilemma, as most of the people are thinking and acting on their self-interests, though at the cost of the overall performance and well-being of the water agency which is no shape to provide quality service without economic wherewithal. The lack of funds has weakened the water agency's capacity to maintain, operate, and expand water infrastructure (the public good). It has depended on the foreign funds from the last three decades to turn itself around, but to no avail (JICA, 2019b). Similarly, the absence of informal institutions, and weak formal governance institutions make pumping the most viable and cheap alternative to the piped water for an average resident. Consequently, the massive groundwater draft has negatively impacted the freshwater aquifer and caused it to decline in the city. It means the present institutional arrangements are not aligned with the social and environmental conditions to make sure groundwater is extracted sustainably. According to the water agency officials, the groundwater level is decreasing at the rate of 2 feet per year (Jamal, 2019, p.17). The investigation conducted by the PCRWR has found that the freshwater layer in some areas is close to depletion, and in others, it is already depleted (Khan et al., 2016, p.3). This situation is an example of a common pool resource dilemma, as it is difficult to monitor and sanction exclude hundreds of thousands of people who are pumping and overusing the groundwater.

*Equity*

The informal governance units are usurping considerable power from the water agency, especially when they perform functions such as monitoring and tariff collection. The biraderies, which are the main constituent of these institutional mechanisms, have an unequal power due to their uneven influence on the politicians and bureaucrats. The variation in the quality of the municipal water supply in various neighborhoods of the city is directly proportional to the differences in this power. For example, in areas where predominately weak biraderies reside, access to piped water is either limited or non-existent. Moreover, the unequal distribution and duration of the water supply combined with the application of rules on some and a blind eye to others, both point to the fact that informal governance units are corrupt and not playing a positive, complementary, or accommodating role vis-à-vis the water agency.

*Efficiency*

The piped water supply system is not working efficiently. The majority of the water connections (95 percent) are not metered. Thus, there is no way to know how much water households/connection users are consuming (individually). In addition, water tariffs are extremely low; even if the bill collection rate were 100 percent, it would not be enough to cover operations and maintenance expenses. The loss of 40 percent of the piped water to leakages and illegal connections is another burden on the water agency. Concerning groundwater, the recently legislated Punjab Water Act-2019 is of particular concern; it prohibits regulation of groundwater extraction for domestic purposes until the local water authorities provide an adequate amount of piped water to the residents (clause-49). This restriction actually relieves the pressure of the water agency to quickly improve its service quality and fulfill the municipal water needs of the public and reverse the groundwater decline.

*Environmental Sustainability*

The main source of the municipal piped water supply is groundwater (86 percent). The current rate of pumping is sustainable as the water tables of its well fields are stable (JICA, 2019b, p. B2-1). Moreover, in order to increase the production of the piped water to fulfill the unmet demand use of the surface water is a more viable option. In Faisalabad, 72.6 percent of households have installed private in-situ groundwater pumps on their premises. In addition, 77 percent of the commercial and industrial entities extract groundwater. The exact volume of water extracted by the groundwater users is not known because aquifer exploitation for domestic usage is not regulated. On the other hand, the technology, and resources to monitor groundwater extraction for non-domestic purposes are not available. At present, the rate of groundwater exploitation is not sustainable as the water table is declining at a pace of 2 feet per year. Meanwhile, the rate of groundwater recharge has not changed in the city except for the minor impact of the lack of rainfall absorption (see section 2.4.1).

*Ostrom's Design Principles*

The outcomes of the action situation are not positive for the piped water supply system and freshwater aquifer in the city. The preceding evaluation of the outcomes from the equity, efficiency, and sustainability perspectives indicate that Ostrom's design principles are violated. Therefore, groundwater governance has been evaluated for weaknesses using the updated design principles by Cox et al. (2010) as well. The action situation shows that the boundaries of the freshwater aquifer are known, and formal rules clearly define legitimate and illegitimate groundwater users. The appropriation and provision rules (and their absence) do not match with the prevailing socio-environmental conditions, as the water table in various parts of the city is diminishing. In addition, the cost of groundwater pumping is less than the benefits accrued in terms of time, expense, and convenience (see Table 2.2).

On the other side of the problem, non-domestic groundwater extraction is regulated by the state, but the consumers on which these rules are applied were not part of the rule-making or rule-modifying processes. Conversely, groundwater pumping for domestic purposes is open access. The water agency does not have any policy, technology, or workforce to monitor the condition of the aquifer and groundwater withdrawal; neither it is accountable to the public regarding the mismanagement. Moreover, sanctions to punish the violators of the groundwater extraction rules are graduated, but they are applied expediently, if at all. In the case of conflicts between users or between the users and public officials, panchayats can be formed to offer rapid, low-cost justice. However, for the marginalized and low-income communities, it is rather difficult to form and use these platforms. The people are allowed to form groups and work to preserve groundwater, but it is not clear if they can work independently of the state. At the same time, there is no example of any community-led group working to conserve groundwater or use it sustainably. Lastly, the formal groundwater governance institutions are arranged in multiple layers, but due to the lack of communication and coordination among them, they are currently ineffective to play their role.

*Table 2.2: Evaluation of Faisalabad's groundwater governance*

| # | **Updated Design Principles (Cox et al., 2010)** | **Faisalabad's Groundwater Governance** | **Evaluation** |
|---|---|---|---|
| Principle 1 | *Clearly-defined boundaries*:<br>A) Clear and locally understood boundaries between legitimate users and nonusers are present.<br>B) Clear boundaries that separate a specific common-pool resource from a larger social-ecological system are present. | *Clearly-defined boundaries*:<br>A) The formal law, the Easement Act-1882, and the Punjab Water Act-2019 have defined legitimate and illegitimate groundwater users.<br>B) The extent of the freshwater layer on top of the saline Indus River Basin is known to the public officials. | Present<br><br>Present |
| Principle 2 | *Congruence with local conditions*:<br>A) Appropriation and provision rules are congruent with local social and environmental conditions.<br>B) Appropriation rules are congruent with provision rules, the distribution of costs is proportional to the distribution of benefits. | *Congruence with local conditions*:<br>A) The rate of groundwater discharge is higher than the rate of recharge.<br><br>B) The value of groundwater, in terms of cost, time, and convenience, is greater than the cost of pumping. | Absent<br><br>Absent |
| Principle 3 | *Collective-choice arrangements*:<br>Most individuals affected by operational rules can participate in modifying the operational rules. | *Collective-choice arrangements*:<br>Resource users do not participate in creating or modifying operational piped water and groundwater management rules. | Absent |
| Principle 4 | *Monitoring*:<br>A) Monitors who are accountable to the users monitor the appropriation and provision levels of the users.<br>B) Monitors who are accountable to the users monitor the condition of the resource. | *Monitoring*:<br>A) The water agency does not have adequate workforce or technology to monitor the groundwater withdrawal of all resource users.<br>B) The water agency does not have the policies, technology, or interest to systematically monitor the condition of the groundwater resource. | Absent<br><br>Absent |
| Principle 5 | *Graduated sanctions*:<br>Appropriators who violate operational rules are likely to be assessed graduated | *Graduated sanctions*:<br>Sanctions to punish violators of the piped water and groundwater | Weak |

| | | | |
|---|---|---|---|
| | sanctions (depending on the seriousness and the context of the offense). | management rules are graduated, although the enforcement of these rules is ad hoc and random. | |
| Principle 6 | *Conflict-resolution mechanism*:<br>Appropriators have rapid access to low-cost local arenas to resolve conflicts between them. | *Conflict-resolution mechanism*:<br>The citizens can access a rapid and low-cost, informal conflict resolution arrangement known as ‘panchayat,’ but sometimes forming these makeshift platforms is not equally attainable. | Weak |
| Principle 7 | *Minimal recognition of rights to organize*:<br>The rights of appropriators to devise their own institutions are not challenged by external governmental authorities. | *Minimal recognition of rights to organize*:<br>The government allows water users to organize and work with it for piped water provision and groundwater withdrawal. However, there is a legal grey area regarding the right of the people to work independently of the state. | Weak |
| Principle 8 | *Nested Enterprises*:<br>Appropriation, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises. | *Nested Enterprises*:<br>Institutions govern groundwater in multiple layers of nested enterprises, but these governance jurisdictions are not currently effective due to the lack of coordination among them. | Weak |

Source: Author

*Role of Institutional Power*

Action situations have helped uncover the impacts of power in the decision-making and enforcement of operational rules pertaining to municipal piped water supply and groundwater withdrawal. The formal rule-making powers are shared by the parliament of Punjab, HUD&PHED, and the water agency. However, the power is not equally shared; parliament and HUD&PHED give the water agency limited authority to function. They can enact laws and change local operational rules, thus undermining the autonomy of the water agency. However, the piped water users and non-domestic groundwater users are not part of any formal collective-choice arena. The power of these government entities is not absolute, since some of it is snatched from the state by the unauthorized informal governance units, especially regarding operational rules like monitoring, sanctioning, and conflict resolution. The informal governance units subvert and bend the rules to accommodate members of the powerful biraderies, as well as other wealthy and highly connected individuals and groups. The donor agencies at the provincial level advise the government to involve people in the planning, design, and delivery stages of the piped water provision and in water resources conservation efforts (i.e., to share power with the consumers). In contrast, the aid agencies at the local level recommend that the water agency completely avoid public involvement. Hence, these foreign donor agencies do exercise some indirect influence over the policy making and operational activities. Ultimately, the de facto power is not concentrated in the hands of a single entity; it is distributed among provincial, local, and informal governance units.

## 2.5 Discussion

The primary objective of this study is to explore the interactions between the performance of municipal water supply system and groundwater consumption. I have chosen Faisalabad, Pakistan as a case study to explore these connections using the IAD framework and Ostrom's design principles. The results of the analysis showed that socio-economic and ecological challenges like rapid population growth, urbanization, and poor rainfall recharge—although important—are not significant enough to deteriorate the piped water supply and urban freshwater aquifer. Rather, these issues can be solved on the foundation of strong formal or informal institutions; for instance, the water agency can employ cheap rainwater harvesting technology developed by the University of Agriculture, Faisalabad, to recharge the freshwater aquifer on a gigantic scale. Likewise, the predicted negative impacts of climate change on the flow of water in the irrigation network, on which the freshwater layer depends for recharge, are expected to materialize in the next 100 years (Kugelman and Hathaway, 2009). Furthermore, the average human being needs between 50 and 100 liters of water per day to meet basic needs like drinking, laundry, kitchen, household hygiene, and personal sanitation (WHO, 2003). In Faisalabad, the average per capita demand is 137 liters per day (JICA, 2019b). So, there is considerable room to reduce the per capita water demand and alleviate some pressure off the municipal piped water system.

Furthermore, an institutional lens provides the best explanation of the dynamics within and between the municipal water supply and groundwater extraction in Faisalabad. The action situation showed that the water agency has fallen into a vicious negative feedback loop, in which lack of funds and unauthorized informal governance units reinforce each other. Due to the paucity of funds, the water agency's operations and maintenance capabilities have deteriorated; pumping and water filtration capacity has shrunken; and there is no budget to install leak detection technology meanwhile 40 percent of the municipal water seeps into the ground. The shortage of piped water forces the public to compete for municipal water through informal governance units. Consequently, some neighborhoods with strong biraderies, or connections, get better water service, leaving the majority dissatisfied with the water agency. For this reason, people neglect paying their utility bills or simply steal water, putting additional financial damage on the water agency. Therefore, the water supply system stays in this self-perpetuating cycle of negativity, causing the performance to further deteriorate.

To get out of a negative feedback loop, the water agency regularly seeks financial help from the foreign donor agencies. The Asian Development Bank gave monetary assistance to construct the Chenab Well Field in 1992; similarly, the World Bank helped build a groundwater pumping station on Jhang Branch Canal in 2007. Currently, the French Development Agency and the Japan International Cooperation Agency are helping develop water policy and water supply infrastructure. Nevertheless, the regular substantial economic help has not been able to reduce the piped water scarcity or arrest the water table decline. The water agency and the international donors are of the view that technocratic solutions are the way to solve water scarcity problems in Faisalabad. In practice, therefore, the availability of external funds has stunted the water agency's ability and sense of urgency to create and modify municipal and groundwater governance institutions to tackle piped water security and groundwater depletion problems differently. For instance, piped water tariffs are so low that they do not even cover the operations and maintenance costs. The availability of external funds and subsidies does not push the water agency toward robust tariff policy as funds kept coming. Moreover, Djankov et al. (2008) argued that foreign aid does not work in places where institutions are weak and corruption is endemic. Adding more money in such cities or utilities means more rent-seeking opportunities for the public officials.

The probability of a governance system to manage the CPR more sustainably increases when it meets Ostrom's design principles (Cox et al., 2010). Analysis of the action situations showed that groundwater governance in Faisalabad satisfies only one out of eight design principles, while the rest of them are either weak or absent (see Table 2.2).

It is a strong indication for the policy makers who want to protect the groundwater to consider these institutional weaknesses (or absent and weak design principles) more seriously. Take for instance Principle #2, congruence with the local conditions. In Faisalabad, local socio-ecological conditions do not match with the formal institutions. For example, the “Punjab Water Act-2019” declared urban groundwater a public property, but domestic groundwater exploitation cannot be regulated until the water agency provides a sufficient amount of piped water to the connection holders. This condition relieves pressure on the water agency to quickly improve piped water service. In addition, residents chose what Hirschman (1970) described as an ‘exit’ option, rather than politically organizing themselves or protesting for better quality water, people choose to go for an alternative source of water, i.e., groundwater. This solution is not sustainable or viable for a long period of time because if people keep exploiting the freshwater layer at the current pace, the city will completely run out of groundwater soon. Therefore, the water agency must start regulating domestic groundwater extraction; this will then put an additional motivation on the water agency to improve its quality of service as to minimize the pressure from the residents to provide water.

Thus, the core issues—free-riding on municipal piped water infrastructure and unregulated and uncontrolled groundwater use—are collective choice problems which are harder to solve with external funds or building more infrastructure. The term collective action refers to a situation in which independent decisions of people produce outcomes whose impacts are jointly felt by everyone (van Soest, 2013). Individuals stuck in these social dilemmas are better off cooperating with each other for the long-term sustainability of the groundwater and efficient provision of piped water for everyone. However, factors such as fragmented or weak formal governance, low administrative capacity, and an absence of informal community-led efforts, as well the users' perception that they will never run out of groundwater, make cooperation harder to materialize. As discussed in the preceding paragraphs, external funds alone cannot solve public goods and CPR dilemmas, since it is extremely difficult to control hundreds of thousands of households pumping on their premises or to encourage people to start paying for the public infrastructure without institutional interventions. Thus, two policy recommendations are laid out in the next section, they can help improve both the piped water and the condition of the freshwater aquifer in Faisalabad.

## 2.6 Policy Recommendations

*Co-Production*

The collective action problems do not disappear with the formulation of few regulations, because the successful implementation of any policy requires cooperation from the willing citizens (Rothstein, 2005). A governance paradigm, co-production, is defined as "a process through which inputs from individuals who are not in the same organization are transformed into goods and services" (Ostrom, 1996, p.1). According to this model, policy-making is not a prerogative of technocrats (Bovaird, 2007) but the citizens can play an active role in producing public goods. They can collaborate with producers and other stakeholders in all or any of the following phases of public goods provision: planning, design, delivery, and assessment (Ostrom, 1996; Nabatchi et al., 2017). Co-production has the potential to alleviate several governance weaknesses identified by the design principles (see Table 2.2). For instance, it can improve monitoring and sanctioning operations using communities as assets (Adams et al., 2019; Ostrom, 1996). In addition, when producers and citizens work together (collective decision-making) in open, nested arenas, all forms of opportunistic behavior (i.e., illegal connections) are likely to get exposed (McGinnis, 1999, p.366). Public services get more responsive to the needs of the public and more accountable to the public (McMullin, 2019). In turn, trust between the consumers and producers increases (Fledderus et al., 2014), which is essential for getting out of social dilemmas (Sobels et al., 2001). Overall, free-riding or non-payment of bills is also expected to decrease, which means more funds for the water agency to invest in the piped water supply infrastructure.

*State-Reinforced Self-Governance*

Co-production between piped water users and the water agency will slowly improve piped water supply system and, in result, relieve some pressure off the freshwater layer. However, for the long-term sustainable use of the groundwater, grassroots efforts to sustain and protect the aquifer are necessary. The community-led interventions are crucial because it is impossible for the government to monitor the discharge from hundreds of thousands of motorized groundwater pumps in the urban area. In addition, due to the shared nature of the aquifer, it is extremely difficult to stop anyone from accessing and exploiting the aquifer. These characteristics of the CPR allow people to consume groundwater and get away without contributing anything towards its replenishment. Furthermore, the state cannot coerce people and kick-start self-governance at the community level. The self-organization must be voluntarily for it to produce institutions which are accepted and followed by all the consumers. Thus, efforts to co-produce piped water must be adopted along with 'State-Reinforced Self-Governance (SRSG)'. It is an innovative common pool resource management policy being used for the management of irrigation commons in Japan. According to this institutional arrangement, the government can work with common pool resource users to avert the tragedy of the commons, and yet remain strategic, cooperative, and non-participatory. It lets the CPR institutions flourish voluntarily at the grassroots (Sarker, 2013).

On the other hand, top-down initiatives crowd out local norms, such as social trust, because external incentives compromise individual intrinsic motivation to genuinely engage with each other, and thus over time, people may act less cooperatively (Bowles, 2008). Notwithstanding, in a community-led groundwater governance repeated interactions among the resource users will increase trust, cooperation, and compliance within the group (Rothstein, 2005). That's the reason, SRSG dictates that state using financial, legal, political, and technological means creates a favorable environment for the people where self-governance flourishes (Sarker, 2013). In Faisalabad, biraderies which are negatively impacting piped water supply system and freshwater aquifer at the municipal level can be used to make a positive impact on the water resources as well. Biraderies are the bases of informal governance units, that have weakened the water agency's enforcement capacity. The government can employ these informal trust networks to provide updated information regarding the groundwater level and the rate of consumption including the consequences of increasing groundwater withdrawal to the biraderi heads. They can disseminate this information among all the members of the biraderi. In addition, state can remove the legal grey area, are informal organizations are allowed to work independent of the state or not by enacting a new law or amending the existing "Water

Supply Faisalabad Regulations-2015". Finally, the state can also provide cheap rainwater harvesting technology to the people and train them how to use it, again using the biraderi based trust-networks. Thus, SRSG combined with co-production of piped water will have strong positive/corrective impact on the weak, and absent design principles, such as congruence with the local conditions, monitoring, minimum rights to organize, and nested enterprises (see Table 2.2).

## 2.7 Conclusions

In this paper, the worsening urban groundwater depletion crisis has been studied in the Global South context. The distinctive approach employed in this study is to analyze the problem of aquifer decline in conjunction with the municipal piped water security. The literature on groundwater governance is bereft of the impacts a poorly performing piped water supply system can have on the groundwater. Thus, considering Faisalabad as a case study and employing the IAD framework and Ostrom's design principles, social, ecological, and institutional factors affecting the functioning of water agency and groundwater withdrawal have been studied. The analysis showed that challenges posed by the ecological and social concerns are manageable if strong formal and informal institutions are present. Notwithstanding, institutional challenges are harder to tackle; for instance, the water agency is trapped in a vicious feedback loop in which lack of funds and informal governance units reinforce each other, pushing the water supply system in a negative downward spiral. The attempts by the water agency to inject external funds from multiple donor agencies have made it an aid-dependent institution and slowed the institutional maturation process. On the other hand, biraderies with more clout and influence have successfully used the informal unauthorized governance units for their benefits and further increased the inequalities in the quality of service.

Action situations showed that people are free-riding on the municipal piped water supply system and overusing groundwater, simultaneously causing public goods and CPR dilemma. Moreover, only one design principle out of eight is present in the groundwater governance of Faisalabad. At the local level the water agency, the government, the HUD&PHED, and informal governance units are the common elements between piped water and groundwater consumption. Hence, the challenge of groundwater depletion in Faisalabad cannot be solved with external monetary help or other technological fixes. It is essential to recognize the institutional nature of this problem, solving it requires collective action from all the stakeholders, primarily resource users and the local water agency. I proposed two policy solutions that must be implemented simultaneously, co-production to rehabilitate the water agency and state reinforce self-governance to provide a conducive environment for the groundwater users to self-govern the aquifer.

Lastly, one of the limitations of this research is the absence of analysis on political will, which is necessary to take up the challenge of groundwater depletion in the city. In addition, there is a dearth of accurate and regularly updated information on groundwater use, as the water agency has no technology or system to monitor the consumption of domestic and non-domestic users. Thus, future research on the groundwater in Faisalabad can explore aspects concerning the political will and add more comprehensive groundwater recharge, discharge, and consumption data in the analysis. The other two avenues of research pertain to the policy recommendations I laid out in this study. The first avenue is to determine the public willingness to co-produce piped water. The second avenue is to explore if residents want to cooperate with each other to manage the aquifer at the grassroots level.

# CHAPTER 3: COOPERATION IN GROUNDWATER GOVERNANCE
# A COMMON POOL RESOURCE EXPERIMENT

## 3.1 Introduction

Faisalabad is a large metropolis of 3.2 million people (Pakistan Bureau of Statistics, 2017). Its residents are exclusively dependent on groundwater as the main source of the public water supply system, and 72.4 percent of households practice self-extraction of groundwater to meet their domestic water needs (JICA, 2019b, p.B5-13). The freshwater aquifer being exploited by the city is a sub-system of the Indus River Basin, which is naturally saline due to its marine origin. However, due to the seepage from surface water irrigation canals built in the late 1800s a freshwater layer on top of the brackish water has developed (JICA, 2019a, p.A3-1). The absence of informal and weak formal, groundwater governance, in addition, at the minor level, urbanization, and population growth, has led to unregulated and uncontrolled exploitation of this freshwater layer (Shahbaz, chapter 2). Today, the aquifer is declining at the rate of 2 feet per year as the rate of discharge exceeds the rate of recharge (Jamal, 2019, p.17). The lowering of the groundwater table has triggered an intrusion of saltwater from a deep fossil aquifer, rendering the freshwater layer unsuitable for domestic consumption (Shakoor et al., 2017).

Numerous cities in the developing world are facing groundwater scarcity and associated governance challenges (e.g., Biswas et al., 2017; El-Naqa et al., 2007; Hossain et al., 2021; Mahmood et al., 2011). The unique difficulties that groundwater managers face can be partly ascribed to the very nature of groundwater. First, it is a common pool resource (CPR), meaning the exploitation of the aquifer by one person reduces its availability for the rest of the community[8]. Additionally, it is extremely difficult to prevent someone from accessing and extracting groundwater. Second, the invisibility of the aquifer adds another layer to the challenge, as it makes it harder to detect free-riding behavior (Kemper, 2007). These groundwater characteristics allow people to easily and frequently exploit the resource without contributing anything towards its replenishment and protection. Thus, individuals who are using CPRs, such as groundwater, face a social dilemma[9]: either choose short-term self-interest and individual gains from the resource or think of its long-term sustainability for everyone (Ostrom, 1999; Rothstein, 2005).

The destruction of commonly held open access resources is inevitable unless they are regulated by the state or privatized (Hardin, 1968). However, state-led groundwater management efforts in urban areas have largely been ineffective because governments usually lack the administrative and technological capacity to monitor large numbers of dispersed water wells (Molle & Closas, 2020). Similarly, privatization of groundwater would likely be unsuccessful because boundaries of the aquifer are often unclear; thus, it is difficult to establish workable individual property rights (Bruggink, 1992). Moreover, it is a

[8] Common-pool resources are characterized by two distinct features 1) difficulty in stopping actors from extracting resource units (i.e., low-excludability) and 2) withdrawal or subtraction of resource unit(s) by one individual/entity

[9] It is a situation in which the private and socially optimal actions do not coincide (van Soest, 2013).

mobile resource, it's use at one place affects its quantity and availability at other places. Elinor Ostrom (1990) contested Hardin's assertion and proposed a third way to manage common pool resources. She argued that human beings can come together and cooperate because they are not so much motivated by self-interest, rather by strategic thinking, i.e., conditional cooperation. There are now hundreds of examples of local communities where collective action has led to the development of self-governing groundwater management institutions (e.g., Garduño et al., 2009; Ostrom, 1965, 1990; Taher, 2016).

The importance of self-governing institutions is even greater in countries like Pakistan where the state is weak (Malik, 2017). The metropolitan government in Faisalabad has failed to protect and regulate groundwater for the benefit of the general public. On the other hand, privatization of aquifer is not possible, owing to its very nature, when it is being shared by millions of people in the urban context. Hence, community-based informal self-regulating institutions are a plausible alternative method of aquifer management. The residents of Faisalabad do have de jure minimal rights to develop their own institutions and operate them but with the consent of the state. The aim of the Citizen Liaison Cell (CLC), created by the water agency in 2013, is to help water users self-organize and collaborate with the state for the conservation of water resources in the city (see section 3.4 for more details). Therefore, there are no serious formal or legal hurdles at the community level that stop citizens from working together for the protection of groundwater. The question though is would the residents be willing to cooperate and collectively govern the aquifer as a common property.

Many factors can impact an individual's level of cooperation in common pool resource dilemmas. The most important element for the success of most, if not all, self-governing institutions is social capital (E. Ostrom, 2000; Sobels et al., 2001). It reduces uncertainty and lowers the transaction costs associated with working together. It also enables people to develop the confidence to invest in collective activities, believing that others will do the same (B. Rothstein & Stolle, 2003). Furthermore, individual preferences like risk-taking (Reynaud & Couture, 2012), patience (Gunatilake et al., 2009), and egalitarianism[10] (Koop et al., 2021) are also known to affect the intensity of cooperation in the collective choice arenas. Given the information laid out in the preceding paragraphs, I am setting up two hypotheses. First, groundwater users in Faisalabad will not cooperate to regulate their groundwater extraction. As the standard noncooperative game theory suggests, that is a social dilemma, the incentives for free, rational, and self-interested individuals are such that stimulating cooperation among individuals to avert the tragedy is difficult.  In addition, the amount of social capital is limited and restricted to kinship-based trust networks (biraderies), which is not enough to overcome the social dilemma and encourage cooperation among all the residents in Faisalabad (Anwar, 2019 and see section 3.4 for more details). The second hypothesis is that social capital, patience, risk-taking behavior, and egalitarianism impact groundwater users' cooperation level and, in turn, affect the intensity of groundwater extraction. To explore the first hypothesis, I conducted a common pool resource experiment with the residents of Faisalabad to elicit their groundwater extraction behavior. The amount of extraction is inversely related to the level of cooperation among the group members. The empirical analysis shows that players are

[10] The term "egalitarian" is often used to refer to a situation that favors a greater degree of equality of income, wealth, and development across a population.

somewhat cooperative as they extract on average 7.23±.166 gallons out of 10 gallons allocated to each one of them. I used an Ordinary Least Squares (OLS) regression model to test the second hypothesis. Findings of the regression analysis show that trust, lack of corruption in the water agency, patience, and egalitarianism increase the cooperation level, and in turn decrease the groundwater extraction.

This paper is organized in the following way: at the outset, I discuss the nature of groundwater as a resource, including different governance modes to manage it. Further, I review current groundwater governance arrangements in Faisalabad. In addition, I explore why cooperation is crucial for the success of self-governance efforts. Then, I present the key factors that impact the level of cooperation in the action arenas. Next, I describe the research methodology that explains the field experiment and statistical analysis employed to explore the respondents' groundwater extraction behavior. Finally, a discussion of the results and policy recommendations are put forth.

### 3.2 Local Level Groundwater Governance

Aquifers are critical sources of water essential to agricultural, municipal, and ecological water needs worldwide (Van der Gun, 2012; WWAP, 2012). They are being exploited in an unsustainable manner causing the water table to diminish rapidly, especially in developing countries (Gherghe, 2008; Gleeson et al., 2012). Water governance authorities everywhere are struggling to reverse this trend and ensure sustainable groundwater use (S. Foster & Garduño, 2013). Moreover, groundwater is a CPR that makes its management uniquely difficult, as exploitation by one user reduces its availability for the rest of the consumers. At the same time, it is also costly to exclude or limit the users' extraction activities (Ostrom, 1990). The invisibility of the aquifer adds another challenge that makes it harder to detect free-riding behavior (Kemper, 2007). Hence, when it comes to common pool resources, incentives are such that an individual would be better off if everyone else cooperates while they free-ride on the resource without making any sacrifice (Ostrom, 1999). In the case of groundwater, people around the world face a dilemma: they have to choose between short-term individual gains (free-riding) or long-term sustainability of the resource (Garduño et al., 2009).

According to Garett Hardin (1968), the dynamics of CPR extraction make the destruction of the resource by self-interested individuals inevitable unless it is privatized or regulated by the state. The comprehensive review of the state-led groundwater management efforts shows that the government has largely been ineffective due to the lack of a high degree of administrative, technological, and legal capacity to monitor a large number of dispersed water users (Molle & Closas, 2017, 2020; Ross & Martinez-Santos, 2010). Nonetheless, even when the state is strong, involvement of local communities is often necessary for improved groundwater governance (Mitchell et al., 2011). For example, groundwater governance problems persist even in the United States where the government is strong (Zuniga & Nathaniel, 2017). Similarly, attempts at aquifer privatization[11] are often unsuccessful because boundaries of the resource are often unclear; thus, it is hard to establish workable property rights (Bruggink, 1992). Although there are some examples of successful CPR

[11] Privatization is the process that attempts to increase excludability by instituting some form of property rights which shift access rights exclusively to specific entities or individuals to enhance the efficiency of use (Partelow et al., 2019).

privatization, e.g., fishing grounds and rangelands (e.g., Guneau & Tozzi, 2008; Pinkerton & Davis, 2015), scholars were unable to find any positive example of aquifer privatization.

Elinor Ostrom is one of the most prominent scholars who contested Hardin's (1968) assertions concerning the common pool resources. She argued that tragedy of the commons is not inevitable, and the state-led and private pathways to govern the CPRs, do not always work, especially when the resource is groundwater (Dietz et al., 2003, p.1907; Ostrom, 1965, 1990). In addition, Rothstein (2013) and Ostrom (2005) challenged the standard game theory assumptions underlying Hardin's analysis. They contend that human beings are not so much motivated by self-interest as they are by strategic thinking, which is based on what other agents do or are expected to do in the action situation. Therefore, in a CPR dilemma, they can potentially adopt cooperative behavior. Lastly, as suggested by Ostrom (1990) and supported by the findings in numerous successful examples of community-led self-governing CPRs (e.g., Baland & Platteau, 1996; Garduño et al., 2009; Ostrom, 1965; Taher, 2016), it is safe to conclude that aquifers can also be managed collectively as a common property[12].

### 3.3 Cooperation in Groundwater Management

Urban groundwater systems are composed of technical, environmental, and social components (House-Peters & Chang, 2011). Therefore, they can be studied as complex social-ecological systems in which heterogeneous individuals and entities interact with the resource contingent upon their diverse value systems and objectives (Pahl-Wostl, 2003).

[12] Common property refers to exclusive collective access, use, and/or management rights to a defined resource at the group level (Partelow et al., 2019).

The inherent complexity and uncertainty associated with the social-ecological systems present a serious management challenge to the stakeholders (Elsawah & Guillaume, 2016). Curtis et al. (2016) have argued the best strategy to handle complex natural resource management issues is to directly involve resource users. They bring local knowledge and trust networks (i.e., social capital) in the collective choice arena that would increase cooperation and in turn improve governance, such as reductions in monitoring costs. Thus, for effective groundwater management social capital is crucial regardless of the governance approach being employed (Bouma et al., 2008; Rothstein, 2005; Sobels et al., 2001). Social capital has even greater significance for bottom-up, self-organizing, self-regulating governance systems (Ostrom, 2000, p.178). Rothstein & Stolle (2003, p.7) defined social capital as "access to beneficial social networks and having generalized trust in other people". It reduces uncertainty, lowers the transaction costs of cooperation, and enables people to develop the confidence to invest in collective activities, believing that others will do the same (Rothstein & Stolle, 2003). There are three types of social capital: bonding, bridging, and linking. The bonding social capital describes the trust and connections within a specific group. On the other hand, bridging social capital specifies the links and relationships between individuals and groups with other groups and people who belong with them. Finally, the linking social capital refers to the ability of people to engage with external agencies, elected officials, etc. To protect any large-scale CPR, the presence of all three types of social capital is essential (Pretty, 2003). However, the importance of bridging and linking social capital is relatively higher because bridging and linking connections enable people to access information and resources outside of their own social networks (Ostrom, 2000). To illustrate, "bridging social capital can generate broader identities and reciprocity" (Putnam, 2000, p.23). In the same way, linking social capital connects people across vertical differentials up and down the formal and informal social scale (Ferlander, 2007).

Trust is the most important aspect of social capital (Grafton, 2005; Rothstein & Stolle, 2003). At the individual level, people who believe that most of the people in their community can be trusted are also more likely to support civic and environmental conservation efforts (Holmberg & Rothstein, 2011; B. Rothstein, 2013). According to Rothstein (2005), there is a causal relationship between trust and corruption. He argued that social trust in a society starts to decline when officials in public institutions are corrupt. Rothstein described a three-part causal mechanism illustrating how a lack of institutional trust leads to lower social trust. In phase one, if the public officials exercising their authority are being partial or corrupt, people will rationally stop trusting them. In phase two, people will logically infer that in a society with corrupt officials, most other people are also involved in corrupt practices to obtain essential goods and services; therefore, they cannot be trusted. In phase three, individuals realize that to get by in a corrupt society, they have to participate in corrupt practices themselves. Thus, being oneself, an untrustworthy person concludes that most other people in the society cannot be trusted as well (Rothstein 2005, p.121-122). Therefore, corruption in public institutions must also be factored in every social capital measurement.

Additionally, individual preferences like risk-aversion, patience, and egalitarianism are also known to affect decision-making behavior in social dilemmas (Reynaud & Couture, 2012; Gunatilake et al., 2009; Koop et al., 2021). The risk-averse individual, according to Stefánsson & Bradley, 2019, p.1), is someone who is "disinclined to pursue actions that have a non-negligible chance of resulting in a loss or whose benefits are not guaranteed". The more risk-averse a person is, the more he or she would be willing to cooperate in the action arena. Similarly, time preference reveals how much an individual would be willing to trade-off present benefits for future benefits (Magdalou et al., 2009). The generally held perception is that impatience leads to lower levels of cooperation, which, in turn, accelerates natural resource harvesting (Gunatilake et al., 2009; Gollier, 1999). Finally, Koop et al. (2021), in their investigation of public attitudes towards water resource conservation, found that people who believe in egalitarianism consider themselves more responsible for addressing resource scarcity issues. They also show a strong belief in the statement that "everyone should have access to the same water services", hinting toward a greater willingness to work with others to protect water resources (Koop et al, 2021 p.5).

### 3.4 Measuring Cooperation

Field experiments are a popular methodology in CPR governance literature to elicit the level of cooperation among the members of the community using the commonly held resource. They are usually employed as experimental games to understand the decision-making behavior of the individuals facing real-life CPR management challenges (e.g., Gehrig et al., 2019; Goldbach, 2017; Meinzen-Dick et al., 2016; Travers et al., 2011). In the game, an individual is mechanically forced to pay attention to issues that the investigator aims to address intuitively. In addition, experimental games allow researchers to establish causality between variables rather than mere correlation (S. Durlauf & Blume, 2009; Harrison & List, 2004). Notwithstanding, field experiments have been criticized for their lack of generalizability beyond the simulated action arena (Galizzi & Navarro-Martinez, 2019). Therefore, the level of cooperation exhibited in the games can only be attributed to the people who belong to the simulated context (Anderies et al., 2011; Fehr & Leibbrandt, 2011; Goldbach, 2017).

In a typical field experiment,[13] a researcher creates a controlled setting or environment in which a set number of participants make decisions. They voluntarily agree to take part in the game and receive instructions on its institutional arrangements either orally and/or in writing. For example, they are informed about the group they belong to, the payoff structure of the game, possible decisions participants are allowed to make, and the outcomes that depend on the decisions of other members of the experiment (Anderies et al., 2011, p.1573). Furthermore, the experimental games are often incentivized to trigger real-life response from the respondents (Camerer & Hogarth, 1999). The payoff structure is designed in a way that if a person extracts more from the CPR, personal earnings increase, but, at the same time, group returns that are shared equally among participants will diminish (Gehrig et al., 2019). Depending on how the experiment is done, all decisions made by the players are made in a private setting, either on a computer or on paper. Payments are also made in private, and the exact amount depends upon the decisions participants made in the game (Anderies et al., 2011, p.1573).

Experimental games have been used to study various aspects of CPR governance throughout the world. For example, Meinzen-Dick et al. (2016) used field experiments in

[13] I will use phrases experimental game and CPR game synonymously.

hard rock areas of Andhra Pradesh, India, to analyze the groundwater use behavior of local farmers. The results showed that when the connection between crop choice and groundwater depletion was made clear to the farmers, they pursued a more conservative behavior towards groundwater. In addition, farmers who reported a higher level of social capital in the community acted more cooperatively. Similarly, Dipierri & Zikos (2020), played an irrigation dilemma game in northwest Argentina to investigate the role of conflict resolution mechanisms under environmental variability. The findings demonstrated that most of the groups lacking rules for conflict resolution extracted more water from the irrigation system when environmental conditions were uncertain. Nevertheless, some groups were able to sustainably manage canal water appropriation even in the absence of conflict resolution mechanisms. Furthermore, Foster et al. (2018) designed a field experiment to study the groundwater extraction behavior of farmers in Guanajuato, Mexico, under three different policy interventions regarding subsidies (i.e., elimination, reduction, and decoupling). The results showed that complete elimination of subsidies had the largest effect on the rate of groundwater extraction, while the reduction in subsidies had only a marginal effect. Ultimately, decoupling (disassociating subsidies from volumetric measures in favor of lump-sums) proved to be the best policy solution, as it produced an effect similar to elimination but without undesirable political implications, such as resistance of elected officials to changes in the status quo.

### 3.4 Groundwater Governance in Faisalabad

Faisalabad is located in the central region of Punjab, Pakistan. In 2017, its population was 3.2 million with 506,879 households (Pakistan Bureau of Statistics, 2017).

The majority of domestic and non-domestic users consume groundwater because only 27.6 percent of households and 10 percent of non-domestic units have municipal water agency connections (JICA, 2019b, p.B5-18). The aquifer located below Faisalabad, on which its residents depend, is a subsystem of the Indus River Basin[14] (Haider, 2000). The native groundwater of this basin is saline. However, due to seepage from the irrigation network developed in the late 1800s, it has gradually developed a freshwater layer on top of the brackish water layer (JICA, 2019, p.A3-1). According to the report published in 2015 by the Pakistan Council of Research in Water Resources, the average thickness of this freshwater layer is nearly 100 feet and decreasing (Khan et al., 2016). High population growth (2.5 percent) is another factor in the increased water demand[15] and explosive urban expansion (167 percent increase) in the last 25 years (JICA, 2019a, p.1). A reduction in rainfall recharge, which was originally contributing 15 percent to the total aquifer replenishment, is one factor in the depletion of the freshwater layer. Urbanization, which has brought more buildings, pavements, and roads, has considerably reduced the rainwater absorption in the city, which is moved out of the city by storm drains (Jamal, 2019).

To date, the local water agency has been unable to regulate groundwater abstraction. Formal rules (Punjab Water Act-2019) prohibit groundwater draft for domestic purposes without permission from the local water agency. However, to implement this rule, the state must provide sufficient access to municipal piped water first. Hence, the water agency in Faisalabad does not enforce its rules when groundwater is extracted for domestic

[14] The Indus River Basin covers 16 million hectares of land.
[15] The estimation based on average per capita water consumption (137 liters), growth rate, and a total population of 3.2 million would increase the water demand up to 2.4 million gallons per day in the immediate next year.

purposes because it has not been able to fulfill the water needs of all the households (Ahmad et al., 2017). In contrast, there is no confusion regarding commercial and industrial groundwater extraction for which permits must be sought under the "Water Supply Faisalabad Regulations–2015" (Clause 17-b). Despite, in practice, these rules, especially monitoring and sanctioning, exist only on paper (Respondent-D, 2021). The most likely reason governments fail to protect groundwater is the very nature of the resource (aquifer) itself: it is not feasible for the state to monitor hundreds of thousands of motorized pumps in individual households. The weak capacity of the state to reconcile conflicting interests and garner the political support necessary for the better groundwater management is another plausible reason (Bruns, 2021). In addition, CPR privatization in the context of groundwater is difficult to implement because aquifers are usually too large for the hundreds of thousands of people who depend upon them to develop pragmatic property rights (Bruggink, 1992). When extracted for domestic purposes, groundwater converts to an open access resource, and because of the shared nature of the aquifer, this leads to unsustainable exploitation of groundwater. Hence, attention must be paid to the alternative that contends that CPRs can be governed as a common property, where communities come together and cooperate in devising informal groundwater management institutions (Ostrom, 1965 and 1990).

The study of formal institutions in Faisalabad shows that there are strong possibilities for community-led informal groundwater management in Faisalabad. To explain, the “Punjab Water Act-2019” enacted by the parliament of Punjab and policies like “Punjab Drinking Water Policy–2011” and “Punjab Urban Water & Sanitation Policy–2007”, issued by the Housing and Urban Development & Public Health Department, an executive branch of the Punjab government, advised local governments to involve water users and civil society in the groundwater decision-making processes. In addition, the water agency established the Citizen Liaison Cell (CLC) in 2013 and permits local communities to self-organize and work with the government to protect water resources. If the local community or a group decides to organize itself, it must first register with the government according to the "Societies Registration Act XXI-1860" (The Urban Unit, 2010). However, it is pertinent to note that the CLC has been non-functional since its inception. It has failed to launch a single program or help develop any self-governing community-based organization for the protection of groundwater (WASA-F, 2020).

Looking through the lens of Ostrom's (1990) design principles, it can be said that groundwater appropriators do have minimal rights to create their own institutions in Faisalabad. The state does not challenge self-governing institutions directly, but there is a legal grey area, as it is not clear if the community-based organizations can work alone without the state's consent. To explicate matters, the presence of the Citizen Liaison Cell (CLC) reveals the state's tacit acceptance of informal methods of governance to achieve better performance outcomes. This implicit recognition of nested governance, where management activities are organized in multiple layers, shows that self-governing groundwater management institutions can vertically link themselves to the water agency. Moreover, a higher level of social capital is crucial for garnering cooperation among the stakeholders (see section 3.3 for details). In Faisalabad, *biraderi-based* [16] trust networks are an example of bonding social capital. The higher the level of communication and

[16] The word biraderi refers to caste, clan, religion, tribe, or sect.

contact between the members of the *biraderi,* the higher the level of trust, which reduces obstacles to cooperation (Gazdar, 2009; Malik, 2017, p.245). In addition, the ability of biraderies to engage with external formal organizations, like the water agency, to get exclusive access to water resources (Anwar, 2019) is an example of linking social capital in society. However, there is a lack of bridging social capital because different biraderies are not cooperating but competing with one another for the scarce water resources (Respondent-D, 2021).

In developing countries like Pakistan, capacity of the state is limited and in consequence many rules of law problems emerge (Acemoglu & Robinson, 2012; Malik, 2017). In such places, adopting self-governing CPR management institutions is even more significant. There is an abundance of evidence that confirms that self-governing institutions perform more efficiently at smaller scales (E. Ostrom, 2012; Ross & Martinez-Santos, 2010; Taher, 2016). Unfortunately, the scale of the resource (aquifer) underneath Faisalabad is large. When the extent of the CPR crosses many socio-cultural, political, institutional, and geographical borders, it becomes harder to scale up the self-regulation efforts (Guerrero et al., 2015; Janssen, 2015). In Faisalabad, due to the large population belonging to different castes, ethnicities, religions, and income groups, heterogeneity is high. Thus, it is extremely hard for any self-governing institution to work independently and be able to improve the condition of the CPR in the city. Wyborn (2015) argued that the best solution out of this quandary is to adopt a polycentric governance system that will help establish cross-scale linkages between a large number of community-led groups. By a polycentric system, I mean multiple autonomous decision-making nodes (Ostrom et al., 1961), which can make large-scale collective action problems more manageable by adjusting institutional solutions to local needs and circumstances (Ostrom, 1999).

### 3.5 Methodology

In the previous section, I have argued that formal water governance institutions give groundwater users minimal freedom to develop their own institutions. There is also a recognition of the fact that community-led institutions can play an important role in the improvement of the groundwater governance. In addition, the presence of bonding and linking social capital in the society expands the possibility of developing successful self-governing institutions. Setting aside the non-functionality and lackluster performance of the water agency, I am interested in exploring if people are willing to make use of minimal formal autonomy and limited social capital[17] to cooperate on matters concerning groundwater depletion. Hence, this study makes two hypotheses: first, groundwater users in Faisalabad will not cooperate to regulate their groundwater extraction. Second, lack of social capital, patience, risk-taking behavior, and egalitarianism influence groundwater users' level of cooperation.

#### 3.5.1 Experimental Game

To explore the first hypothesis, I employed a one-shot common pool resource game designed and adopted by Goldbach (2017) and Rand & Kraft-Todd (2014). According to Harrison & List's (2004, p.1014) classification of controlled experiments, it is an artefactual field experiment in which participants are chosen from the actual location of the study, who perform an abstract CPR task (Harrison & List, 2004). The goal of this study is

[17] Social capital is limited because bridging social capital is absent in the city

to explore respondents' willingness to cooperate with other community members regarding the reduction in CPR abstraction. In the following paragraph, I have explained how this game was conducted.

(1) The instructions and rules of the game were relayed to players orally in Punjabi or Urdu. They could also choose to read them on their computer screens in English. Before the game, I informed the players that they can earn up to 40 PKR ($0.25). The exact amount of money they could earn depended on their own decisions and the decisions of others participating in the game. (2) The players were asked to extract from a resource held in common with three other members (a total of 4 people in one group) of their community. The three members were actually the last three participants of the CPR game. None of the players knew the identities of the others. Furthermore, to make the decision-making task clear and facilitate greater comprehension, the game was framed as a groundwater extraction scenario. In the game, each player was asked to imagine that the groundwater reservoir underneath their community/neighborhood contains 40 gallons of water. They can extract up to 10 gallons of water or choose to leave all of it behind in the aquifer. The players got only one opportunity to extract the groundwater. The other three members of the group were given the same decision choice. (3) I explained the payoff function to the players. The private earning from the groundwater extracted by an individual generated 2 PKR for every one gallon extracted. The groundwater not withdrawn from the aquifer yielded a group earning of 4 PKR for every one gallon left in the ground, which was equally shared among the group members. I used real incentives in this game to recreate a kind of 'commons dilemma' that people face in real life, where their earnings or benefits do not depend on their decision alone. (4) I asked the players two comprehension questions. The

purpose of these questions was to make sure that respondents have understood that their earnings are composed of both private and group gains. If the player's answers were not right, I attempted to clarify the confusion and describe why their answer is incorrect. (5) Regardless of whether the player answered the control questions correctly or not, they were asked to decide what amount of water they wanted to abstract from the aquifer. (6) Once the player decided on the amount of groundwater they wanted to extract; I estimated the total amount they have earned. The payment was made in cash immediately after the game. The players were also informed about the decisions that other group members have made (see Appendix-IV for CPR experiment).

### 3.5.2 Eliciting Trust and Individual Preferences

To investigate the second hypothesis, after the CPR game, I directly asked players a few questions about their beliefs and attitudes. With this information in hand, I can avoid making subjective interpretations as to why some respondents in the game cooperated while others chose not to, as advised by Durlauf (2002). First, to measure the level of social (generalized) trust, I asked the following questions: (1) "Generally speaking, would you say that most of the time people try to be helpful, or that they are mostly just looking out for themselves?". This question (and its iterations) has been used by the *General Social Survey* in the United States and the *World Values Survey* as an indicator of cognitive social trust at an individual level. The respondents answered it on a stated three-point Likert scale: *helpful, neither,* and *selfish*. (2) "Do you think corruption exists in the water agency?" This question about corruption has a strong impact on social trust (Rothstein, 2005) and was answered on a three-point Likert scale as well: *no, do not know,* and *yes*.

I am also interested in examining what impact individual preferences, like risk-aversion, patience, and egalitarianism, have on the respondent's level of cooperation and on their groundwater extraction level in the game. To elicit information on risk and time preferences, I asked players to respond to the following statements on a five-point Likert scale ranging from *strongly disagree* to *strongly agree*, including a *neutral* option: "In general, I am willing to take risks" and "I am a patient person" (same as Goldbach, 2017). Lastly, to obtain evidence of egalitarianism, I asked players, "Would you consider living in a community where your water supply service is the same for everyone?". The respondent can answer *yes* or *no* (see, for example, Koop et al., 2021).

### 3.6 Data Collection

The CPR game was played with 204 residents from February 2021 to July 2021. Only the household heads were interviewed since they are mainly responsible for groundwater use decision-making in their homes. According to the water agency, 60 percent of the households are located in the public water supply service areas, and 40 percent are located in unserved areas (WASA-F, 2020). Therefore, to give equal representation of the households, I performed 120 experiments in service areas and 84 experiments in unserved areas. To make the sample further representative of the population, I used a two-stage cluster sampling technique to reach households belonging to different income groups and locales within the service and non-service areas. In the first stage, I developed a total of 20 clusters all over the city (13 in service and 7 in unserved areas). There were 6-12 respondents in each cluster; the exact number depended upon the positive rate of response to the survey invitation in the cluster (see Table 3.1). This recruitment strategy was used in the study "Mortality before and after the 2003 invasion of Iraq: cluster sample survey" by Roberts et al. (2004). In the second stage, I chose households for interviews. The first household in each cluster was selected randomly. Then, every sixth house from the last house that participated in the game was invited to take part in the experiment. To elucidate, after the first interview, the location of the first household acted as a starting point to select other households in the cluster. This recruitment methodology was adopted by DiJulio et al. (2018) in their study "Views and Experiences of Puerto Ricans One Year After Hurricane Maria." Finally, to represent all income groups in the sample, clusters were formed in the city's poor, middle-, and rich-income areas. While creating each cluster, I ensured that at least one neighborhood (or *mohalla* in local vernacular) of different incomes lies on its boundaries. The goal of this meticulous sampling strategy was to collect data across all key variables significant to address the hypotheses and thus compensate for the relatively small sample size.

Furthermore, due to the Covid-19 epidemic, I conducted the experiments online via video conferencing software (Skype). The survey starts with socio-demographic questions, followed by questions about egalitarianism, corruption, trust, risk-aversion, and patience. The CPR game was played at the end of the interview. To ensure a smooth interview and game experience, an online survey hosting platform (Survey Monkey) was employed to digitally display questions and instructions on a computer screen in front of the respondent.

*Table 3.1: Neighborhoods in which clusters were developed*

| Service Areas | Non-Service Areas |
| --- | --- |
| Awami Colony, Nasir Colony, CM Colony, Essa Nagar, Muhammad Pura, New Green Town, Kaleem Shaheed Colony, Gobindpura, 7-Chak J.B., Christian Town, Gosia-Abad, Sarfaraz Colony and Dawood Nagar-A | Khayaban, Shirian-wala, Rabbani Colony, Shamsa-Abad, Dawood Nagar-B, Kuriwala, and Khalid Garden |

## 3.7 Model Development and Results

The whole interview including the CPR game, took on average 30 minutes to complete. Each respondent earned around 181 PKR (=1.3 USD[18]) in cash for participating in the interview and the experiment. The amount of this payout is a little more than the poor household's hourly family income in Faisalabad. To further explore and perform statistical analysis on the dataset, I used the popular software called Stata (version 16). A first look at the socio-demographic characteristics shows that all household heads, except one, are male. In terms of age, 53.72 percent of the respondents were born in 1975 or before and 46.28 percent were born from 1976 to 2001. Moreover, 19.58 percent of households are poor, 42.86 percent belonged to the lower-middle class, 16.40 percent belonged to the upper-middle class, and 21.16 percent belonged to high-income families. The majority of the respondents, 71.43 percent, have an education up to secondary school (10$^{th}$ grade) or less. The average family size of the respondents is 6.68 people.

The descriptive statistics of the data pertaining to the game and ancillary survey are presented in Table 3.2. The factors *lacking trust, corruption, risk-taking, patience,* and *egalitarianism* are dummy variables. *Family size* and *groundwater extraction* are

[18] Conversion rate 1 USD=159.5 PKR on July 18, 2021.

continuous variables. The first glance at the mean values shows that 70 percent of the players think that in general people only look out for themselves (are selfish), and 70 percent perceive the water agency as a corrupt institution. Moreover, only 4 percent of respondents strongly agree that they love taking risks, and 35 percent perceive themselves as patient people. Lastly, nearly all respondents, 98 percent, believe in high egalitarianism and that everyone in the community should have equal access to water resources. The average groundwater extraction in the CPR game was 7.23±.166 gallons (out of 10 gallons) signifying that players only marginally limited their level of extraction. 36.27 percent of the players extracted 10 gallons of water, implying non-cooperative behavior. The second largest group, 30.57 percent, chose to extract 5 gallons signaling better cooperation among group members in the game (see Figure 3.1).

*Table 3.2: Descriptive Statistics*

| **Variable** | **Value Range** | **Mean** | **Std. Dev** |
|---|---|---|---|
| Lacking Trust | [0, 1] | 0.70 | 0.46 |
| Corruption | [0, 1] | 0.70 | 0.46 |
| Risk Taking | [0, 1] | 0.04 | 0.20 |
| Patience | [0, 1] | 0.35 | 0.48 |
| Egalitarianism | [0, 1] | 0.98 | 0.12 |
| Family Size | [2, 16] | 6.68 | 2.76 |
| Groundwater Extraction | [3, 10] | 7.23 | 2.28 |

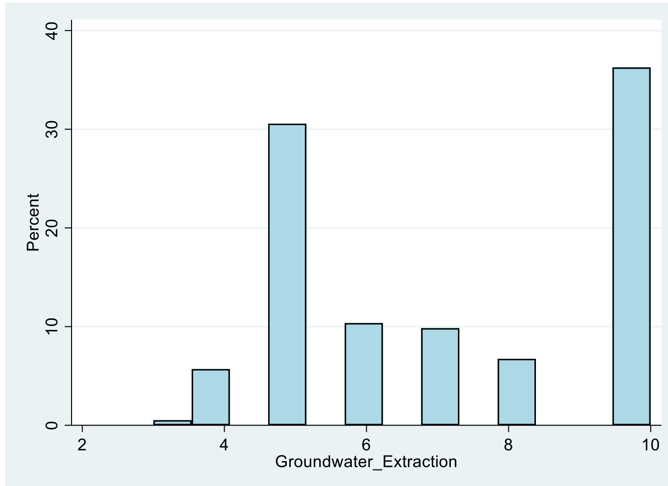


Figure 3.1: The distribution of groundwater extraction in the CPR game

### 3.7.1 Regression Results

To further examine the groundwater extraction behavior and underlying factors that influence it, three Ordinary Least Squares (OLS) regression models were built (Table 3.3). In these models, *groundwater extraction* is the dependent variable which refers to the amount of water extracted during the CPR game. The explanatory variables, *lacking trust* and *corruption*, are the measures of social capital. Moreover, the variables *risk-taking*, *patience*, and *egalitarianism* are the measures of individual beliefs. These factors are known to affect the environmental behavior of people and their level of cooperation in social dilemmas (see Koop et al., 2021). I have also added *family size* as the control variable to know if it impacts the resident's groundwater extraction decision-making in the simulated action arena. Additionally, *groundwater extraction* and *family size* are natural log-transformed to measure how responsive a variable is to a change in other variables. Finally, even though 204 responses were collected, only 189 fully complete observations were added to the model.

Total three models were created. In the model-1, variables related to social capital, individual preferences, and family size, except risk-taking, are included. The value of the adjusted-$R^2$, 0.303, shows that overall, the model has a moderate fit. The signs of all the variables were expected; *lacking trust*, *corruption*, and *family size* have positive signs, while *patience* and *egalitarianism* have negative signs. The coefficients, *lacking trust, egalitarianism, and family size, are significant at a 1 percent level. On the other hand, corruption* and *patience* are significant at a 5 percent level. *To further elaborate,* going from trust (lacking trust=0) to mistrust (lacking trust=1) leads to an 11.7 percent increase in the groundwater extraction, going from the perception that water agency is not corrupt (corruption=0) to corrupt (corruption=1) leads to a 10.6 percent rise in the groundwater extraction, and 1 percent increase in the number of family members leads to 0.403 percent rise in the groundwater draft. Similarly, going from impatience (patience=0) to patience (patience=1) leads to a 9.9 percent decrease in groundwater abstraction and going from the people saying they believe that everyone in their community should not have equal access to water services (egalitarianism=0) to equal access (egalitarianism=1) leads to a 45 percent decrease in groundwater draft.

In model-2, all the variables regarding social capital and individual preferences are included. The control variable family size was not a part of this model. The value of the adjusted-$R^2$, 0.085, shows that overall, the model has a poor fit. The signs of all the variables were expected; *lacking trust*, *corruption*, and *risk-taking* have positive signs, while *patience* and *egalitarianism* have negative signs. The coefficients, *lacking trust* and *patience, are not significant in this model. The variable, corruption, is significant at a*

*1 percent level, while risk-taking and egalitarianism* are significant at a 5 percent level. *In addition,* going from the perception that water agency is not corrupt (corruption=0) to corrupt (corruption=1) leads to a 13.2 percent rise in the groundwater extraction, going from an unwillingness to take risks (risk taking=0) to willingness (risk taking=1) leads to a 24.2 percent increase in groundwater abstraction, and going from the people saying they believe that everyone in their community should not have equal access to water services (egalitarianism=0) to equal access (egalitarianism=1) leads to a 41.5 percent decrease in groundwater draft.

In model-3, all the variables related to social capital, individual preferences, and family size were included. The value of the adjusted-$R^2$, 0.303, shows that overall, the model has a moderate fit. The signs of all the coefficients were expected; *lacking trust*, *corruption*, *risk-taking*, and *family size* have positive signs, while *patience* and *egalitarianism* have negative signs. The coefficients, *lacking trust, corruption, and patience, are significant at a 5 percent level. On the other hand, egalitarianism* and *family size* are significant at a 1 percent level. *To further illustrate,* going from trust (lacking trust=0) to mistrust (lacking trust=1) leads to an 11.3 percent increase in the groundwater extraction, going from the perception that water agency is not corrupt (corruption=0) to corrupt (corruption=1) leads to a 10.6 percent rise in the groundwater draft, and 1 percent increase in the number of family members leads to a 0.394 percent rise in the groundwater abstraction. Moreover, going from impatience (patience=0) to patience (patience=1) leads to a 9.9 percent decrease in groundwater extraction, and going from the people saying they believe that everyone in their community should not have equal access to the water services (egalitarianism=0) to equal access (egalitarianism=1) leads to 45.5 percent decrease in groundwater draft.

*Table 3.3: OLS Regression Results, natural log groundwater extraction is a dependent variable*

| Variables | Model-1 | Model-2 | Model-3 |
|---|---|---|---|
| ***N*** | 189 | 189 | 189 |
| ***F-Value*** | 17.35*** | 4.52*** | 14.63*** |
| ***Adj $R^2$*** | 0.303 | 0.085 | 0.303 |
| Lacking Trust | 0.117*** (0.043) | 0.078 (0.050) | 0.113** (0.044) |
| Corruption | 0.106** (0.044) | 0.132*** (0.020) | 0.106** (0.044) |
| Patience | -0.099** (0.042) | -0.075 (0.048) | -0.099** (0.042) |
| Risk-Taking | | 0.242** (0.113) | 0.100 (0.100) |
| Egalitarianism | -0.450*** (0.159) | -0.415** (0.183) | -0.455***(0.159) |
| ln(Family Size) | 0.403*** (0.507) | | 0.394*** (0.052) |
| Constant | 1.514*** (0.185) | 2.205*** (0.188) | 1.535*** (0.186) |

Notes*:* *p≤0.1; **p≤0.05; ***p≤0.01*; standard errors in parenthesis; Adj =adjusted*

## 3.8 Discussion

I have made two hypotheses in this paper: first, groundwater users in Faisalabad will not cooperate to regulate their groundwater extraction; second, social capital, patience, risk-taking behavior, and egalitarianism impact groundwater users' cooperation level, and, in turn, affect the intensity of groundwater extraction. The results of the CPR game reject the first hypothesis since players moderately cooperated with other members of their group in the simulated CPR dilemma. The mean value of the groundwater extracted in the game was 7.23+.166 out of 10 gallons, implying that some people cooperate and reduce their groundwater draft. On the other hand, regression analysis (Table 3.3) supports the second hypothesis, as *social capital* (trust and corruption), *patience, family size*, and *egalitarianism* (except *risk-taking*) are statistically significant predictors of groundwater extraction. These results align with the conclusions drawn by previous studies (see, e.g., Gehrig et al., 2019; Goldbach, 2017; Koop et al., 2021).

The predictions based on the regression results of model-3 are presented in Figure 3.2. The scale measuring the level of groundwater extraction is laid out along the Y-axis, and regression coefficients are shown along the X-axis. The variables 'OE' depicts observed mean groundwater extraction, and 'PE' is the predicted mean groundwater extraction in the game. The results according to the graph show that predicted groundwater extraction in the CPR experiment is slightly less than the observed overall groundwater extraction during the game. Moving on, looking at the mean prediction scores of the independent variables, where 'T' is equal to the presence of trust and 'NT' represents the lack of trust; 'C' shows the presence of the perception that corruption exists in the water agency and 'NC' water agency is not corrupt; 'R' illustrates the scenario when the respondent is willing to take risks and 'NR' when they are risk aversion; 'P' depicts the high level of patience in the respondents and 'NP' the impatient behavior; 'E' represents the presence of egalitarianism among the players and 'NE' the absence of egalitarianism. Here again, the values confirm the regression results that high trust, less corruption, risk-aversion, patient behavior, and egalitarianism lead to lower groundwater extraction.

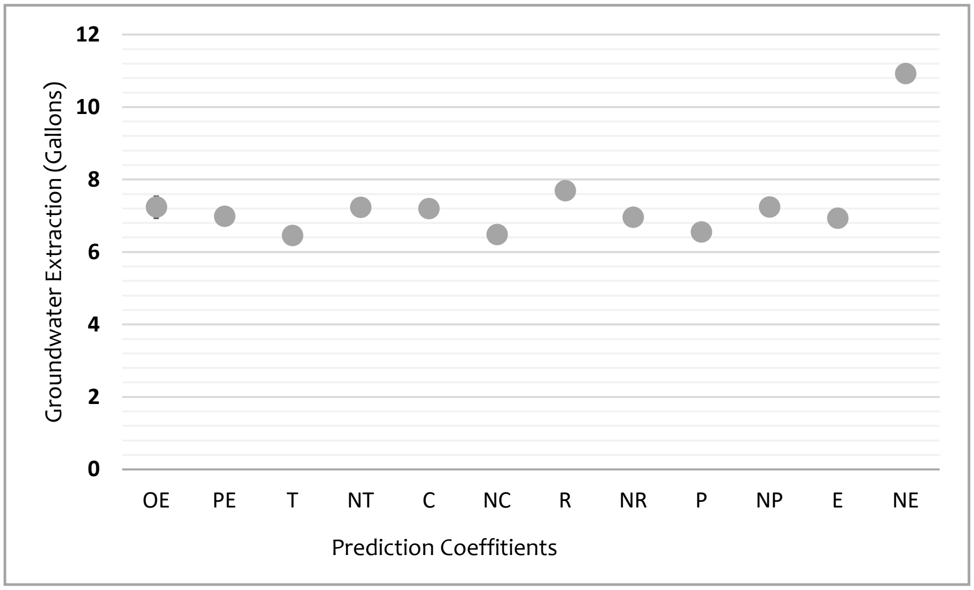


Figure 3.2: Predicted means of the dependent and independent variables of the regression model

All the variables used in the regression models except for the dependent variable, groundwater extraction, and independent variables, *family size*, and *egalitarianism* are measured on a Likert scale. To see how robust the regression analysis results are, I ran the same three models presented in Table 3.3 with the true scale of the coefficients in which the variables are measured initially. The results validate the findings of model-1, model-2, and model-3. Similarly, the distribution of the groundwater extraction (see Figure 3.1) shows that people overwhelmingly select either 5 gallons or 10 gallons. Maybe people thought if they extract 5 gallons, then it is cooperation and more than that, it is equal to defection. Hence, I generated a new dependent variable, in which extraction 5 gallons and less is coded as '0' and extraction more than 5 gallons are coded as '1'. Moreover, the continuous variable *family size* is mean-centered, so the regression coefficient can be interpreted as the deviation from the average family size rather than presenting a weird explanation for the value zero (0). Thenceforth, I ran another (logit) model using updated dependent variable (score 0 & 1), mean-centered *family size*, and other variables in their true Likert scale. The results of the logit model are the same as OLS regression except for the variable trust, which is not significant anymore. Hence, model-3 is the best model overall compared to the logit model.

A deeper look at the results of the experiment reveals that 36.8 percent of the respondents extracted 5 gallons or less of groundwater. In other words, they have demonstrated a moderate to high level of cooperation with their fellow group members. In contrast, the high level of extraction (>5 to 10 gallons) by 63.2 percent of the respondents must be seen in the light of the fact that one-shot games consist of only one round and communication among the players was not allowed. Other research has shown that when people are allowed to communicate in a multi-round game, cooperation among them rises (Balliet, 2010; van Soest, 2013). The impact of communication is especially relevant for conditional cooperators who need more information to make their decisions (Janssen et al., 2014). As per the experiment conducted by Fischbacher et al. (2001), many (50 percent) people are actually conditional cooperators. Hence, bridging social capital and social trust, in general, can help people communicate beyond the borders of biraderies, income, or religious affiliation to improve cooperation on matters such as groundwater protection.

### 3.9 Policy Recommendations

The primary policy recommendations for the success of informal community-led groundwater governance in Faisalabad are:

*Big Bang*

Improvement in the water agency's quality of governance is the critical first step to ensure that community-led initiatives are welcomed and allowed to function along with the formal groundwater governance apparatus, especially in big urban areas where millions of people live in close proximity. Moreover, the water agency is the state's de jure most powerful administrative arm in matters concerning water supply and groundwater in Faisalabad. However, 70 percent of the population in the city perceive that water agency is highly corrupt. Corrupt organizations are unpredictable and may do more harm to self-governing efforts than help. However, it is difficult to deal with corruption directly or incrementally. It is particularly true when corruption is endemic and cannot be corrected with a political push or a technical fix because these measures are not strong enough to convince a substantial number of actors to move away from corrupt practices (Diamond, 2007). Rothstein (2011), based on historical evidence, presented an indirect Big Bang approach as a viable alternative to tackle corruption. It calls for a quick, radical change in institutions to resolve quality of government issues. Therefore, following the Big Bang approach, I propose jettisoning the existing municipal water agency and supplanting it with a new water governance institution. This action might seem drastic, but it has been successfully tried in several places globally. For example, the municipal water supply system of Phnom Penh, Cambodia, a country where corruption was rampant, used the Big Bang approach to improve its water supply service (Araral, 2008). The National Highways & Motorways Police (NH&MP) in Pakistan, which was created to replace corrupt, incompetent, and occasionally violent highway police forces (Abbas, 2011), is an example of the Big Bang approach. According to public surveys, today, the NH&MP is considered the most trustworthy and upright among all Pakistan's civilian law enforcement agencies (Arain & Arain, 2016).

The regression analysis points out that an increase in the perception that corruption exists in the water agency leads to higher groundwater extraction. The Big Bang approach, when successfully applied, can create corruption-free impartial governance that helps institutional and social trust among the members of a society (Rothstein, 2005; Rothstein & Teorell, 2008). Again, according to the regression results, higher trust means less groundwater draft and more cooperation. Furthermore, the corruption-free impartial government would also ensure that all of its rules, including those that allow people to self-organize, or rules that protect the rights of the appropriators to devise their own institutions, are applied fairly.

*State-Reinforced Self-Governance*

For the long-term sustainable use of the groundwater, grassroots efforts to sustain and protect the aquifer are necessary. Community-led interventions are crucial because it is impossible for the government to monitor the discharge from hundreds of thousands of groundwater extraction pumps. In addition, due to the shared nature of the aquifer, it is difficult to stop anyone from accessing and pumping it. These characteristics of the CPR allow people to consume it and get away without contributing anything towards its replenishment. The state cannot coerce people and kick-start self-governance at the community level. Self-organization must be voluntary to produce enduring institutions, which are accepted and followed by all the consumers. The 'state-reinforced self-governance (SRSG)' is an innovative common pool resource management policy used to manage irrigation commons in Japan. According to this institutional arrangement, the government can work with common pool resource users to reinforce their self-organizing initiatives to avert the tragedy of the commons and yet remain strategic, cooperative, and non-participatory. It lets the CPR institutions flourish voluntarily at the grassroots (Sarker, 2013).

On the other hand, top-down initiatives crowd out local norms, such as social trust, because external incentives compromise individual intrinsic motivation to genuinely engage with other people, and thus over time, people may act less cooperatively (Bowles, 2008). Notwithstanding, in a community-led groundwater governance repeated interactions among the resource users will increase trust, cooperation, and compliance within the group (Rothstein, 2005). That’s the reason, SRSG dictates that state using financial, legal, political, and technological means creates a favorable environment for the people where self-governance flourishes (Sarker, 2013). In Faisalabad, biraderies which are negatively impacting piped water supply system and freshwater aquifer at the municipal level can be used to make a positive impact on the water resources as well. Biraderies are the bases of informal governance units, that have weakened the water agency’s enforcement capacity. The government can employ these informal trust networks to provide updated information regarding the groundwater level and the rate of consumption including the consequences of increasing groundwater withdrawal to the biraderi heads. They can disseminate this information among all the members of the biraderi. In addition, state can remove the legal grey area, are informal organizations are allowed to work independent of the state or not by enacting a new law or amending the existing “Water

Supply Faisalabad Regulations-2015". Finally, the state can also provide cheap rainwater harvesting technology to the people and train them how to use it, again using the biraderi based trust-networks. Thus, when the SRSG is applied together with the Big Bang, a robust governance framework emerges which can improve the water agency's quality of governance and in turn, create a suitable environment for the self-governance of the groundwater to deal with the CPR dilemma.

### 3.10 Conclusions

In this study, I played a common pool resource game with the residents of Faisalabad to explore their willingness to cooperate in the CPR dilemma. The empirical analysis showed that people moderately cooperate as they extracted 7.23±.166 out of 10 gallons allocated to them in the game. Moreover, lack of trust, corruption in the water agency, impatience, and reduction in egalitarianism negatively impact the cooperation level and, in turn, increase the rate of groundwater extraction. However, this study is not without limitations; for instance, one-shot artefactual field experiments are not dynamic, so they are not a good representation of human cognition in games (Brozyna, 2019). The experimental games are played in particular socio-economic and institutional contexts; hence one must be diligent before generalizing the results to other locations. A dynamic framed field experiment must be employed to further investigate self-governance and cooperation issues related to groundwater management in Faisalabad. The framed field experiments usually consist of multiple rounds; they provide opportunities to introduce different interventions, such as allowing subjects to communicate with each other, changing the group size, or instituting sanctions to gather more realistic data and corroborate the conclusions of this study.

# CHAPTER 4: CO-PRODUCTION AND IMPARTIALITY IN THE URBAN PIPED WATER SUPPLY GOVERNANCE

## 4.1 Introduction

Today, 58 percent of the world's population have piped water connections in their dwellings (WHO/UNICEF, 2015). In the Global South, 42 percent of urban households and 63 percent in South Asian cities have direct access to piped water networks (Beard & Mitlin, 2021). However, access to the piped water connections does not always mean that households actually get water. For instance, in Karachi, Pakistan, 28 percent of the households have piped water connections, but they receive water for only three days a week, two hours a day (Mitlin et al., 2019). To fulfill their unmet water demand, urban dwellers seek alternatives; usually, they settle for groundwater (Foster et al., 2010) and, to a lesser extent, tanker water (Mitlin et al., 2019). The seminal report published by the United Nations in 2003, *'Water for People, Water for Life'* argued that the water crises and other related uncertainties that the world is facing today are actually crises of governance (WWAP, 2003). The key challenges, such as high rate of corruption, weak administrative capacity, lack of finance, and absent or inadequate infrastructure, afflicting the water supply systems in the developing cities are all governance problems (Bakker et al., 2008; Plummer, 2008; WWAP, 2012). It is often difficult to tackle these problems directly with technocratic solutions, like building more infrastructure or seeking external funds for the continuous operations and management of the water supply systems (Kenny, 2004). These measures offer only temporary respite because the water governance institutions in developing countries usually struggle to exploit local resources or implement stipulated laws and policies; and therefore, they regurgitate the same problems after a short while (Acemoglu & Robinson, 2012; B. Rothstein, 2011). The real and more robust solutions lie in reforming existing institutions or creating new ones, which is a governance issue or a collective problem (Ostrom, 1990). Institutions are the instrument through which the formation and execution of the governance[19] occur (Kooiman, 2003). Institutions refers to formal and informal rules, norms, and shared strategies (Ostrom, 2005). Hence, to ensure that majority of the residents in the urban Global South have access to the piped water connections and supply of an adequate amount of water, focus on institutions underlying various problems is critical.

It is pertinent to note that, water is a common pool resource if it is extracted from the aquifer or accessed through the piped water supply system. Unlike water, the water supply infrastructure is a public good as it is: a) non-rival: the use of pipelines by one person does not reduce the availability of others, b) non-exclusionary: as utilities are legally bound to serve everyone (Flint, 2011). The ownership of the infrastructure can be open access if not managed, but usually, it is owned by the public, private entities, or may be held in common by the community (Bakker, 2007). Another important factor responsible for devising and enforcing operational rules to optimize the productivity of the resource and efficacy of the infrastructure, is the governance (Jiménez et al., 2020). Typically, in developing countries, government authorities provide piped water to residents. The

[19] The term governance can be defined as "the sum total of the institutions and processes by which society orders and conducts its collective or common affairs (Institute of Governance Studies, 2009, p.1), which takes place both inside and outside of formal institutions at multiple levels and scales (Ostrom, 2005, p.215)".

infrastructure is publicly-owned and managed by state officials, and it operates in a strict top-down bureaucratic manner. In addition, there are few examples of private companies (Kohl, 2004) and community-based water cooperatives providing water to the public (Zaidi, 2016). Overall, these traditional governance paradigms have failed to provide goods and services to urban residents (e.g., Ashir, 2019; Bakker, 2008; Kjellén, 2000).

For the last few decades, the focus on two governance approaches has been steadily building, 1) Co-Production, according to which consumers of goods and services can play an active role in producing and delivering them (Ostrom, 1996). The public participation in the production activities is an effective way to incorporate community values in decision-making, reduce conflict, and improve the accountability of the public officials (Bovaird, 2007). 2) Quality of Government (QoG) as Impartiality seeks to apply rules indicating that public officials must treat everyone equally. Impartial governance reduces corruption, improves bureaucratic quality, and generates social capital among participants and the general public (Rothstein 2011). These governance mechanisms have been also gaining popularity in developing cities (e.g., Holmberg & Rothstein, 2011; Moretto et al., 2018) and, even when applied separately, they can improve governance. Although, for optimal results, impartiality and co-production must be employed together (see section 4.2.2 for details).

To further explore the institutional dynamics of urban piped water supply systems in the Global South context and discuss the innovative water governance models, I am using Faisalabad, Pakistan, as a case study. It is located in the central region of the Punjab province of Pakistan (Javed & Qureshi, 2019). It is the third biggest city in the nation, with a population of about 3.2 million. The total number of households is 506,870, and the average family size is 6.45 people (Pakistan Bureau of Statistics, 2017). Only 140,000, or 26 percent of households in the city, have piped water connections (JICA, 2019b, p.B5-18). The infrastructure network covers only 60 percent of the urban area (WASA-F, 2015). Securing a water connection or establishing access to the network does not mean that households will have water access 24-hours a day. The official records show that the water agency supplies water intermittently for only four hours a day (Respondent-W2, 2020). Approximately 72.6 percent of the households have installed private in-situ motorized pumps on their premises to extract groundwater and compensate for the lack of municipal water (JICA, 2019b, p.B5-13). Thus, improvement in the water agency's quality of service is not only beneficial for the residents but also crucial to relieve pressure off the aquifer.

Impartial governance and co-production are critical institutional arrangements to revamp piped water supply systems. Nonetheless, the question remains 'do the people in Faisalabad desire a governance approach that is comprised of impartiality and/or co-production?. To explore residents' choice for the piped water governance mode, including the influence of key factors such as corruption, social capital, and perception of water-related insecurities on their decision-making, a Discrete Choice Experiment (DCE) consisting of both ownership (municipal, private, and cooperative) and governance approaches (impartiality and co-production) was developed. The data was collected from 204 household heads, who were randomly selected from the case study area. Then, I used the conditional logit model to estimate the discrete choice model. The empirical analysis showed that across all the alternatives, respondents compared to the existing water governance mode (municipal ownership without impartiality and co-production) prefer a state-owned piped water supply system with both impartiality and elements of co-production. On the other hand, respondents are least likely to prefer privately-owned piped water supply systems absent of impartiality and co-production.

I have structured this paper in the following way: at the outset, I laid out different water governance models with detailed discussion on ownership and governance. Then I presented a comprehensive analysis on the piped water governance situation in Faisalabad. Further, I explained the process of the DCE preparation and data collection. Penultimately, I introduced the conditional logit model and the discussion of the regression results. Lastly, I put forth a couple of policy proposals and a brief conclusion with future research directions.

## 4.2 Theoretical Background

There are four types of goods: *public*, *private*, *club*, and *common pool* (McGinnis, 2011). When accessed through the piped water network, water is a common pool resource (rival and non-excludable). On the other hand, water supply infrastructure is a public good (non-rival and non-excludable) in which the water flows and is delivered to households[20]. Similar to the types of goods, property rights/ownership are also of four kinds: *private, common*, *public,* and *open-access* (McGinnis, 2011). Although water infrastructure is a public good, it is not a public property automatically. In practice, the infrastructure can be public, private, or commonly held by the users. When it comes to the governance of piped

[20] A good or service is a public good whose benefits are accrued to all agents whether or not they contribute to its provision, and the use by one agent does not reduce the benefits for other agents (van Soest, 2013).

water supply, ownership of the public good (i.e., piped water supply network and ancillary infrastructure) is more important as it is the conduit of the water. Whoever owns and manages the piped water infrastructure has a disproportionately larger impact on the decision-making about how operational and collective choice rules will be created and enforced. In contrast, the nature of the good, water being a CPR, possibly has a limited effect on the performance of the piped water service.

### 4.2.1 Ownership of the Water Supply System

The distinctive features of the municipal/public, private, and community-owned piped water supply systems are briefly discussed below:

*Public*

The state, as a guardian of the public interest, provides piped water in most of the cities of the world, especially in the Global South (Beard & Mitlin, 2021; Kopaskie, 2016; Van Doorn et al., 2020). The state normally takes this responsibility because building centralized networks of water pumping, filtration, storage, treatment, and delivery is a highly capital-intensive endeavor. The private sector and other lending organizations are typically unwilling to invest huge sums of money for a long-lived highly durable infrastructure that does not yield substantial profits (Hanemann, 2006).

*Community/Cooperative*

In some non-service urban and peri-urban areas, residents instead of waiting on the state or the private sector to provide piped water, build their own infrastructure (Arvonen et al., 2017). The most practiced and known form of a commonly owned water supply system is the water cooperative (Juuti & Katko, 2005). In cooperatives, people voluntarily get together to meet their "common economic, social and cultural needs through a jointly owned and democratically controlled enterprise" (MacPherson, 1995, p.3). There are only a handful of community-led schemes that, at a small scale, have been able to provide cheap and clean water to the people, for instance, in Orangi Town, Karachi (Zaidi, 2016), and small urban communities in northwest Cameroon (Tantoh et al., 2019).

*Private*

The rapid urban growth and lack of funds led the local governments in many cities of the developing world, to experiment with private water utilities, starting in the early 1990s (Araral, 2008; Franceys, 2003). The proponents of privately owned piped water systems argued that a  private utility functions better than a state-controlled utility in a competitive market (Bishop & Kay, 1989). In addition, a private company can invest in large infrastructure projects, easily extend the coverage of the water supply network, augment staff productivity, and lower the cost of water production (De Albuquerque and Winkler, 2010). However, private companies struggled to achieve profitability in the developing cities and consequently left those places over time (Beard & Mitlin, 2021). Thus, today, the majority of the private piped water systems are present in developed countries like Manchester, UK, and Seville, Spain (Dore et al., 2004).

### 4.2.2 Governance

Although there are exceptions, publicly owned water utilities are often operated by the state itself. The private water supply systems are managed by one or more private companies, while cooperatives are run by local communities. In state-led water supply systems, public officials set goals, deliver water, and enforce agreed-upon rules (Newig and Fritsch, 2009, p.200). They might use technocratic solutions, such as building more infrastructure, to increase the amount of water produced or opt for other management approaches to govern the water supply system (Bakker, 2010). In terms of performance, state-owned and governed piped water systems in developing countries have largely failed to provide quality water service to the public (e.g., Biswas et al., 2017; Shirley & Ménard, 2002). The key factors that have negatively affected the public water utilities are low tariffs, overstaffing, rent-seeking, bribery, lack of or unequal enforcement of laws, and extremely low tariffs of piped water (Bakker, 2010). In contrast, market mechanisms are a regulatory framework of privately owned and operated systems. The proponents of the private sector involvement expected greater efficiency, cost recovery, and better customer service at a higher price than the public systems (Cross & Morel, 2005). However, just like the public, privatization of water supply systems in developing countries has received only the modicum of success (Kjellén, 2006). The failure is due to the fact that private companies focus more on optimizing corporate profitability and are often reluctant to invest in much-needed infrastructure (Swyngedouw et al., 2002). Similarly, privatization was unsuccessful in Jakarta, Indonesia, and Cochabamba, Bolivia, because of widespread corruption and disregard for socio-political realities (Kohl, 2004; Bakker, 2010). The failure of state and market-driven models has triggered the emergence of community-based water supply systems, i.e., water cooperatives (McDonald & Ruiters, 2012, p. 201). The cooperatives are expected to be more responsive to people's needs and serve the community's interests (Day, 2009; Bakker, 2010). However, the evidence shows that water cooperatives in developing countries often fail due to high tariffs and poor quality of the water supply. Additionally, poor financial and operational management are other causal factors underlying the ineffective water cooperatives (Bakker, 2008).

The performance reviews of the water supply utilities in Asia, the United States, and Europe indicate that ownership, though important, does not predict the efficiency of water supply systems (e.g., Bakker, 2008; Bayliss, 2003; Braadbaart, 2002; Prasad, 2006; Renzetti & Dupont, 2004). Institutions related to the governance have a greater impact on the utility's quality of service (Martin, 2004). Notwithstanding, in developing countries, regulatory institutions exist mainly on paper, rules and policies are often ignored, subverted, or applied on an ad hoc basis; a situation that is conducive to sow confusion and mistrust in the governing authorities among the general public (Acemoglu & Robinson, 2012; Kessides, 2005, p.86). The above discussion indicates that when governance apparatus fails to follow the agreed-upon formal or informal operational rules, when it is rife with corruption and administrative inefficiencies, ownership does not  to matter much. To investigate the significance of institutions in the governance processes, I have discussed the concepts of Quality of Government as Impartiality and Co-production in the next following paragraphs.

*Impartiality*

The idea of Quality of Government (QoG) as Impartiality views *impartiality* as the most important and all-encompassing principle for the quality of governance[21]. It implies that public officials while performing their duties, "shall not take into consideration anything about a citizen/case which is not beforehand stipulated in the policy or the law" (Rothstein & Teorell, 2008, p.170). Geoffrey Cupit frames it like this, "to act impartially is to be unmoved by certain sorts of considerations–such as special relationships and

[21] The government does not strictly mean 'state' but governance by any entity regardless of the ownership type.

personal preferences" (Cupit, 2000, p.16). Thus, when public officials apply monitoring, conflict resolution, collective decision-making, or other stipulated laws equally on everyone, impartiality increases, and so does the quality of government. However, it must be kept in mind that treating everyone equally does not mean everybody must get the same service or good because "only people in need of a kidney transplant should get one." In other words, people will be treated based on the severity and merit of their needs (Rothstein 2011, p.16).

Corruption, such as free-riding, deception, and other forms of untrustworthy behavior, is a threat to the effectiveness and fairness of institutions (Rothstein & Varraich, 2017). Transparency International's 'Global Corruption Report-2008' contended that corruption is the most prevalent governance problem faced by the water sectors of the developing countries today. According to Oscar Kurer (2005, p.230), corruption "involves a holder of public office violating the impartiality principle to achieve [a] private gain." In other words, corruption occurs when public officials are not impartial in exercising their duties, which ultimately causes an institution to falter (Rothstein, 2011). Corruption pervades all aspects of water management (Jenkins, 2017), but remains the least confronted issue (Davis, 2004). Moreover, corruption is not limited to rent-seeking, bribery, or state capture. Other examples of corruption include tweaking water provision and pricing in favor of influential supporters, diverting money from public budgets into their own pockets (Transparency International, 2008), or applying laws arbitrarily or unfairly (UN-Water, 2009).

Consequently, when public officials exercising their authority are partial or corrupt, people will rationally stop trusting them. They will logically infer that most people in a society are also involved in corrupt practices to obtain essential services (Rothstein 2005, p.121-122). It is a situation where rationally minded people, even if they want to play fair, cannot stop participating in corrupt practices because everyone else is expected to be playing dirty (Schiemann, 2000). The lack of trust eventually leads people into a social trap/social dilemma (Rothstein, 2005), in which crude individual rationality might very well turn into a collective irrationality, such as free-riding public goods (Lichbach, 1997). In the water sector, the non-payment of bills is akin to free-riding, as connection holders have access to the public good (water infrastructure) without contributing to its provision (Jensena & Chindarkarb, 2017). As a result, most water utilities in the Global South cities are in a financially unstable condition. The lack of funds further degrades the quality of government because it diminishes their ability to provide or resume providing efficient water supply service to the people (Transparency International, 2008).

Few studies have analyzed the idea of Quality of Government in the water sector. For example, Povitkina & Bolkvadze (2019) explored the relative importance of impartial institutions and democracy in the provision of water service. The authors found that more democracy benefits only when the quality of government is high. Democracy alone, in the absence of quality institutions, can be more harmful because political arenas cannot make long-term goals, commitments, and plans. They are very good at setting the agenda of the public good and bringing it onto the political platforms, but it is the administrative institutions that shape and implement policies. Similarly, Parag & Roberts (2009) investigated the link between public water supply institutions and rise in the bottled water use in the world using the idea of Quality of Government. They found that increasing flight from the tap water is partly due to the growing distrust of the state to protect the health of its citizens. Additionally, the bottled water firms contribute to creating this distrust and weakening of public policy responses.

Moreover, impartiality principles can help water utilities trapped in social dilemmas to reform themselves and get out of the social trap. For instance, Phnom Penh, Cambodia, is well endowed with freshwater, but until the early 1990s, the local water supply system known as the Phnom Penh Water Supply Authority (PPWSA) was in terrible condition. The coverage of the piped water supply network and bill collection rate was 50 percent. The staff was unmotivated, and 80 percent of them worked less than two hours a day (Biswas & Tortajada, 2010). Only 12 percent of connections had meters, and 72 percent of the water was either stolen or leaked into the ground. In addition, public officials were involved in all sorts of corruption (bribes, rent-seeking, state capture, and political particularism), thus eliminating public trust from the PPWSA. People were unwilling to pay bills, thus the water utility started looking for external funds (though not always successfully) to maintain the status quo (Araral, 2008). However, in a decade, the PPWSA managed to make a massive turnaround. It was able to reduce corruption using measures such as meritocratic recruitment policy, internal checks, and balances reinforced by the norms of integrity set by its top management and responsive customer service. Moreover, supportive actions by the political leaders had a significant psychological effect on the general public in the city. Politicians, rather than avoiding payments, started to pay their water bills publicly. This gesture enhanced the credibility of the PPWSA in the eyes of the public (Tortajada & Biswas, 2019). The water agency officials started to follow and enforce agreed-upon laws impartially, as a result, corruption and bureaucratic inefficiencies started to decrease. With time, uncertainty diminished, and trust between the consumers and the PPWSA increased. Today, nearly 100 percent of the connection holders pay their bills, and 92 percent of Phnom Penh's population has access to piped water (Craig & Kielburger, 2020).

### *Co-Production*

The idea and the term *co-production* originally came from Elinor Ostrom and her colleagues in the 1970s (Ostrom, 1996). This concept refers to an institutional arrangement where producers of goods (and services) and the consumers work together in the development and/or delivery of these goods. Individuals and groups who produce for exchange in society are regular producers, while individuals or groups of consumers who act outside of regular production roles and contribute to the production of a good are consumer producers. For instance, when consumers feel that their opportunity costs are low and wish to supply the service with their own input, they become consumer producers. On the other hand, consumers who think that their opportunity costs exceed the wages of the regular producers, prefer to have their services supplied by regular producers (Parks et al., 1981). The collaboration between the producers and consumers can take different forms: 1) co-planning, a process that involves strategically identifying and prioritizing much needed public services, 2) co-design, activities that incorporate inputs from users in operational decision-making, 3) co-delivery, a joint effort among state actors and users at the point of delivery of services, 4) co-assessment, processes of monitoring and evaluation (Nabatchi et al., 2017). Furthermore, co-production has the potential to make public services more transparent, accountable, and responsive to the needs of the clients (McMullin, 2019). It can cut production and delivery costs, and improve monitoring and sanctioning operations using communities as assets (Adams et al., 2019; Ostrom, 1996). McGinnis (1999, p.366) adds that when producers and citizens work together in diverse sets of open, nested arenas, productivity increases, and all forms of opportunistic behavior are more likely to exposed.

There are several examples of water utilities in the world that have successfully adopted co-production as a water governance strategy. For instance, in the Malawian cities of Lilongwe and Blantyre, community-based water user associations partnered with the city administration to improve the domestic water supply system. The collaboration stabilized tariffs, enhanced transparency in the operations, and ensured accountability of the officials (Adams & Zulu, 2015). In the same way, the government of Iran launched an integrated participatory crop management program (IPCM) in 2009 to conserve depleting resources of freshwater in the country. This program aims to bring together a plurality of the knowledge types, research capacities of local farming communities, scientific and bureaucratic institutions to facilitate the adoption of eco-friendly and economically sound adaptation strategies. The progress so far revealed that the application of co-produced knowledge has significantly increased water productivity and helped identify key opportunities for building resilience under water-scarce conditions (Zarei et al., 2020). Moreover, in Bandung, Indonesia, households, communities, and private actors collaborated to expand the water supply network to unserved areas and ensure equitable access. The findings suggest that institutionalized co-production arrangements led to an improved access to affordable water supply (Nastiti et al., 2017).

*Combining Impartiality and Co-Production*

The best possible governance framework emerges when co-production and impartiality are employed together. The institutional trust that impartial institutions generate is essential for consumers to collaborate with the producers. It is because impartial institutions are accessible, transparent, accountable, and most of all, less corrupt. Impartial governance mechanisms are also clear and enforced on everyone equally. Therefore, impartial institutions are also crucial to reap the benefits of co-production (e.g., better monitoring and sanctioning). There are numerous cases where co-production as a governance strategy failed to realize its goals (Adams & Zulu, 2015; Rusca et al., 2015). In almost all these examples' institutions producing the resource, or managing the consumer and producer relationships, were not impartial. For example, co-production rather than abolishing the existing power structures reproduced them (Steen et al., 2018). Thus, impartiality can also act as a critical check against the negative impacts of co-production. Furthermore, when the collaboration between stakeholders increases, communication among them helps develop horizontal relationships, and social trust (Putnam, 1993). The higher the level of trust among the partners, the bigger the possibility of all forms of opportunistic behavior, like corruption, of getting exposed (McGinnis, 1999, p.366), which will enhance the quality of government (or impartiality). Therefore, co-production and impartiality complement and reinforce each other. The combination of co-production and impartiality provides a robust and cohesive governance framework, an optimal way to get out of social dilemmas like non-payment of bills and corruption.

### 4.2.3 Situation in Faisalabad

The total domestic and non-domestic water demand in Faisalabad is 170 million gallons per day. In contrast, the designed capacity of the water agency is only 110 million gallons per day (Respondent-W1, 2021). In addition, the water agency is operating at 64 percent of its production capacity, further reducing the production of piped water from 110 million gallons per day to 70.4 million gallons per day (JICA, 2019a, p.A8-3). This reduction is mainly caused by the deteriorated water uptake capacity of the pumping stations at Chenab well field (43 percent reduction), Jhang Branch Canal (28 percent reduction), Rakh Branch Canal (88 percent reduction), and water treatment plants (56.5 percent reduction). The water agency is unable to maintain crumbling infrastructure and cuts in the hours of operations to avoid exorbitant electricity charges (JICA, 2019b, p.B3-7). Furthermore, the total amount of water produced by the water agency does not reach the consumers; 40 percent of it leaks through pipes or is stolen via illegal connections. Therefore, the actual amount of water in the water supply network is only 42 million gallons per day (or 25 percent of the demand), of which 37.8 million gallons are supplied to households and 4.2 percent to non-domestic users. Thus, the total water shortage is 128 million gallons per day (JICA, 2019b, p. A8-3). Moreover, there is no way to know how much water connection holders are consuming because water connections are not metered in the city (WASA-F, 2017).

In 2013 the water agency developed the *Citizen Liaison Cell (CLC)* under the guidance of the “Punjab Urban Water and Sanitation Policy-2007” and “Punjab Drinking Water Policy-2011”. The goal was to establish community-based organizations (CBOs) to amplify and include the voice of the citizens in the service delivery and enforcement activities of the water agency. In addition, it aims to employ the ‘component sharing model’ as a development strategy, in which potential water users financially contribute to building new infrastructure to expand the water supply infrastructure to the un-served areas (WASA-F, 2020). In the last seven years, only four CBOs have been established. The first CBO was located in the Shahbaz Nagar neighborhood, where the government of Punjab, the water agency, and the local community worked together to build an independent water supply system using a component sharing model. The other three CBOs work to recover unpaid utility bills (Respondent-W1, 2021). Overall, the CLC achieved a modicum of success, as the CBO in Shahbaz Nagar achieved its objectives due to the World Bank funding (Respondent-D, 2021), while the other CBOs struggle to recover unpaid bills (JICA, 2019a, p. A7-19).

There are several reasons as to why the CLC has not been able to effectively perform in Faisalabad. For instance, the comprehensive review of the Citizen Community Boards (CCBs) established between 2001-2008 under the military rule via the 'Local Government Ordinance 2001' shows that most citizens are economically and politically dependent on powerful individuals (e.g., biraderi heads, politicians, etc.). They could not imagine taking any public initiative on their own. In addition, many poor and middle-income residents stated that they do not have additional time and resources to do the 'social work'. They also believe that community groups led by a pooror less influential person would not be successful. No one would join them since the leaders of these groups do not have connections with the powerful and wealthy. Thus, in practice, all the CCBs end up in the hands of powerful individuals who use these organizations to line their pockets with government funds (Gazdar et al., 2013). In addition, academics and donor agencies at the local level discourage community involvement in the municipal water provision and groundwater conservation activities stating, that it would rather harm marginalized communities than help them (Respondent-W1, 2021; Respondent-A, 2020).

Furthermore, another big hurdle in the development of collaborative relationships between local communities and public officials is a corrupt water governance. The water agency has been captured by the informal governance authority, which consists of biradari[22] based trust-networks, politicians, and bureaucrats (Anwar, 2019). Thus, formal rules that are supposed to guide the water agency's operations are largely ignored, selectively applied, or followed when expedient. According to Malik (2017), this connection between informal trust networks and state officials is an example of type-III, or unauthorized, collective choice units that "provide rules and determine who gets what when and how, at times directly contradicting laws and formal rules" (Malik, 2017, p.65-66). . These governance units are an example of a patronage system, in which patrons (e.g., politicians and bureaucrats) give clients (e.g., members of the biraderi) goods and services in return for votes, employment, bribes, promotions, or unspecified support (Malik, 2017). A patronage system is inherently corrupt because it does not give access to goods and services based on need or merit but instead on connection with the powerful (Rothstein & Varraich, 2017). In addition, politicians are known to protect neighborhoods where illegal connections are commonplace and areas where consumers do not pay their utility bills (JICA, 2019b; Respondent-D, 2021). The partiality of officials in their decision-making and the decline in the quality of water service caused by the lack of funds leave people unsatisfied with the organization (the water agency). According to Rothstein (2005), in

[22] The term *biraderi* refers to caste, clan, religion, tribe, or sect.

such situations, institutional trust, and in turn, social trust, falls in society. Individuals and groups (e.g., biradaries) stop cooperating and start pursuing their self-interests. It is a perfect environment for people to begin free-riding the good/service and stimulate a public goods dilemma.

## 4.3 Data and Methodology

The existing piped water supply system in Faisalabad is owned and operated by the municipal government. There are no private piped water supply systems, and only one community-owned water system exists in the Shahbaz Nagar neighborhood. The water agency has created CBOs to involve local communities in crucial operations, such as the recovery of unpaid bills, and infrastructure expansion (co-production). On the governance front, the water agency has been captured by the powerful informal governance units that influence the day-to-day activities of the water agency in favor of well-connected and wealthy; therefore, it is not impartial. Given this information, I have investigated the residents' water governance mode choice, which consists of the ownership and the governance approaches for the piped water supply system in Faisalabad. In addition, I have explored the impact of social capital, public perception of corruption in the water agency, and the perception concerning piped water insecurities (i.e., scarcity and pollution) on their governance mode choice.

### 4.3.1 Experimental Design

To elicit residents' preferences regarding the ownership and governance of the hypothetical piped water supply system, I used the *Discrete Choice Experiment (DCE).* It is a popular technique, particularly useful when the proposed good or service is multi-dimensional, and the trade-offs between the attributes that make up the good are of particular interest (Hosking et al., 2014). In this study, only two attributes of governance are part of the DCE: co-production and impartiality. In the survey protocol, I have labeled them as *community involvement* and *non-preferential treatment*, respectively, so people can understand these concepts more clearly. Each attribute has two distinguishable levels: ‘yes’ and ‘no’. The full factorial experiment design technique[23] generates four choice tasks (or alternatives), allowing for the estimation of main effects and interactions. Interviewees were presented with a total of five alternatives, four are the choice tasks, and the fifth option is ‘none’ for those who want to opt out of the DCE (see Table 4.1). In addition, to elicit residents’ choice regarding the ownership of piped water supply system, participants were asked to choose one of the following four options: municipal/state, membership organization (cooperative), a private company, and none.

Table 4.1: Piped Water Supply mode choice Scenarios

| **Attributes** | **Alternative-1** | **Alternative-2** | **Alternative-3** | **Alternative-4** | **Alternative-5** |
|---|---|---|---|---|---|
| Non-Preferential Treatment | Yes | Yes | No | No | None ☐ |
| Community Involvement | Yes | No | Yes | No | |
| *Which alternative do you prefer the most?* | ☐ | ☐ | ☐ | ☐ | |
| *Which alternative do you prefer the least?* | ☐ | ☐ | ☐ | ☐ | |

Further, to collect information about social capital/social trust in the society, I asked respondents the following three questions: 1) “Generally speaking, would you say that most

[23]In statistics, a full factorial experiment design consists of two or more factors, each with discrete possible levels, and whose experimental units or choice tasks take on all possible combinations of these levels across all the factors (Oimoen, 2019).

people can be trusted, or that you can't be too careful in dealing with people?” 2) “Do you think most people would try to take advantage of you if they got the chance, or would they try to be fair?” 3) “Generally speaking, would you say that most of the time people try to be helpful, or that they are mostly just looking out for themselves?". These three questions have been used by the *General Social Survey* in the United States and the *World Values Survey* as an indicator of cognitive social trust at the individual level. Similarly, to measure public perception regarding the corruption in the water agency, I asked the following questions developed and used by Rothstein (2005): 1) “Do you think corruption exists in the water agency?”, 2) “Do you think water users bribe WASA officials?”, 3) “Do WASA officials ask for bribes?”. Finally, to gauge public perception about the piped water insecurities, the following four questions were asked: 1) “How do you rate your experience with piped water scarcity compared to an average person in your community/city?”, 2) “If you think about the next 5 years, how likely is it that you will experience reduction in the piped water availability?”, 3) “How do you rate your experience with polluted piped water compared to an average person in your community/city?”, 4) “If you think about the next 5 years, how likely is it that you will experience polluted piped water?”. The respondents answered all the questions on a stated three-point Likert scale (please see the questionnaire attached as Appendix-V for more details).

### 4.3.2 Sampling Approach

To determine the sample size, term that refers to a group of subjects which are selected from the general population and are considered a representative of the population for a particular study, I used the equation provided by (Dilman et al., 2014, p.78). Considering the available human and financial resources, at the 90 percent confidence interval and ± 6 percent sampling error at least 188 individuals must be surveyed to maintain the precision of the statistical estimates and the power of the study to draw conclusions (IWH, 2008). Furthermore, I chose to interview household heads who are responsible for bill payments and decision-making related to the water usage in their homes. To collect a representative dataset, I contacted households from diverse locations and income groups in the metropolis. First, using a proportionate sampling approach, an estimated sample (i.e., 188) was divided into two groups. This action ensures that an adequate number of houses are selected from the service areas, which covers 60 percent of the city, and the areas without service, which cover 40 percent of the city (WASA-F, 2020). To identify service and non-service areas, I superimposed the municipal water agency's water supply network map on the google image of Faisalabad. This process helped me locate neighborhoods connected to the piped water network and those outside of it. So, I performed 124 surveys in the service and 80 surveys in the non-service areas, 16 surveys more than the 188 required. Next, I used a two-stage cluster sampling technique to further diversify the population reached for the interviews. First, I created 20 clusters, 13 in service and 7 in non-service areas (see Table 4.2). From each cluster 6-12 respondents were selected; the exact number was determined by the local response rate to the interview invitation. This recruitment strategy was used in the study, "Mortality before and after the 2003 invasion of Iraq: cluster sample survey" by Roberts et al. (2004). Second, the first respondent in each cluster was chosen randomly. Then, to select second and subsequent respondents, every sixth house from the last house that participated in the interview was invited to take part in the survey to capture the variations in the responses. To elucidate, after the first interview, the location of the first household acted as a starting point to select remaining households for interviews in each cluster. This recruitment technique is followed in the study “Views and Experiences of Puerto Ricans One Year After Hurricane Maria”, by DiJulio et al. (2018). To fully represent all income groups in the sample, clusters were formed in *poor, middle,* and *high-income* areas of the city.

Table 4.2: List of service and non-service areas surveyed

| **Service Areas** | **Non-Service Areas** |
|---|---|
| Awami Colony, Nasir Town, CM Colony, Essa Nagar, Muhammad Pura, New Green Town, Kaleem Shaheed Colony, Gobindpura, 7-Chak J.B., Christian Town, Gosia-Abad, Sarfaraz Colony and Dawood Nagar-A | Khayaban, Shirian-wala, Rabbani Colony, Shamsa-Abad, Dawood Nagar-B, Kuriwala, and Khalid Garden |

Furthermore, households were interviewed from February 2021 to July 2021. Due to the restrictions caused by the Covid-19 pandemic, I used online video conferencing software and an online survey hosting platform to digitally display questions on the respondent’s computer screen, making the interview experience smoother. All the questions in the survey are structured. It starts with questions about socio-demographic information, household water use, and household preference for the ownership of the piped water provider. Then, the DCE was presented followed by questions about corruption, social capital, and perception about the water-related insecurities. At the start of the choice experiment, the meaning of the terms, *‘community-involvement’* and *‘non-preferential treatment’* were explained with examples in local languages (Punjabi and Urdu).

### 4.4 Data

In total 204 responses were collected but 190 fully completed surveys were used for the statistical analysis. The statistical software, Stata (version 16), was used for the socio-demographic, descriptive, and regression analysis. A first glance at the socio-demographic data shows that there are marked differences in the official and observed values. According to the official data, 27.10 percent of the population is older, and 72.9 percent is younger than 45 years. But, in the sampled data, 53.44 percent and 46.56 percent of the population are older and younger than 45 years, respectively. The older population is over-, while the younger is under-represented in the data. Furthermore, 99.35 percent of the respondents were male as, culturally, only males assume the role of household heads. The average family size in the observed data is 6.75 persons which is slightly higher than the official 6.45 persons. The values of the three categories of education (primary, school, high school, and graduate school) are substantially different. The census data shows that 31.73 percent of the population have studied up to primary school, 5.91 percent high school, and only 1.07 percent have graduate degrees. In contrast, the observed data shows that 19.47 percent of the respondents have primary, 11.58 percent have high school, and 13.68 percent have graduate degrees. In terms of income, an extremely poor population is not represented in the sample. In addition, the poor are 42 percent of the actual population but only 19.47 percent of the respondents in the sample are poor. The rich who constitute around 7 percent of the population are over-represented in the sample, 21.58 percent.

Table 4.3: Official and observed socio-demographic information

| Variable | Official Values^ (%) | Observed Values (%) |
|---|---|---|
| **Age** | | |
| ≤1975 | 27.10 | 53.44 |
| >1975 | 72.90 | 46.56 |
| **Gender** | | |
| Male | 51 | 99.35 |
| Female | 49 | 0.65 |
| **Family Size** | 6.45 persons | 6.75 persons |
| **Education** | | |
| No Education | 19.16 | 18.42 |

| | | |
|---|---|---|
| Primary School | 31.73 | 19.47 |
| Secondary School | 38.59 | 33.16 |
| High School | 5.91 | 11.58 |
| Undergraduate | 3.23 | 3.68 |
| Graduate | 1.07 | 13.68 |
| **Income** | | |
| Extremely Poor | 9 | - |
| Poor | 42 | 19.47 |
| Middle | 31 | 43.16 |
| Upper Middle | 11 | 15.79 |
| Rich | 7 | 21.58 |

^ The source of this information is the Pakistan Bureau of Statistics (2017)

In the discrete choice experiment, respondents select an alternative they prefer the most and an alternative they prefer the least. The descriptive statistics of the ownership and governance factors (alternative-specific variables of both the most preferred and least preferred options) are laid out in Table 4.4. In the case of the most preferred option, 60.5 percent of the respondents chose *municipal*, 24.7 percent *private*, and 14.7 percent selected *cooperative* ownership for the piped water supply system. In the same way, 95.7 percent of the respondents want impartiality (or non-preferential treatment), and 60 percent want co-production (or community involvement) in the piped water governance. On the other hand, in the case of the least preferred option, 31 percent of the respondents selected *municipal*, 42.1 percent *private*, 26.8 percent *cooperative* ownership. In terms of governance, 2.6 percent of respondents prefer impartiality and 6.3 percent community involvement in piped water governance.

Table 4.4: Descriptive Statistics (Alternative-Specific Variables)

| **Variables** | | | **Most Preferred** | | | **Least Preferred** | | |
|---|---|---|---|---|---|---|---|---|
| **Label** | **Description** | **Value Range** | **Mean** | **95% CI** | **Std. Dev** | **Mean** | **95% CI** | **Std. Dev** |
| Municipal | Municipal Ownership | [0, 1] | 0 .605 | 0.535, 0.675 | 0.490 | 0.310 | 0.244, 0.376 | 0.464 |
| Private | Private Ownership | [0, 1] | 0.247 | 0.185, 0.309 | 0.433 | 0.421 | 0.350, 0.492 | 0.495 |
| Cooperative | Cooperative Ownership | [0, 1] | 0.147 | 0.096, 0.198 | 0.355 | 0.268 | 0.204, 0.332 | 0.444 |
| Impartiality | Impartial Governance | [0, 1] | 0.957 | 0.929, 0.986 | 0.201 | 0.026 | 0.003, 0.049 | 0.160 |
| Co-Production | Collaborative Governance | [0, 1] | 0.60 | 0.529, 0.670 | 0.491 | 0.063 | 0.028, 0.098 | 0.244 |

Furthermore, descriptive statistics of the case-specific variables (corruption, social capital, and piped water problems) are presented in Table 4.5. The three variables are related to *corruption*, the mean values of these factors show that 70 percent of the respondents believe that corruption exists in the water agency, 32.1 percent of the believe that other water users pay bribes to the public officials, and 41.6 percent said that water agency officials ask for bribes. Similarly, the three variables represent *social capital*. The mean values illustrate that only 13.2 percent of participants think that other people can be trusted, 21 percent believe that other people are fair, and 27 percent said that other people try to be helpful. Moreover, four variables denote water-related problems. According to the mean values, 44.2 percent and 75.7 percent of the respondents think that they experience higher risks related to the reduced piped water supply and polluted piped water supply than an average person in the community, respectively. In the same way, 22.6 percent and 46.3

percent of the survey participants believe that in the next five years, they have a higher risk of experiencing reduced piped water and polluted piped water.

Table 4.5: Descriptive Statistics (Case-Specific variables)

| Variable | Description | Value Range | Mean | 95% CI | Std. Dev |
|---|---|---|---|---|---|
| Corruption | Corruption in the water agency. | [0, 1] | 0.7 | 0.634, 0.765 | 0.459 |
| | Piped water users pay bribes. | [0, 1] | 0.321 | 0.254, 0.388 | 0.468 |
| | Public officials ask for bribes. | [0, 1] | 0.416 | 0.345, 0.486 | 0.493 |
| Social Capital | Most people can be trusted. | [0, 1] | 0.132 | 0.083, 0.180 | 0.338 |
| | Most people try to be fair. | [0, 1] | 0.210 | 0.152, 0.269 | 0.408 |
| | Most people try to be helpful. | [0, 1] | 0.273 | 0.209, 0.337 | 0.447 |
| Piped Water Problems | Experience of reduced piped water supply compared to an average person in the community. | [0, 1] | 0.442 | 0.370, 0.513 | 0.497 |
| | In the next 5 years, the likely risk of experiencing reduced piped water supply. | [0, 1] | 0.226 | 0.166, 0.286 | 0.419 |
| | Experience of polluted piped water supply compared to an average person in the community. | [0, 1] | 0.757 | 0.696, 0.819 | 0.429 |
| | In the next 5 years, the likely risk of experiencing polluted piped water supply. | [0, 1] | 0.463 | 0.392, 0.534 | 0.499 |

To further examine the water governance mode choice behavior and influence of factors such as corruption and social capital on the decision making, a Conditional Logit (CL) model was estimated. The CL regression is a popular econometric model developed by McFadden (1973) to interpret discrete choice data (Wang et al., 2020). The CL is an appropriate method to use when the choice among alternatives is modeled as a function of the attributes rather than the characteristics of the individual making a choice (Hoffman & Duncan, 1988). To build the CL model, I have updated the DCE with three ownership variables, municipal, private, and cooperative, in addition to the two governance factors, impartiality, and co-production, already present in it. According to the full factorial experimental design, there are 12 alternatives available to each individual.

The analysis of the alternative selection patterns of the respondents are presented in Table 4.6 and Table 4.7. The ownership of alternatives 1-4 is municipal and labeled in the conditional model as Alt-MIC, Alt-MIX, Alt-MXC, and Alt-MXX, respectively. Similarly, ownership of alternatives 5-8 is cooperative and labeled in the conditional model as, Alt-CIC, Alt-CIX, Alt-CXC, and Alt-CXX, respectively. Finally, the ownership of alternatives 9-12 is private and labeled in the conditional model as, Alt-PIC, Alt-PIX, Alt-PXC, and Alt-PXX, respectively. The alternative selection pattern of the most preferred option (Table 4.6) shows that respondents did not select alternatives 7, 8, 11, and 12. Moreover, people overwhelmingly prefer state-owned water supply system, to a lesser extent, privately owned, and least of all, the option of water cooperative. When it comes governance, people mainly select options that offer impartiality and co-production. The alternative selection pattern of the least preferred option (Table 4.7) shows that respondents did not select alternatives 1, 5, 6, and 10. They overwhelmingly dislike privately owned water supply system, to a lesser extent, municipal, and least of all, the option of water cooperative. In addition, respondents most dislike alternatives that do not offer either or both impartiality and co-production.

Table 4.6: Water Governance Alternatives Selection (Most-Preferred Option)

| Governance/ Ownership | Municipal | | | Cooperative | | | Private | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Alt** | **Freq** | **Label** | **Alt** | **Freq** | **Label** | **Alt** | **Freq** | **Label** |
| Impartiality and Co-Production | 1 | 63 | Alt-MIC | 5 | 20 | Alt-CIC | 9 | 28 | Alt-PIC |
| Impartiality | 2 | 44 | Alt-MIX | 6 | 8 | Alt-CIX | 10 | 19 | Alt-PIX |
| Co-Production | 3 | 3 | Alt-MXC | 7 | - | Alt-CXC | 11 | - | Alt-PXC |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| None | 4 | 5 | Alt-MXX | 8 | - | Alt-CXX | 12 | - | Alt-PXX |

*Note: Alt=Number of the Alternative; Freq=Number of times alternatives are selected*

Table 4.7: Water Governance Alternatives Selection (least-preferred option)

| Governance/ Ownership | Municipal | | | Cooperative | | | Private | | |
|---|---|---|---|---|---|---|---|---|---|
| | Alt | Freq | Label | Alt | Freq | Label | Alt | Freq | Label |
| Impartiality and Co-Production | 1 | - | Alt-MIC | 5 | - | Alt-CIC | 9 | 4 | Alt-PIC |
| Impartiality | 2 | 1 | Alt-MIX | 6 | - | Alt-CIX | 10 | - | Alt-PIX |
| Co-Production | 3 | 2 | Alt-MXC | 7 | 1 | Alt-CXC | 11 | 5 | Alt-PXC |
| None | 4 | 56 | Alt-MXX | 8 | 50 | Alt-CXX | 12 | 71 | Alt-PXX |

*Note: Alt=Number of the Alternative; Freq=Number of times alternatives are selected*

Additionally, I prepared two datasets, one to model the most preferred options and the other to model the least preferred alternatives. The alternatives not selected by the respondents are removed from the data (see Tables 4.6 and 4.7). As per full factorial statistical experiment design principles, there were 1520 rows/cases in each dataset as there were eight alternatives for every one of the 190 decision-makers. The structure of this dataset is different from what is typically used in any other regression analysis. It is a matrix where each row represents an alternative available to a decision-maker, and each column represents attributes of the alternative. Additionally, I have created five dummy variables to see if the factors, *impartiality*, *co-production*, *municipal*, *cooperative*, and *private,* are selected or rejected by the respondents in each dataset.[24] The presence of the attribute is coded as "1", and absence is coded as "0". Another dummy variable, *choice*, was created

[24] A dummy variable is dichotomous, takes only two values, "0" or "1". It represents the absence or presence of categorical data, such as gender, political affiliation, etc.

to depict the preference/selection of the decision-maker. It is a dependent variable whose value is "1" when the respondent chooses a case/alternative and "0" for the rest of the alternatives (see Appendix-VI). I have also created three composite variables, *corruption*, *social capital*, and *piped water problems*, combining the scores of three corruption variables (corruption in water agency, paying bribes, and asking for bribes), three social capital variables (trust, fairness, helpfulness), and four piped water-related factors (reduced piped water and polluted piped water) respectively. These composite variables or metrics produce the joint effect of the indicators they are made of. Lastly, alternative-4 (Alt-MXX) was taken as a base alternative in the regression analysis to depict the ownership and governance of the current water supply system and compare the result with this alternative. Afterward, using the statistical software Stata (version 16.0), four CL models were estimated.

**4.5 Regression Results**

Model-1 and model-2 are based on the dataset representing the most preferred water governance mode (Table 4.8). Model-1 is comprised of alternative specific variables only. The results show that signs of the variables, *private*, *impartiality*, and *co-production*, are positive and as excepted. However, the positive sign with municipal ownership was unexpected as 70 percent of the respondents believe that the existing state-led piped water governance system is corrupt. The ownership coefficients, *municipal* and *private*, are significant at a 1 percent and 5 percent level, respectively, while the *cooperative* ownership is omitted from the model to avoid multicollinearity. The coefficients related to governance, *impartiality*, and *co-production*, are significant at a 1 percent level. Thus, succinctly, the results of model-1 show that people prefer a state-led water utility that governs itself impartially and is willing to involve water users in the development and delivery of piped water supply.

Model-2 consists of both alternative and case-specific variables. The signs of all the alternative specific variables are positive and similar to model-1. The ownership variables, *municipal* and *private*, are still significant at 1 percent and 5 percent levels, respectively. The *impartiality* is significant at 1 percent, and *co-production* is now significant at 10 percent level. The case-specific variable, *social capital,* is not significant in any alternative. In the Alt-MIC, which combines public ownership with impartiality and co-production, a sign of the case-specific variable, *corruption*, is unexpectedly positive and significant at a 5 percent level. The coefficient *piped water problems* has a negative sign, and it is statistically insignificant. The Alt-AMIX unites *municipal* ownership and *impartiality*. The sign of *corruption* is unexpectedly positive and significant at a 5 percent level, and *piped water problems* has a negative sign, and it is significant at a 10 percent level. The Alt-MXC offers respondents *municipal* ownership with *co-production*. The signs of coefficients, *corruption* and *piped water problems,* are the same as Alt-MIC and Alt-AMIX. In addition, *corruption* is significant at a 1 percent level, and *piped water problems* is insignificant. Moving on, Alt-CIC combines cooperative ownership with impartiality and co-production. The sign of *corruption* is positive as expected and is significant at a 1 percent level. The sign of *piped water problems* is negative and significant at a 1 percent level. The Alt-CIX merges *cooperative* ownership with *impartiality*. The sign of *corruption* is positive as expected and significant at a 1 percent level. The sign of *piped water problems* is negative and insignificant. The Alt-PIC combines *private* *ownership* with *impartiality* and *co-production.* The Alt-PIX unites *private ownership* with *impartiality*. In these alternatives, the sign of *corruption* is positive as expected and statistically significant at a 1 percent level. The *piped water problems* are negative and significant at 5 percent and 10 percent levels in Alt-PIC and Alt-PIX, respectively.

Table 4.8: Results of Conditional Logit Model (Most Preferred Alternative)

| **Variables** | **Model-1** | **Model-2** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ***Alt-MIC*** | ***Alt-MIX*** | ***Alt-MXC*** | ***Alt-CIC*** | ***Alt-CIX*** | ***Alt-PIC*** | ***Alt-PIX*** |
| ***N*** | 1520 | 1520 | | | | | | |
| ***Cases*** | 190 | 190 | | | | | | |
| ***Wald Chi2(4)*** | 93.96*** | 93.21*** | | | | | | |
| ***Log likelihood*** | -333.919 | -288.695 | | | | | | |
| Municipal | 1.340*** (0.212) | 1.792*** (0.315) | | | | | | |
| Private | 0.518** (0.238) | 0.699** (0.357) | | | | | | |
| Impartiality | 2.593*** (0.366) | 5.647*** (1.464) | | | | | | |
| Co-production | 0.405*** (0.148) | 0.304* (0.177) | | | | | | |
| Social Capital | | 0.439 (0.677) | 0.617 (0.683) | -0.946 (1.380) | 0.562 (0.728) | 0.078 (0.820) | 0.856 (1.625) | -0.018 (0.762) |
| Corruption | | 3.647** (1.567) | 3.715** (1.567) | 9.006*** (3.345) | 5.449*** (1.659) | 5.339*** (1.732) | 5.621*** (1.625) | 5.204*** (1.653) |
| Piped Water Problems | | -1.459 (0.995) | -1.704* (1.010) | -0.393 (1.439) | -3.761*** (1.207) | -1.776 (1.170) | -2.337** (1.078) | -2.039* (1.097) |

*Notes: : * p≤0.1; **p≤0.05; **p≤0.01; standard errors in parenthesis*

Model-3 and model-4 are based on the dataset representing the least preferred water governance mode (Table 4.9). Model-3 is composed of alternative specific variables only. The results show that the signs of the variables, *municipal* and *private*, are positive, while the signs of *impartiality* and *co-production* are negative as excepted. The ownership coefficients, *municipal* and *private,* are significant at 10 percent and 5 percent level respectively. The governance coefficients, *impartiality,* and *co-production* are significant at a 1 percent level. Thus, overall, the results of model-3 show that people strongly dislike private water utilities without impartiality and co-production. Model-4 has both alternative and case-specific variables. The signs of all the alternatives specific variables are same as model-3 except municipal ownership coefficient, *municipal*, is negative and insignificant. The *private* is still positive and significant at a 5 percent level. The signs of governance variables are negative as expected. The *impartiality* and *co-production* are significant at a 1 percent level.

In model-4, similar to model-2, *social capital* is not significant in any alternative. In the Alt-MIX, that combines *municipal* ownership with *impartiality*. The sign of the coefficient, *corruption,* is positive as expected but statistically insignificant. The sign of the *piped water problems* is positive and significant at a 10 percent level. The Alt-MXC unites *municipal* ownership and *impartiality*. In this alternative, none of the case-specific variables is significant. The Alt-CXC offers respondents *cooperative* ownership with *co-production*. The sign of the coefficient, *corruption,* is negative as expected and significant at a 1 percent level, while the *piped water problems* is insignificant. In addition, the Alt-CXX is an option that proffer cooperatively owned piped water supply system without impartiality or co-production. Similarly, the Alt-CXC sign of the variable, *corruption,* is negative as expected and significant at a 1 percent level, and *piped water problems* is insignificant. The Alt-PIC merges *private* ownership with *impartiality* and *co-production*. The sign of *corruption* is negative as expected and significant at a 1 percent level, while the sign of *piped water problems* is positive and significant at a 10 percent level. The Alt-PXC combines *private ownership* with *co-production.* The sign of corruption is negative as expected but insignificant. The sign of the *piped water problems* is positive and significant at a 1 percent level. The Alt-PXX offer *private ownership* without *impartiality* or *co-production*. In this alternative, the sign of *corruption* is negative as expected and statistically significant at a 1 percent level. The *piped water problems* is positive and significant at a 5 percent level.

Table 4.9: Results of Conditional Model (Least Preferred Alternative)

| **Variables** | **Model-3** | **Model-4** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ***Alt-MIX*** | ***Alt-MXC*** | ***Alt-CXC*** | ***Alt-CXX*** | ***Alt-PIC*** | ***Alt-PXC*** | ***Alt-PXX*** |
| ***N*** | 1520 | 1520 | | | | | | |
| ***Cases*** | 190 | 190 | | | | | | |
| ***Wald Chi2(4)*** | 122.33*** | 125.00*** | | | | | | |
| ***Log likelihood*** | -267.301 | -224.718 | | | | | | |
| Municipal | 0.065* (0.194) | -0.357 (0.265) | | | | | | |
| Private | 0.444** (0.179) | 0.364** (0.192) | | | | | | |
| Impartiality | -2.416*** (0.464) | -3.864*** (1.294) | | | | | | |
| Co-production | -2.708*** (0.298) | -3.302*** (0.488) | | | | | | |
| Social Capital | | -0.609 (1.164) | 0.540 (0.682) | -0.381 (0.853) | 0.058 (0.229) | -0.477 (0.743) | 0.325 (0.508) | -0.231 (0.228) |
| Corruption | | 0.214 (1.949) | -0.322 (1.487) | -2.892*** (1.025) | -2.142*** (0.496) | -6.526*** (1.657) | -1.053 (0.943) | -2.328*** (0.483) |
| Piped Water Problems | | 2.197* (1.320) | 0.679 (1.346) | -0.227 (1.413) | 0.995 (0.420) | 2.951* (1.295) | 2.377*** (0.806) | 0.901** (0.402) |

*Notes: : * p≤0.1; **p≤0.05; **p≤0.01; standard errors in parenthesis*

Furthermore, the DCE presented to the respondents comprises governance variables, *impartiality,* and *co-production* (see Table 4.1). Models 1, 2, 3 & 4 are based on the artificial construct, based not only on governance but ownership variables as well. Hence, to check the robustness of the results presented in the conditional models (Tables 4.5 & 4.6), I estimated two more conditional models that consist of governance variables only. The model-5 represents the most preferred option, and model-6 represents the least preferred option (Table 4.7). The results show that the main effects of the variable *impartiality* are the same as models 1 (positive and significant at 1 percent level) and 3 (negative and significant at 1 percent level). However, the main effects (negative and insignificant) of the variable co-production are different from model-1 (positive and significant at 1 percent level) but the same as model-3 (negative and significant at 1 percent level). The interaction effects between impartiality and co-production are also explored (Table 4.7). In model-5, the interaction between impartiality and co-production is positive and not significant. In model-6, the interactions between them are positive and significant at a 1 percent level.

Table 4.10: Conditional Regression Results (Governance Variables only)

| **Variables** | **Model-5** | **Model-6** |
|---|---|---|
| ***N*** | 760 | 760 |
| ***Cases*** | 190 | 190 |
| ***Wald Chi2(4)*** | 81.76*** | 166.31*** |
| ***Log likelihood*** | -161.031 | -61.618 |
| Impartiality | 2.681***<br>(0.462) | -3.789***<br>(0.505) |
| Co-production | -0.510<br>(0.730) | -3.566***<br>(0.453) |
| Impartiality x Co-production | 0.911<br>(0.745) | 3.566***<br>(0.840) |

*Notes: : * p≤0.1; **p≤0.05; **p≤0.01; standard errors in parenthesis*

## 4.6 Discussion

This study aims to explore residents' piped water governance mode choice in Faisalabad, Pakistan. Preferences of the public were elicited using a discrete choice experiment, and four conditional logit models were estimated. The results of model-1 show that respondents prefer impartial state-owned piped water system, whose institutional arrangements allow for collaboration (co-production) with water users in the governance processes. To a lesser extent, people prefer private ownership with both impartiality and co-production. In model-2, in addition to the alternative, case-specific coefficients were added. The results of this model show that preference for the impartial municipally-owned piped water system is still strong, while the choice of the co-production got statistically weaker. The influence of case-specific variables on the selection of individual alternatives reveals that Alt-MIC is selected by people who believe the water agency is corrupt. Likewise, respondents who prefer Alt-MIX do not perceive a high risk of experiencing piped water problems and think the water agency is corrupt. Furthermore, Alt-MXC and Alt-CIX are selected by those who think that the water agency is corrupt. In the same way, those who choose Alt-CIC, Alt-PIC, and Alt-PIX do not think there is a high risk of experiencing piped water problems and  believe that corruption exists in the water agency.

The results of model-3 show that respondents least prefer the alternatives which are privately-owned, not impartial, and do not allow for collaboration with water users. To a lesser extent, people least prefer municipal ownership without impartiality and co-production. In model-4, alternative and case-specific coefficients were added. The results of this model show that a dislike for the privately-owned piped water system, which is not operating impartiality and involving the local community in the decision-making, is still the same. In addition, municipal ownership got statistically insignificant. Moreover, dislike for Alt-MIX and Alt-PXC by those who believe that there is a high risk of experiencing piped water problems. Those who reject Alt-CXC and Alt-CXX do not think corruption exists in the water agency. Lastly, people who least prefer Alt-PIC and Alt-PXX do not believe the water agency is corrupt but perceive a high risk of experiencing piped water problems.

The choice of impartiality and co-production across all the alternatives in model-1 and model-2, and the dislike of options that do not have impartiality and co-production in model-3 and model-4 show that the residents of Faisalabad prefer to have these two institutional arrangements in their piped water supply system. The combination of impartiality and co-production is the best possible public utility governance option (see section 4.2.2). Regarding the ownership, piped water system in models 1 & 2, people strongly prefer the municipal ownership over the private. In models 3 & 4, respondents reject private ownership, while the municipal ownership is either disliked or statistically insignificant. Overall, the residents  chose the municipal piped water system over the privately owned systems. These results show that public preferences in Faisalabad match with the findings of previous studies, which maintained that governance institutions have a greater impact on the utility's quality of service (Martin, 2004) than the ownership (Braadbaart, 2002; Prasad, 2006).

Additionally, insignificance of the co-production in the most-preferred option (model-5) shows that impartiality has the strongest effect when people select their most preferred alternative. In contrast, the interaction effects among them shows are not preferred together. On the other hand, in the least preferred option (model-6), respondents dislike alternatives without impartiality and co-production, but the interaction between them is unexpectedly positive. It means people tend to dislike the alternative in which both impartiality and co-production are present together but at the same time dislike the alternatives in which impartiality and co-production are absent individually. In sum, looking over all the models, people prefer alternatives with impartiality more strongly than the co-production. Simultaneously, people dislike alternatives in which both impartiality and co-production are present together. Or, in other words, they would like to have one of them as the piped water governance mode.

When it comes to social capital, its insignificance in all the alternatives is surprising and requires some explanation. Rothstein & Stolle (2003, p.7) defined social capital as "access to beneficial social networks and having generalized trust in other people." There are three types of social capital: bonding, linking, and bridging. Bonding social capital describes the trust and connections within a specific group, e.g., among the members of the biraderies. On the other hand, linking social capital discusses the ability of groups to engage with external agencies, elected officials, etc. As representatives of biraderies, leaders have informal connections with the water agency, although these connections are not equal for all the groups. Finally, bridging social capital explains the links to other groups and individuals. The social capital metric used in this study is the measure of bridging social capital. To get out of a social dilemma, the presence of all three types of social capital is essential (Pretty, 2003). The importance of bridging and linking social capital is relatively high as they enable people to access information and resources outside of their social networks (Ostrom, 2000). The descriptive statistics show that (bridging) social capital is low, but it did not impact the respondent's water governance mode choice. This finding can be further explored in future studies. Moreover, it makes sense for the people to select alternatives that combines cooperative and private ownerships when corruption in the public water supply system is high. However, the results pertaining to the alternatives with municipal ownership in model-2 are particularly interesting. Despite having the perception that the existing public water agency is corrupt, residents chose alternatives with municipal ownership. Thus, further analysis on the issue of corruption is also warranted.

### 4.7 Policy Recommendations

The DCE reveals that respondents have a strong preference for impartiality, municipal ownership and to lesser extent co-production (compare models 1 & 5). However, the current municipal piped water supply system in Faisalabad is not impartial. Additionally, efforts to promote collaboration between water users and the water agency (co-production) were mainly unsuccessful. Nonetheless, people still would like to have a public piped water supply system with impartiality or community involvement. In the following paragraphs, I laid out two policy proposals to metrialize these public preferences.

*Big Bang*

To introduce impartiality in the water agency's operations, which has been captured by the informal governance units, I recommend adopting an indirect "Big Bang" approach. It calls for a quick, radical change in institutions to resolve the issues of quality of governance. This approach is especially beneficial when it is difficult to dealwith challenges such as corruption is difficult. To explain, when in a society corruption is endemic, tackling it with a political push or a technical fix is not enough to convince a substantial number of actors to move away from corrupt practices (Diamond, 2007). Following the Big Bang approach, I recommend scrapping the water agency and replacing it with new water governance institutions built on impartiality principles (e.g., robust accountability mechanism). This action might seem drastic, but it has been successfully tried in several places globally. For example, the municipal water supply system of Phnom Penh, Cambodia, a country where corruption was rampant, used the Big Bang approach to improve its water supply service (Araral, 2008). The creation of the National Highways & Motorways Police (NH&MP) in Pakistan is another example of successful implementation of Big Bang approach to replace corrupt, incompetent, and occasionally violent highway police forces (Abbas, 2011). According to public surveys, today, the NH&MP is considered the most trustworthy and upright among all the civilian law enforcement agencies in Pakistan (Arain & Arain, 2016). The impartial governance creates institutional and social trust, which are crucial for initiating successful co-production efforts.

*Citizen Liaison Cell*

Once the new state-led impartial water supply system is in place, introduce the agreed-upon institutional arrangements that support co-production like the creation of Citizen Liaison Cell (CLC). The office of the CLC will encourage community involvement in activities such as monitoring, delivery, tariff setting, bill collection, etc. Citizens' participation in the public service provision will increase institutional and social trust, which are essential for successful collective action. Moreover, since co-production is challenging to adopt independently because problems such as power imbalances or a large, diverse population can become a hindrance, it requires support from strong impartial institutions to ameliorate the negative impacts of these obstacles (Popovici et al., 2020). Impartial governance using its rule-making and financial powers can, to a large extent, help overcome these barriers (e.g., power imbalances).

## 4.8 Conclusions

The piped water supply system in Faisalabad is in shambles, and people are not satisfied with its performance. Water users do not pay their bills and steal piped water, leaving the water agency without funds to improve its operations. Such a situation (free-riding on the public good) has contributed to the creation of a public goods dilemma. This paper explored households' preferences regarding new water governance mode to revamp the water agency using a discrete choice experiment. The results of the conditional logit models show that, across all the alternatives, people prefer to have a state-owned impartial piped water supply system. Moreover, to a lesser extent people also prefer to get involved in the production and delivery processes. In addition, respondents do not prefer, in fact dislike when impartiality and co-production are combined. Hence, they do not select an institutional framework that is potentially more effective to help them get out of social dilemmas. One of the limitations of this research is the corruption metric, which is comprised of three factors, a) perception of corruption in the water agency, b) bribes paid by people, c) bribes asked by public officials. The measure of corruption is very limited as it does not include other forms of corruption prevalent in the water agency, like patronage and state capture. Thus, the issue of corruption must be further explored to validate the results of this study.

# CHAPTER 5: CONCLUSION

In this dissertation, I explored urban groundwater governance from the institutional perspective. The unique contribution of this study is that groundwater is investigated alongside piped water supply system. In Global South, municipal piped water agencies do not provide adequate water to the citizens. In turn, people usually end up using groundwater. Due to the weakness or absence of formal and informal institutions to govern the groundwater withdrawal, people usually over-exploiting the aquifer. It is too simplistic to propose solutions for groundwater management in isolation, especially when there is a strong connection between these two major water sources in developing cities. Moreover, improvement in piped water supply must be an essential part of the groundwater management plan because more piped water for the public means less pressure on the aquifer. Therefore, the ultimate goal of this research was to understand the dynamics between groundwater and piped water and provide both relevant and pragmatic policy recommendations to manage groundwater.

## 5.1 Summary of the Findings

In chapter 2, factors affecting groundwater and piped water supply were thoroughly examined. The results showed that many factors negatively impact the piped water supply, such as (partial) capture of the water agency by the informal governance units, aid dependency, and corruption. In addition, the water agency has fallen into a negative feedback loop, lack of funds and informal governance units reinforce each other, causing further damage to the water agency. The deterioration in the quality of piped water supply means more pressure on the groundwater. Similarly, factors negatively affecting the groundwater withdrawal are the absence of informal groundwater governance rules, weakness of formal rules, groundwater draft for domestic purposes is open access. The common factor between piped water supply and groundwater is the weak water agency, responsible for piped water provision and regulating groundwater in the city. Hence, efforts to protect groundwater go hand in hand with improving the piped water supply system/water agency.

In chapter 3, the possibility of developing bottom-up informal groundwater governance institutions was explored. It is challenging to manage the common pool resource using exclusively using state regulations or privatizing the resource. Local communities must come together and self-organize for the long-term sustainability of the resource. Hence, to assess would people cooperate in Faisalabad, a one-shot common pool resource game was played with the household heads. The results showed that people do moderately cooperate to manage groundwater. Moreover, factors like trust, corruption in the water agency, patience, and egalitarianism impact the respondent's decision-making.

In chapter 4, I focused on how to improve piped water supply system. I laid out that theoretically, the combination of Impartial governance and co-production is a robust institutional arrangement to reform a public utility. I asked for the residents' preferences regarding the piped water governance mode using DCE. The results showed that people overwhelmingly prefer state-owned impartial piped water supply system. or state-owned system with opportunities for co-production of piped water. Overall, the conclusion across all the papers is that it is impossible to ensure sustainable groundwater withdrawal without reforming the water agency. As water agency supplies piped water and enact operational rules concerning groundwater. The impartial water agency will make sure groundwater regulations are fairly enforced and help create a conducive environment for the informal self-governance of the groundwater at the community level.

## 5.2 Limitations

- A small sample of interviews in the chapter 2, and CPR and DCE experiments in the chapters 3 and 4.
- The focus of analysis in the chapters 3 and 4 is on domestic groundwater and domestic piped water users.
- The groundwater scarcity is occurring due to increasing pollution of the aquifer. The analysis in the chapter 1, did not include this aspect of the problem.

## 5.3 Future Research Directions

This research work can be extended in the following two significant ways:

*Rural-Urban Water Use Connection*

The natural progression of my research would be to explore ways to get surface water for the municipal piped water supply system. Currently, canal water is almost exclusively used by the farmers in the Faisalabad district. It will be interesting to explore the conditions under which farmers will be willing to give up some water for the city. The use of surface water will help relieve some pressure off the freshwater aquifer.

*Urban Groundwater Pollution*

Groundwater quality is deteriorating in Faisalabad. The wastewater is thrown into the open drains without treatment. When this wastewater seeps into the ground, it pollutes the groundwater aquifers. People cannot use this polluted groundwater for domestic purposes because of the high levels of mercury and arsenic. The contaminated groundwater is exacerbating the problem of water scarcity. The groundwater quality and water scarcity issues are tied in the city. Using the institutional analysis, I will first explore then propose policy solutions to tackle this problem.

# REFERENCES

***Chapter 1***

Anwar, A. (2019). The Role of Biraderies in the Politics of Faisalabad Division. *Pakistan Vision*, *20*(2), 11.

Araral, E. (2008). Public provision for urban water: Getting prices and governance right. *Governance*, *21*(4), 527–549.

Arbúes, F., Barberan, R., & Villanua, I. (2004). Price impact on urban residential water demand: A dynamic panel data approach. *Water Resources Research*, *40*(11).

Biswas, A. K., Saklani, U., & Tortajada, C. (2017). *Solution to Delhi's never-ending water problems*. India Water Review. https://www.google.com/search?q=Solution+to+Delhi%27s+never-ending+water+problems&rlz=1C1SQJL_enUS835US835&oq=Solution+to+Delhi%27s+never-ending+water+problems&aqs=chrome..69i57j69i60.267j0j7&sourceid=chrome&ie=UTF-8

Bureau of Reclamation California. (2019). *Water Facts—Worldwide Water*. Central California Area Office (CCAO) - American River Water Education Center (ARWEC). https://www.usbr.gov/mp/arwec/water-facts-ww-water-sup.html

Foster, S. (2020). Global Policy Overview of Groundwater in Urban Development—A Tale of 10 Cities! *Water*, *12*(2), 456.

Gazdar, H. (2007). Class, caste or race: Veils over social oppression in Pakistan. *Economic and Political Weekly*, 86–88.

Jütting, J., Drechsler, D., Bartsch, S., & de Soysa, I. (2007). *Informal Institutions: How Social Norms Help Or Hinder Development*. OECD (ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT).

Kessides, I. N. (2005). Infrastructure privatization and regulation: Promises and perils. *The World Bank Research Observer*, *20*(1), 81–108.Klassert, C., Sigel, K., Gawel, E., & Klauer, B. (2015). Modeling residential water consumption in amman: The role of intermittency, storage, and pricing for piped and tanker water. *Water*, *7*(7), 3643–3670.

Malik, A. (2017). *Polycentricity, Islam, and Development: Potentials and Challenges in Pakistan*. Lexington Books.

Ramachandran, M. (2008). Reversing the race to the bottom: Urban groundwater use in developing countries. *Environment: Science and Policy for Sustainable Development*, *50*(4), 50–58.

Rothstein, B. (2005). *Social traps and the problem of trust*. Cambridge University Press.

Rothstein, B., & Varraich, A. (2017). *Making sense of corruption*. Cambridge University Press.

Saleth, R. M., & Dinar, A. (2004). *The institutional economics of water: A cross-country analysis of institutions and performance*. The World Bank & Edward Elgar Publishing Limited.

Seckler, D., Barker, R., & Amarasinghe, U. (1999). Water scarcity in the twenty-first century. *International Journal of Water Resources Development*, *15*(1–2), 29–42.

Seward, P., & Xu, Y. (2019). The case for making more use of the Ostrom design principles in groundwater governance research: A South African perspective. *Hydrogeology Journal*, *27*(3), 1017–1030.

Silva, R. C. G., Grönwall, J., van der Kwast, J., Danert, K., & Foppen, J. W. (2020). Estimating domestic self-supply groundwater use in urban continental Africa. *Environmental Research Letters*, *15*(10), 1040b2.

UNESCO. (2012). *World's groundwater resources are suffering from poor governance*. United Nations Educational, Scientific and Cultural Organization. http://www.unesco.org/new/en/media-services/single-view/news/worlds_groundwater_resources_are_suffering_from_poor_gove

WWAP. (2003). *Water for People, Water for Life: The United Nations World Water Development Report*. UNESCO (World Water Assessment Programme).

***Chapter 2***

Adams, E. A., Sambu, D., & Smiley, S. L. (2019). Urban water supply in Sub-Saharan Africa: Historical and emerging policies and institutional arrangements. *International Journal of Water Resources Development*, *35*(2), 240–263.

AFD. (2019). *Extension of water resources in Faisalabad*. French Development Agency. https://www.afd.fr/en/carte-des-projets/extension-water-resources-faisalabad

Anderies, J. M., Janssen, M. A., & Ostrom, E. (2004). A framework to analyze the robustness of social-ecological systems from an institutional perspective. *Ecology and Society*, *9*(1).

Anwar, A. (2019). The Role of Biraderies in the Politics of Faisalabad Division. *Pakistan Vision*, *20*(2), 11.

Araral, E. (2008). Public provision for urban water: Getting prices and governance right. *Governance*, *21*(4), 527–549.

Bakker, K. (2003). *Good governance in restructuring water supply: A handbook*. Federation of Canadian Municipalities Ottawa, Canada.

Bakker, K. (2007). The “commons” versus the “commodity”: Alter-globalization, anti-privatization and the human right to water in the global south. *Antipode*, *39*(3), 430–455.

Bakker, K., Kooy, M., Shofiani, N. E., & Martijn, E.-J. (2008). Governance failure: Rethinking the institutional dimensions of urban water supply to poor households. *World Development*, *36*(10), 1891–1915.

Banerji, B. (2013). *Institutional analysis of municipal water reforms: Framework and application to Jakarta, Indonesia* [PhD Thesis]. The George Washington University.

Biswas, A. K., Saklani, U., & Tortajada, C. (2017). *Solution to Delhi’s never-ending water problems*. India Water Review. https://www.google.com/search?q=Solution+to+Delhi%27s+never-ending+water+problems&rlz=1C1SQJL_enUS835US835&oq=Solution+to+Delhi%27s+never-ending+water+problems&aqs=chrome..69i57j69i60.267j0j7&sourceid=chrome&ie=UTF-8

Bovaird, T. (2007). Beyond engagement and participation: User and community coproduction of public services. *Public Administration Review*, *67*(5), 846–860.

Bowles, S. (2008). Policies designed for self-interested citizens may undermine" the moral sentiments": Evidence from economic experiments. *Science*, *320*(5883), 1605–1609.

Carrard, N., Foster, T., & Willetts, J. (2019). Groundwater as a source of drinking water in southeast Asia and the Pacific: A multi-country review of current reliance and resource concerns. *Water*, *11*(8), 1605.

Clement, F. (2010). Analysing decentralised natural resource governance: Proposition for a "politicised" institutional analysis and development framework. *Policy Sciences*, *43*(2), 129–156.

Dionisio, F., & Gordo, I. (2006). The tragedy of the commons, the public goods dilemma, and the meaning of rivalry and excludability in evolutionary biology. *Evolutionary Ecology Research*, *8*(2), 321–332.

Epstein, G., Bennett, A., Gruby, R., Acton, L., & Nenadovic, M. (2014). Studying power with the social-ecological system framework. In *Understanding society and natural resources* (pp. 111–135). Springer, Dordrecht.

Epstein, G., Pittman, J., Alexander, S. M., Berdej, S., Dyck, T., Kreitmair, U., Rathwell, K. J., Villamayor-Tomas, S., Vogt, J., & Armitage, D. (2015). Institutional fit and the sustainability of social–ecological systems. *Current Opinion in Environmental Sustainability*, *14*, 34–40.

Fledderus, J., Brandsen, T., & Honingh, M. (2014). Restoring trust through the co-production of public services: A theoretical elaboration. *Public Management Review*, *16*(3), 424–443.

Flint, S. S. (2011). Public Goods, Public Utilities, and the Public's Health. *Health & Social Work*, *36*(1), 75.

Foster, S. D., Hirata, R., & Howard, K. W. (2011). Groundwater use in developing cities: Policy issues arising from current trends. *Hydrogeology Journal*, *19*(2), 271–274.

Foster, S., Hirata, R., Misra, S., & Garduno, H. (2010). *Urban groundwater use policy: Balancing the benefits and risks in developing nations*. The World Bank.

Gazdar, H. (2007). Class, caste or race: Veils over social oppression in Pakistan. *Economic and Political Weekly*, 86–88.

Grönwall, J., & Danert, K. (2020). Regarding groundwater and drinking water access through a human rights lens: Self-Supply as a norm. *Water*, *12*(2), 419.

Haider, G. (2000). Proceedings of the International Conference on Regional Groundwater Management, *Pakistan Water Partnership*, Islamabad, Pakistan.

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*(3859), 1243–1248.

Helmke, G., & Levitsky, S. (2006). *Informal institutions and democracy: Lessons from Latin America*. jhu Press.

Holmberg, S., & Rothstein, B. (2011). *Quality of Government and Access to safe Water*. THE QUALITY OF GOVERNMENT INSTITUTE: University of Gothenburg.

House-Peters, L. A., & Chang, H. (2011). Urban water demand modeling: Review of concepts, methods, and organizing principles. *Water Resources Research*, *47*(5).

HUD & PHED. (2021). *What We DO* [Government]. Housing, Urban Development and Public Health Department. https://hudphed.punjab.gov.pk/

Ibrahim, G. R. F. (2015). *Impact of Urban Growth on Groundwater Levels using Remote Sensing-Case Study: Erbil City, Kurdistan Region of Iraq*.

Jamal, S. (2019). *Situational Analysis of Water Resources in Faisalabad City: Establishing a Case for Water Stewardship*. World Wildlife Fund, Pakistan (WWF).

Javed, N., & Qureshi, N. N. (2019). City Profile: Faisalabad, Pakistan. *Environment and Urbanization ASIA*, *10*(2), 233–254.

Jensena, O., & Chindarkarb, N. (2017). *Why Don't People Pay Their Water Bills? Evidence of Values and Perceptions of Water Supply from Urban India*.

JICA. (2019a). *Excecutive Summary: The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad.* Japan International Cooperation Agency (JICA).

JICA. (2019b). *Main Report-The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad.* (p. 226). Japan International Cooperation Agency (JICA).

JICA. (2019c). *Part-B Water Supply: The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad.* (p. 226). Japan International Cooperation Agency (JICA).

Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental models: An interdisciplinary synthesis of theory and methods. *Ecology and Society*, *16*(1).

Jütting, J., Drechsler, D., Bartsch, S., & de Soysa, I. (2007). *Informal Institutions: How Social Norms Help Or Hinder Development*. OECD (ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT).

Kadirbeyoglu, Z., & Özertan, G. (2015). Power in the Governance of Common-Pool Resources: A comparative analysis of irrigation management decentralization in Turkey. *Environmental Policy and Governance*, *25*(3), 157–171.

Kalhor, K., & Emaminejad, N. (2019). Sustainable development in cities: Studying the relationship between groundwater level and urbanization using remote sensing data. *Groundwater for Sustainable Development*, *9*, 100243.

Kamran, M. A., & Shivakoti, G. P. (2013). Comparative institutional analysis of customary rights and colonial law in spate irrigation systems of Pakistani Punjab. *Water International*, *38*(5), 601–619.

Kessides, I. N. (2005). Infrastructure privatization and regulation: Promises and perils. *The World Bank Research Observer*, *20*(1), 81–108.

Khan, A. D., Naveed, I., Ashraf, M., & Sheikh, Ashfaq. A. (2016). *Groundwater Investigations and Mapping in the Upper Indus Plain*. Pakistan Council of Research in Water Resources (PCRWR).

Khan, M. A., & Ahmed, A. (2007). Foreign aid—blessing or curse: Evidence from Pakistan. *The Pakistan Development Review*, 215–240.

Klassert, C., Sigel, K., Gawel, E., & Klauer, B. (2015). Modeling residential water consumption in amman: The role of intermittency, storage, and pricing for piped and tanker water. *Water*, *7*(7), 3643–3670.

Knüppe, K., & Pahl-Wostl, C. (2011). A framework for the analysis of governance structures applying to groundwater resources and the requirements for the sustainable management of associated ecosystem services. *Water Resources Management*, *25*(13), 3387–3411.

Kooiman, J. (2003). *Governing as governance*. Sage.

Kugelman, M., & Hathaway, R. M. (2009). *Running on Empty: Pakistan's Water Crisis*. Woodrow Wilson International Center for Scholars-Asia Program.

Laghari, A. N., Vanham, D., & Rauch, W. (2012). The Indus basin in the framework of current and future water resources management. *Hydrology and Earth System Sciences*, *16*(4), 1063.

Lawrence, T. B. (2008). Power, Institutions and Organizations. In *The Sage handbook of organizational institutionalism*. SAGE Publications, Incorporated.

Lee, B., Hamm, S.-Y., Jang, S., Cheong, J.-Y., & Kim, G.-B. (2014). Relationship between groundwater and climate change in South Korea. *Geosciences Journal*, *18*(2), 209–218.

Lopez-Gunn, E. (2003). The role of collective action in water governance: A comparative study of groundwater user associations in La Mancha aquifers in Spain. *Water International*, *28*(3), 367–378.

Lu, F., Ocampo-Raeder, C., & Crow, B. (2014). *Equitable water governance: Future directions in the understanding and analysis of water inequities in the global South*. Taylor & Francis.

Lukes, S. (2005). *Power: A radical view*. Red Globe Press.

McDonald, R. I., Weber, K., Padowski, J., Flörke, M., Schneider, C., Green, P. A., Gleeson, T., Eckman, S., Lehner, B., & Balk, D. (2014). Water on an urban planet: Urbanization and the reach of urban water infrastructure. *Global Environmental Change*, *27*, 96–105.

McGinnis, M. D. (1999). *Polycentric governance and development: Readings from the workshop in political theory and policy analysis*. University of Michigan Press.

McGinnis, M. D. (2011). An introduction to IAD and the language of the Ostrom workshop: A simple guide to a complex framework. *Policy Studies Journal*, *39*(1), 169–183.

McGinnis, M. D., & Hall, O. (2019). Connecting commons and the IAD framework. In *Routledge Handbook of the Study of the Commons* (pp. 50–62). Routledge.

McGinnis, M. D., & Ostrom, E. (2014). Social-ecological system framework: Initial changes and continuing challenges. *Ecology and Society*, *19*(2).

McMullin, C. (2019). The who, what, how and why of co-production of public services. *Dr. Caitlin McMullin*. https://caitlinmcmullin.com/2019/03/28/the-who-what-how-and-why-of-co-production-of-public-services/

Nabatchi, T., Sancino, A., & Sicilia, M. (2017). Varieties of participation in public services: The who, when, and what of coproduction. *Public Administration Review*, *77*(5), 766–776.

O'Donnell, G. (2006). On informal institutions once again. In *Informal Institutions and Democracy: Lessons from Latin America*. The Jphns Hopkins University Press.

Olson, M. J. (1965). *The logic of collective action: Public goods and the theory of groups*. Harvard University Press.

Ostrom, E. (1996). Crossing the great divide: Coproduction, synergy, and development. *World Development*, *24*(6), 1073–1087.

Ostrom, E. (2000). Social capital: A fad or a fundamental concept. *Social Capital: A Multifaceted Perspective*, *172*(173), 195–198.

Ostrom, E. (2005). Understanding institutional diversity Princeton University press. *New Jersey*, 393–432.

Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. *American Economic Review*, *100*(3), 641–672.

Ostrom, E., Gardner, R., Walker, J., Walker, J. M., & Walker, J. (1994). *Rules, games, and common-pool resources*. University of Michigan Press.

Ostrom, E., & Ostrom, V. (2011). The institutional perspective on values and virtues. In *Value and Virtue in Public Administration* (pp. 115–134). Springer.

Ostrom, Elinor. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press. http://catdir.loc.gov/catdir/toc/cam025/90001831.html

Pahl-Wostl, C. (2003). The importance of the human dimension in integrated assessment models and processes: Actor based analysis and modeling approaches. *Proceedings of the Modelling and Simulation Society of Australia and New Zealand, MODSIM*, 465–472.

Pahl-Wostl, C., Lebel, L., Knieper, C., & Nikitina, E. (2012). From applying panaceas to mastering complexity: Toward adaptive water governance in river basins. *Environmental Science & Policy*, *23*, 24–34.

Polski, M. M., & Ostrom, E. (1999). An institutional framework for policy analysis and design. *1999*.

Pretty, J. (2003). Social capital and the collective management of resources. *Science*, *302*(5652), 1912–1914.

Qasim, M., Ahmad, S., Akhtar, S., Imran, S., & Qureshi, K. N. (2018). *Urban Population Behaviour and Knowledge Assessment aboutWater Quality, Consumption, and Conservation in Pakistan*.

Ramachandran, M. (2008). Reversing the race to the bottom: Urban groundwater use in developing countries. *Environment: Science and Policy for Sustainable Development*, *50*(4), 50–58.

Riker, W. H. (1980). Implications from the Disequilibrium of Majority Rule for the Study of Institutions. *American Political Science Review*, *74*(2), 432–446.

Ross, A., & Martinez-Santos, P. (2010). The challenge of groundwater governance: Case studies from Spain and Australia. *Regional Environmental Change*, *10*(4), 299–310.

Rothstein, B. (2005). *Social traps and the problem of trust*. Cambridge University Press.

Saleth, R. M., & Dinar, A. (2004). *The institutional economics of water: A cross-country analysis of institutions and performance*. The World Bank & Edward Elgar Publishing Limited.

Sarker, A. (2013). The role of state-reinforced self-governance in averting the tragedy of the irrigation commons in Japan. *Public Administration*, *91*(3), 727–743.

Schlüter, A., & Theesfeld, I. (2010). The grammar of institutions: The challenge of distinguishing between strategies, norms, and rules. *Rationality and Society*, *22*(4), 445–475.

Searle, J. R. (2005). What is an institution? *Journal of Institutional Economics*, *1*(1), 1–22.

Silva, R. C. G., Grönwall, J., van der Kwast, J., Danert, K., & Foppen, J. W. (2020). Estimating domestic self-supply groundwater use in urban continental Africa. *Environmental Research Letters*, *15*(10), 1040b2.

Sobels, J., Curtis, A., & Lockie, S. (2001). The role of Landcare group networks in rural Australia: Exploring the contribution of social capital. *Journal of Rural Studies*, *17*(3), 265–276.

Stahl, T. (2011). Institutional Power, Collective Acceptance, And Recognition. In *Recognition and social ontology* (pp. 349–372). Brill.

Sterman, J. D. (2006). Learning from evidence in a complex world. *American Journal of Public Health*, *96*(3), 505–514.

Stone-Jovicich, S., Lynam, T., Marshall, N., Herr, A., Smajgl, A., Straton, A., Vella, K., & Nursey-Bray, M. (2009). *Outback institutions: An application of the Institutional Analysis and Development (IAD) framework to four case studies in Australia's Outback*.

Tilly, C. (2005). *Trust and rule*. Cambridge University Press.

Tortajada, C. (2006). Water management in Singapore. *Water Resources Development*, *22*(2), 227–240.

UN-DESA. (2018). *World Urbanization Prospects*. Department of Economics and Social Affairs, United Nations.

UNESCO. (2012). *World's groundwater resources are suffering from poor governance*. United Nations Educational, Scientific and Cultural Organization. http://www.unesco.org/new/en/media-services/single-view/news/worlds_groundwater_resources_are_suffering_from_poor_gove

UN-Water. (2009). Water in a changing world. *UNESCO Publications, The United United Nations World Water Development Report 3*.

UN-Water. (2021). *Summary Progress Update 2021: SDG 6—Water and sanitation for all*.

Vairavamoorthy, K., Gorantiwar, S. D., & Pathirana, A. (2008). Managing urban water supplies in developing countries–Climate change and water scarcity scenarios. *Physics and Chemistry of the Earth, Parts A/B/C*, *33*(5), 330–339.

van Leeuwen, C. J., Dan, N. P., & Dieperink, C. (2016). The challenges of water governance in Ho Chi Minh City. *Integrated Environmental Assessment and Management*, *12*(2), 345–352.

van Soest, D. P. (2013). Experiments on common property management. *Encyclopedia of Energy, Natural Resource and Environmental Economics*, 293–298.

Villholth, K. G., & Conti, K. I. (2017). Groundwater governance: Rationale, definition, current state and heuristic framework. In *Advances in groundwater governance* (pp. 3–31). CRC Press.

WASA-F. (2020). *WASA Faisalabad: An Overview*. http://wasafaisalabad.gop.pk/

Wasko, M. M., & Teigland, R. (2004). Public goods or virtual commons? Applying theories of public goods, social dilemmas, and collective action to electronic networks of practice. *Journal of Information Technology Theory and Application (JITTA)*, *6*(1), 4.

Whaley, L. (2018). The critical institutional analysis and development (CIAD) framework. *International Journal of the Commons*, *12*(2).

World Population Review. (2020). *Faisalabad Population*. https://worldpopulationreview.com/world-cities/faisalabad-population

WWAP. (2003). *Water for People, Water for Life: The United Nations World Water Development Report*. UNESCO (World Water Assessment Programme).

Zozmann, H., Klassert, C., Sigel, K., Gawel, E., & Klauer, B. (2019). Commercial Tanker Water Demand in Amman, Jordan—A Spatial Simulation Model of Water Consumption Decisions under Intermittent Network Supply. *Water*, *11*(2), 254.

***Chapter 3***

Abbas, H. (2011). Reforming Pakistan‘s police and law enforcement infrastructure. *US Institute of Peace, Washington, DC*.

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty*. Crown Books.

Ahmad, S., Ali, S., Mirza, M., & Lotia, H. (2017). The limits of water pricing in a developing country metropolis: Empirical lessons from an industrial city of Pakistan. *Water*, *9*(7), 533.

Anderies, J. M., Janssen, M. A., Bousquet, F., Cardenas, J.-C., Castillo, D., Lopez, M.-C., Tobias, R., Vollan, B., & Wutich, A. (2011). The challenge of understanding decisions in experimental studies of common pool resource governance. *Ecological Economics*, *70*(9), 1571–1579.

Anwar, A. (2019). The Role of Biraderies in the Politics of Faisalabad Division. *Pakistan Vision*, *20*(2), 11.

Arain, S. M., & Arain, A. M. (2016). *National Highways and Motorway Police in Pakistan: An Illuminative Study*. Lulu. com.

Araral, E. (2008). Public provision for urban water: Getting prices and governance right. *Governance*, *21*(4), 527–549.

Baland, J.-M., & Platteau, J.-P. (1996). *Halting degradation of natural resources: Is there a role for rural communities?* Food & Agriculture Org.

Balliet, D. (2010). Communication and cooperation in social dilemmas: A meta-analytic review. *Journal of Conflict Resolution*, *54*(1), 39–57.

Bouma, J., Bulte, E., & Van Soest, D. (2008). Trust and cooperation: Social capital and community resource management. Journal of Environmental Economics and Management, 56(2), 155–166.

Biswas, A. K., Saklani, U., & Tortajada, C. (2017). *Solution to Delhi's never-ending water problems*. India Water Review. https://www.google.com/search?q=Solution+to+Delhi%27s+never-ending+water+problems&rlz=1C1SQJL_enUS835US835&oq=Solution+to+Delhi%27s+never-ending+water+problems&aqs=chrome..69i57j69i60.267j0j7&sourceid=chrome&ie=UTF-8

Brozyna, C. (2019). *Three Experimental Examinations of Aspects of Institutions Governing Natural Resource* [PhD Thesis]. University of Rhode Island.

Bruggink, T. (1992). Privatization versus groundwater central management: Public policy choices to prevent a water crisis in the 1990s. *American Journal of Economics and Sociology*, *51*(2), 205–222.

Bruns, B. (2021). Polycentric solutions for groundwater governance in Sub-Saharan Africa: Encouraging institutional artisanship in an extended ladder of participation. *Water*, *13*(5), 630.

Camerer, C. F., & Hogarth, R. M. (1999). The effects of financial incentives in experiments: A review and capital-labor-production framework. *Journal of Risk and Uncertainty*, *19*(1), 7–42.

Curtis, A., Mitchell, M., & Mendham, E. (2016). Social science contributions to groundwater governance. In *Integrated Groundwater Management* (pp. 477–492). Springer, Cham.

Diamond, L. (2007). A quarter-century of promoting democracy. *Journal of Democracy*, *18*(4), 118–120.

Dietz, T., Ostrom, E., & Stern, P. C. (2003). The struggle to govern the commons. *Science, 302*(5652), 1907–1912.

DiJulio, B., Muñana, C., & Brodie, M. (2018). Views and Experiences of Puerto Ricans One Year After Hurricane Maria. *Henry J. Kaiser Family Foundation (2018/September). California, EE. UU. Recuperado de Http://Files. Kff. Org/Attachment/Report-Views-and-Experiences-of-Puerto-Ricans-One-Year-After-Hurricane-Maria Www. Scielo. Org. Co/Pdf/Apl/V32n1/V32n1a04. Pdf*.

Dipierri, A. A., & Zikos, D. (2020). The Role of Common-Pool Resources' Institutional Robustness in a Collective Action Dilemma under Environmental Variations. *Sustainability*, *12*(24), 10526.

Durlauf, S., & Blume, L. (2009). *Microeconometrics* (1st ed.). Palgrave Macmillan.

Durlauf, S. N. (2002). On the empirics of social capital. *The Economic Journal*, *112*(483), F459–F479.

El-Naqa, A., Al-Momani, M., Kilani, S., & Hammouri, N. (2007). Groundwater deterioration of shallow groundwater aquifers due to overexploitation in northeast Jordan. *CLEAN–Soil, Air, Water*, *35*(2), 156–166.

Elsawah, S., & Guillaume, J. H. (2016). Incorporating human aspects into groundwater research and policy making: A soft and critical systems thinking approach. In *Integrated Groundwater Management* (pp. 619–637). Springer, Cham.

Fehr, E., & Leibbrandt, A. (2011). A field study on cooperativeness and impatience in the tragedy of the commons. *Journal of Public Economics*, *95*(9–10), 1144–1155.

Ferlander, S. (2007). The importance of different forms of social capital for health. *Acta Sociologica*, *50*(2), 115–128.

Fischbacher, U., Gächter, S., & Fehr, E. (2001). Are people conditionally cooperative? Evidence from a public goods experiment. *Economics Letters*, *71*(3), 397–404.

Foster, E. T., Rapoport, A., & Dinar, A. (2018). Alternative policies for subsidizing groundwater extraction: A field study in Mexico. *Journal of Behavioral Economics for Policy*, *2*(2), 55–69.

Foster, S., & Garduño, H. (2013). Groundwater-resource governance: Are governments and stakeholders responding to the challenge? *Hydrogeology Journal*, *21*(2), 317–320.

Galizzi, M. M., & Navarro-Martinez, D. (2019). On the external validity of social preference games: A systematic lab-field study. *Management Science*, *65*(3), 976–1002.

Garduño, H., Foster, S., Raj, P., & van Steenbergen, F. (2009). Addressing groundwater depletion through community-based management actions in the weathered granitic basement aquifer of drought-prone Andhra Pradesh-India. *GW-MATE Case Profile Collection*, *19*.

Gazdar, H. (2009). Policy responses to economic inequality in Pakistan. *Policy Brief*, *3*.

Gehrig, S., Schlüter, A., & Hammerstein, P. (2019). Sociocultural heterogeneity in a common pool resource dilemma. *PloS One*, *14*(1), e0210561.

Gherghe, V. (2008). Formal and Informal Institutions in Groundwater Governance in Rajasthan. *QoG WORKING PAPER SERIES*, *2008*(1), 1.

Gleeson, T., Wada, Y., Bierkens, M. F., & Van Beek, L. P. (2012). Water balance of global aquifers revealed by groundwater footprint. *Nature*, *488*(7410), 197–200.

Goldbach, C. (2017). *Linking environmental change, preferences and migration in coastal areas of Ghana and Indonesia* [PhD Thesis]. IRC-Library, Information Resource Center der Jacobs University Bremen.

Gollier, C. (1999). *Time horizon and the discount rate*.

Grafton, R. Q. (2005). Social capital and fisheries governance. *Ocean & Coastal Management*, *48*(9–10), 753–766.

Guerrero, A. M., Mcallister, R. R., & Wilson, K. A. (2015). Achieving cross-scale collaboration for large scale conservation initiatives. *Conservation Letters*, *8*(2), 107–117.

Gunatilake, H. M., Wickramasinghe, W. A. R., & Abeygunawardena, P. (2009). *Time preference and natural resource use by local communities: The case of Sinharaja Forest in Sri Lanka*.

Guneau, S., & Tozzi, P. (2008). Towards the privatization of global forest governance? *International Forestry Review*, *10*(3), 550–562.

Haider, G. (2000). Proceedings of the International Conference on Regional Groundwater Management, *Pakistan Water Partnership*, Islamabad, Pakistan.

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*(3859), 1243–1248.

Harrison, G. W., & List, J. A. (2004). Field experiments. *Journal of Economic Literature*, *42*(4), 1009–1055.

Holmberg, S., & Rothstein, B. (2011). *Quality of Government and Access to safe Water*. The quality of government institute: University of Gothenburg.

Hossain, M. Z., Nikam, B. R., Srivastav, S. K., & Gupta, P. K. (2021). Estimating groundwater resource and understanding recharge processes in the rapidly urbanizing Dhaka City, Bangladesh. *Groundwater for Sustainable Development*, *12*, 100514.

House-Peters, L. A., & Chang, H. (2011). Urban water demand modeling: Review of concepts, methods, and organizing principles. *Water Resources Research*, *47*(5).

Jamal, S. (2019). *Situational Analysis of Water Resources in Faisalabad City: Establishing a Case for Water Stewardship*. World Wildlife Fund, Pakistan (WWF).

Janssen, M. A. (2015). A behavioral perspective on the governance of common resources. *Current Opinion in Environmental Sustainability*, *12*, 1–5.

Janssen, M., Tyson, M., & Lee, A. (2014). The effect of constrained communication and limited information in governing a common resource. *International Journal of the Commons*, *8*(2).

JICA. (2019a). *Main Report-The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad.* (p. 226). Japan International Cooperation Agency (JICA).

JICA. (2019b). *Part-B Water Supply: The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad.* (p. 226). Japan International Cooperation Agency (JICA).

Kemper, K. E. (2007). Instruments and institutions for groundwater management. *The Agricultural Groundwater Revolution: Opportunities and Threats to Development*, 153–172.

Khan, A. D., Naveed, I., Ashraf, M., & Sheikh, Ashfaq. A. (2016). *Groundwater Investigations and Mapping in the Upper Indus Plain*. Pakistan Council of Research in Water Resources (PCRWR).

Koop, S. H. A., Clevers, S. H. P., Blokker, E. J. M., & Brouwer, S. (2021). Public attitudes towards Digital Water Meters for households. *Sustainability*, *13*(11), 6440.

Magdalou, B., Dubois, D., & Nguyen-Van, P. (2009). *Risk and inequality aversion in social dilemmas*.

Mahmood, K., Rana, A. D., Tariq, S., Kanwal, S., Ali, R., & Haidar, A. (2011). Groundwater Levels Susceptibility to Degradation in Lahore Metropolitan. *Depression*, *150*, 8–01.

Malik, A. (2017). *Polycentricity, Islam, and Development: Potentials and Challenges in Pakistan*. Lexington Books.

Meinzen-Dick, R., Chaturvedi, R., Domènech, L., Ghate, R., Janssen, M. A., Rollins, N. D., & Sandeep, K. (2016). Games for groundwater governance: Field experiments in Andhra Pradesh, India. *Ecology and Society*, *21*(3).

Mitchell, M., Curtis, A., Sharp, E., & Mendham, E. (2011). Social research to improve groundwater governance: Literature review. *Institute for Land, Water and Society, Charles Stuart University: Albury, Australia*.

Molle, F., & Closas, A. (2017). *Groundwater governance: A synthesis [Groundwater governance in the Arab world: taking stock and addressing the challenges]*.

Molle, F., & Closas, A. (2020). Why is state-centered groundwater governance largely ineffective? A review. *Wiley Interdisciplinary Reviews: Water*, *7*(1), e1395.

Ostrom, E. (1965). Public entrepreneurship: A case study in ground water management. *Unpublished Dissertation, University of California at Los Angeles*.

Ostrom, E. (1999). Coping with tragedies of the commons. *Annual Review of Political Science*, *2*(1), 493–535.

Ostrom, E. (2000). Social capital: A fad or a fundamental concept. *Social Capital: A Multifaceted Perspective*, *172*(173), 195–198.

Ostrom, E. (2005). Understanding institutional diversity Princeton University press. *New Jersey*, 393–432.

Ostrom, E. (2012). Nested externalities and polycentric institutions: Must we wait for global solutions to climate change before taking actions at other scales? *Economic Theory*, *49*(2), 353–369. https://doi.org/10.1007/s00199-010-0558-6

Ostrom, Elinor. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press. http://catdir.loc.gov/catdir/toc/cam025/90001831.html

Ostrom, V., Tiebout, C. M., & Warren, R. (1961). The organization of government in metropolitan areas: A theoretical inquiry. *American Political Science Review*, *55*(4), 831–842.

Pahl-Wostl, C. (2003). The importance of the human dimension in integrated assessment models and processes: Actor based analysis and modeling approaches. *Proceedings of the Modelling and Simulation Society of Australia and New Zealand, MODSIM*, 465–472.

Pakistan Bureau of Statistics. (2017). *Provisional summary results of 6th population and housing census-2017*. Government of Pakistan.

Partelow, S., Abson, D., Schlüter, A., Fernández-Giménez, M., von Wehrden, H., & Collier, N. (2019). Privatizing the commons: New approaches need broader evaluative criteria for sustainability. *International Journal of the Commons*, *13*(1).

Pinkerton, E., & Davis, R. (2015). Neoliberalism and the politics of enclosure in North American small-scale fisheries. *Marine Policy*, *61*, 303–312.

Pretty, J. (2003). Social capital and the collective management of resources. *Science*, *302*(5652), 1912–1914.

Putnam, R. D. (2000). *Bowling alone: The collapse and revival of American community*. Simon and schuster.

Rand, D. G., & Kraft-Todd, G. T. (2014). Reflection does not undermine self-interested prosociality. *Frontiers in Behavioral Neuroscience*, *8*, 300.

Reynaud, A., & Couture, S. (2012). Stability of risk preference measures: Results from a field experiment on French farmers. *Theory and Decision*, *73*(2), 203–221.

Roberts, L., Lafta, R., Garfield, R., Khudhairi, J., & Burnham, G. (2004). Mortality before and after the 2003 invasion of Iraq: Cluster sample survey. *The Lancet*, *364*(9448), 1857–1864.

Ross, A., & Martinez-Santos, P. (2010). The challenge of groundwater governance: Case studies from Spain and Australia. *Regional Environmental Change*, *10*(4), 299–310.

Rothstein, B. (2005). *Social traps and the problem of trust*. Cambridge University Press.

Rothstein, B. (2013). Corruption and social trust: Why the fish rots from the head down. *Social Research*, *80*(4), 1009–1032.

Rothstein, B. O., & Teorell, J. A. (2008). What is quality of government? A theory of impartial government institutions. *Governance*, *21*(2), 165–190.

Rothstein, B., & Stolle, D. (2003). Social capital, impartiality and the welfare state: An institutional approach. In *Generating social capital* (pp. 191–209). Springer.

Sarker, A. (2013). The role of state-reinforced self-governance in averting the tragedy of the irrigation commons in Japan. *Public Administration*, *91*(3), 727–743.

Shakoor, A., Mahmood Khan, Z., Arshad, M., Farid, H. U., Sultan, M., Azmat, M., Shahid, M. A., & Hussain, Z. (2017). Regional groundwater quality management through hydrogeological modeling in LCC, West Faisalabad, Pakistan. *Journal of Chemistry*, *2017*.

Sobels, J., Curtis, A., & Lockie, S. (2001). The role of Landcare group networks in rural Australia: Exploring the contribution of social capital. *Journal of Rural Studies*, *17*(3), 265–276.

Stefánsson, H. O., & Bradley, R. (2019). What is risk aversion? *The British Journal for the Philosophy of Science*, *70*(1), 77–102.

Taher, T. M. (2016). Groundwater abstraction management in Sana'a Basin, Yemen: A local community approach. *Hydrogeology Journal*, *24*(6), 1593–1605.

Travers, H., Clements, T., Keane, A., & Milner-Gulland, E. J. (2011). Incentives for cooperation: The effects of institutional controls on common pool resource extraction in Cambodia. *Ecological Economics*, *71*, 151–161.

Van der Gun, J. (2012). *Groundwater and Global Change: Trends, Opportunities and Challenges (Vol. 1)*. Paris, France: UNESCO. Retrieved from https://www. un-igrac. org/resource ….

van Soest, D. P. (2013). Experiments on common property management. *Encyclopedia of Energy, Natural Resource and Environmental Economics*, 293–298.

WASA-F. (2020). *WASA Faisalabad: An Overview*. http://wasafaisalabad.gop.pk/

WWAP. (2012). *The United Nations World Water Development Report 4: Managing Water under Uncertainty and Risk*. UNESCO (World Water Assessment Programme).

Wyborn, C. (2015). Cross-scale linkages in connectivity conservation: Adaptive governance challenges in spatially distributed networks. *Environmental Policy and Governance*, *25*(1), 1–15.

Zuniga, T. A., & Nathaniel, D. (2017). Groundwater governance in the United States: A mosaic of approaches. In *Advances in groundwater governance* (pp. 483–509). CRC Press.

***Chapter 4***

Abbas, H. (2011). Reforming Pakistan's police and law enforcement infrastructure. *US Institute of Peace, Washington, DC*.

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty*. Crown Books.

Adams, E. A., Sambu, D., & Smiley, S. L. (2019). Urban water supply in Sub-Saharan Africa: Historical and emerging policies and institutional arrangements. *International Journal of Water Resources Development*, *35*(2), 240–263.

Adams, E. A., & Zulu, L. C. (2015). Participants or customers in water governance? Community-public partnerships for peri-urban water supply. *Geoforum*, *65*, 112–124.

Anwar, A. (2019). The Role of Biraderies in the Politics of Faisalabad Division. *Pakistan Vision*, *20*(2), 11.

Arain, S. M., & Arain, A. M. (2016). *National Highways and Motorway Police in Pakistan: An Illuminative Study*. Lulu. com.

Araral, E. (2008). Public provision for urban water: Getting prices and governance right. *Governance*, *21*(4), 527–549.

Arvonen, V., Kibocha, S. N., Katko, T. S., & Pietilä, P. (2017). Features of Water Cooperatives: A Comparative Study of Finland and Kenya. *Public Works Management & Policy*, *22*(4), 356–377.

Ashir, Z. (2019). *Karachi's water challenge*.

Bakker, K. (2003). *Good governance in restructuring water supply: A handbook*. Federation of Canadian Municipalities Ottawa, Canada.

Bakker, K. (2007). The "commons" versus the "commodity": Alter-globalization, anti-privatization and the human right to water in the global south. *Antipode*, *39*(3), 430–455.

Bakker, K. (2008). The ambiguity of community: Debating alternatives to private-sector provision of urban water supply. *Water Alternatives*, *1*(2), 236–252.

Bakker, K. (2010). *Privatizing water: Governance failure and the world's urban water crisis*. Cornell University Press.

Bakker, K., Kooy, M., Shofiani, N. E., & Martijn, E.-J. (2008). Governance failure: Rethinking the institutional dimensions of urban water supply to poor households. *World Development*, *36*(10), 1891–1915.

Bayliss, K. (2003). Utility privatisation in Sub-Saharan Africa: A case study of water. *The Journal of Modern African Studies*, *41*(4), 507–531.

Beard, V. A., & Mitlin, D. (2021). Water access in global South cities: The challenges of intermittency and affordability. *World Development*, *147*, 105625.

Bishop, M. R., & Kay, J. A. (1989). Privatization in the United Kingdom: Lessons from experience. *World Development*, *17*(5), 643–657.

Biswas, A. K., Saklani, U., & Tortajada, C. (2017). *Solution to Delhi's never-ending water problems*. India Water Review. https://www.google.com/search?q=Solution+to+Delhi%27s+never-ending+water+problems&rlz=1C1SQJL_enUS835US835&oq=Solution+to+Delhi%27s+never-ending+water+problems&aqs=chrome..69i57j69i60.267j0j7&sourceid=chrome&ie=UTF-8

Biswas, A. K., & Tortajada, C. (2010). Water supply of Phnom Penh: An example of good governance. *International Journal of Water Resources Development*, *26*(2), 157–172.

Bovaird, T. (2007). Beyond engagement and participation: User and community coproduction of public services. *Public Administration Review*, *67*(5), 846–860.

Braadbaart, O. (2002). Private versus public provision of water services: Does ownership matter for utility efficiency? *Journal of Water Supply: Research and Technology—AQUA*, *51*(7), 375–388.

Craig, & Kielburger, M. (2020). *Phnom Penh Water Supply Authority*. https://ppwsa.com.kh/en/index.php?page=newsdetail&id=20

Cross, P., & Morel, A. (2005). Pro-poor strategies for urban water supply and sanitation services delivery in Africa. *Water Science and Technology*, *51*(8), 51–57.

Cupit, G. (2000). When does justice require impartiality. *London: Political Studies Association-UK 50th Annual Conference, April*, 10–13.

Davis, J. (2004). Corruption in public service delivery: Experience from South Asia's water and sanitation sector. *World Development*, *32*(1), 53–71.

Day, S. J. (2009). Community-based water resources management. *Waterlines*, 47–62.

De Albuquerque, C., & Winkler, I. T. (2010). Neither Friend nor Foe: Why the Commercialization of Water and Sanitation Services is Not the Main Issue in Realization of Human Rights. *Brown J. World Aff.*, *17*, 167.

Diamond, L. (2007). A quarter-century of promoting democracy. *Journal of Democracy*, *18*(4), 118–120.

DiJulio, B., Muñana, C., & Brodie, M. (2018). Views and Experiences of Puerto Ricans One Year After Hurricane Maria. *Henry J. Kaiser Family Foundation*

*(2018/September). California, EE. UU. Recuperado de Http://Files. Kff. Org/Attachment/Report-Views-and-Experiences-of-Puerto-Ricans-One-Year-After-Hurricane-Maria Www. Scielo. Org. Co/Pdf/Apl/V32n1/V32n1a04. Pdf.*

Dilman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method*. NJ: Wiley.

Dore, M. H., Kushner, J., & Zumer, K. (2004). Privatization of water in the UK and France—What can we learn? *Utilities Policy*, *12*(1), 41–50.

Flint, S. S. (2011). Public Goods, Public Utilities, and the Public's Health. *Health & Social Work*, *36*(1), 75.

Foster, S., Hirata, R., Misra, S., & Garduno, H. (2010). *Urban groundwater use policy: Balancing the benefits and risks in developing nations*. The World Bank.

Franceys, R. (2003). *Tapping the market: The challenge of institutional reform in the urban water sector*. Palgrave Macmillan.

Gazdar, H., Masood, S. Q., & Naqvi, H. (2013). Bottom Up or Top Down? Exclusion and Citizenship in Pakistan. *International Household Survey Network*.

Hanemann, W. M. (2006). The economic conception of water. *Water Crisis: Myth or Reality*, *61*, 74–76.

Hoffman, S. D., & Duncan, G. J. (1988). Multinomial and conditional logit discrete-choice models in demography. *Demography*, *25*(3), 415–427.

Holmberg, S., & Rothstein, B. (2011). *Quality of Government and Access to safe Water*. THE QUALITY OF GOVERNMENT INSTITUTE: University of Gothenburg.

Hosking, S., Hosking, J., Preez, M. du, & Hosking, J. (2014). *A Choice Experiment Study of User Preferences for Levels of Water Service* (No. 2087/3/14). Water Research Commission.

IWH. (2008). *Sample size and power*. Institute for Work & Health, Toronto. https://www.iwh.on.ca/what-researchers-mean-by/sample-size-and-power

Javed, N., & Qureshi, N. N. (2019). City Profile: Faisalabad, Pakistan. *Environment and Urbanization ASIA*, *10*(2), 233–254.

Jenkins, M. (2017). The impact of corruption on access to safe water and sanitation for people living in poverty. *U4 Anti-Corruption Resource Centre. Chr. Michelsen Institute, Bergen, Norway.*, *24*.

Jensena, O., & Chindarkarb, N. (2017). *Why Don't People Pay Their Water Bills? Evidence of Values and Perceptions of Water Supply from Urban India*.

JICA. (2019a). *Main Report-The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad.* (p. 226). Japan International Cooperation Agency (JICA).

JICA. (2019b). *Part-B Water Supply: The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad.* (p. 226). Japan International Cooperation Agency (JICA).

Jiménez, A., Saikia, P., Giné, R., Avello, P., Leten, J., Liss Lymer, B., Schneider, K., & Ward, R. (2020). Unpacking Water Governance: A Framework for Practitioners. *Water*, *12*(3), 827.

Juuti, P. S., & Katko, T. S. (2005). *Water, time and European cities: History matters for the futures*. Tampere University Press.

Kenny, C. (2004). Corruption in water–a matter of life and death. *Global Corruption Report 2008*, *32*(1), 16.

Kessides, I. N. (2005). Infrastructure privatization and regulation: Promises and perils. *The World Bank Research Observer, 20*(1), 81–108.

Kjellén, M. (2000). Complementary water systems in Dar es Salaam, Tanzania: The case of water vending. *International Journal of Water Resources Development*, *16*(1), 143–154.

Kjellén, M. (2006). *From public pipes to private hands: Water access and distribution in Dar es Salaam, Tanzania* [PhD Thesis]. Acta Universitatis Stockholmiensis.

Kohl, B. (2004). Privatization Bolivian style: A cautionary tale. *International Journal of Urban and Regional Research*, *28*(4), 893–908.

Kooiman, J. (2003). *Governing as governance*. Sage.

Kopaskie, A. (2016). *Public vs private: A national overview of water systems*.

Kurer, O. (2005). Corruption: An alternative approach to its definition and measurement. *Political Studies*, *53*(1), 222–239.

Lichbach, M. I. (1997). Social theory and comparative politics. *Comparative Politics: Rationality, Culture, and Structure*, 239–276.

Lu, F., Ocampo-Raeder, C., & Crow, B. (2014). *Equitable water governance: Future directions in the understanding and analysis of water inequities in the global South*. Taylor & Francis.

MacPherson, I. (1995). *Co-operative Principles for the 21st Century* (Vol. 26). International Co-operative Alliance.

Malik, A. (2017). *Polycentricity, Islam, and Development: Potentials and Challenges in Pakistan*. Lexington Books.

Martin, N. (2004). Corporatization as a means of improving water quality: The experience in Victoria, Australia. *Journal of Toxicology and Environmental Health, Part A*, *67*(20–22), 1889–1899.

McDonald, D. A., & Ruiters, G. (2012). *Alternatives to privatization: Public options for essential services in the global South*. Routledge.

McFadden, D. (1973). *Conditional logit analysis of qualitative choice behavior*.

McGinnis, M. D. (1999). *Polycentric governance and development: Readings from the workshop in political theory and policy analysis*. University of Michigan Press.

McGinnis, M. D. (2011). An introduction to IAD and the language of the Ostrom workshop: A simple guide to a complex framework. *Policy Studies Journal*, *39*(1), 169–183.

McMullin, C. (2019). The who, what, how and why of co-production of public services. *Dr. Caitlin McMullin*. https://caitlinmcmullin.com/2019/03/28/the-who-what-how-and-why-of-co-production-of-public-services/

Meinzen-Dick, R. (2007). Beyond panaceas in water institutions. *Proceedings of the National Academy of Sciences*, *104*(39), 15200–15205.

Mitlin, D., Beard, V. A., Satterthwaite, D., & Du, J. (2019). *Unaffordable and undrinkable: Rethinking urban water access in the global south*.

Moretto, L., Faldi, G., Ranzato, M., Rosati, F. N., Ilito Boozi, J.-P., & Teller, J. (2018). Challenges of water and sanitation service co-production in the global South. *Environment and Urbanization*, *30*(2), 425–443.

Nabatchi, T., Sancino, A., & Sicilia, M. (2017). Varieties of participation in public services: The who, when, and what of coproduction. *Public Administration Review*, *77*(5), 766–776.

Nastiti, A., Meijerink, S. V., Oelmann, M., Smits, A. J. M., Muntalif, B. S., Sudradjat, A., & Roosmini, D. (2017). Cultivating innovation and equity in co-production of commercialized spring water in peri-urban Bandung, Indonesia. *Water Alternatives*, *10*(1), 160.

Newig, J., & Fritsch, O. (2009). Environmental governance: Participatory, multi-level– and effective? *Environmental Policy and Governance*, *19*(3), 197–214.

Oimoen, S. (2019). *Classical Designs: Full Factorial Designs*.

Ostrom, E. (1996). Crossing the great divide: Coproduction, synergy, and development. *World Development*, *24*(6), 1073–1087.

Ostrom, E. (2000). Social capital: A fad or a fundamental concept. *Social Capital: A Multifaceted Perspective*, *172*(173), 195–198.

Ostrom, E. (2005). Understanding institutional diversity Princeton University press. *New Jersey*, 393–432.

Ostrom, Elinor. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press. http://catdir.loc.gov/catdir/toc/cam025/90001831.html

Pakistan Bureau of Statistics. (2017). *PROVISIONAL SUMMARY RESULTS OF 6TH POPULATION AND HOUSING CENSUS-2017*. Government of Pakistan.

Parag, Y., & Roberts, J. T. (2009). A battle against the bottles: Building, claiming, and regaining tap-water trustworthiness. *Society and Natural Resources*, *22*(7), 625–636.

Parks, R. B., Baker, P. C., Kiser, L., Oakerson, R., Ostrom, E., Ostrom, V., Percy, S. L., Vandivort, M. B., Whitaker, G. P., & Wilson, R. (1981). Consumers as coproducers of public services: Some economic and institutional considerations. *Policy Studies Journal*, *9*(7), 1001–1011.

Plummer, J. (2008). Water and corruption: A destructive partnership. *Global Corruption Report 2008*.

Popovici, R., Mazer, K. E., Erwin, A. E., Ma, Z., Cáceres, J. P. P., Bowling, L. C., Bocardo-Delgado, E. F., & Prokopy, L. S. (2020). Coproduction Challenges in the Context of Changing Rural Livelihoods. *Journal of Contemporary Water Research & Education*, *171*(1), 111–126.

Povitkina, M., & Bolkvadze, K. (2019). Fresh pipes with dirty water: How quality of government shapes the provision of public goods in democracies. *European Journal of Political Research*, *58*(4), 1191–1212.

Prasad, N. (2006). Privatisation results: Private sector participation in water services after 15 years. *Development Policy Review*, *24*(6), 669–692.

Pretty, J. (2003). Social capital and the collective management of resources. *Science*, *302*(5652), 1912–1914.

Putnam, R. (1993). The prosperous community: Social capital and public life. *The American Prospect*, *13*(Spring), Vol. 4. Available online: http://www. prospect. org/print/vol/13 (accessed 7 April 2003).

Renzetti, S., & Dupont, D. (2004). The performance of municipal water utilities: Evidence on the role of ownership. *Journal of Toxicology and Environmental Health, Part A*, *67*(20–22), 1861–1878.

Roberts, L., Lafta, R., Garfield, R., Khudhairi, J., & Burnham, G. (2004). Mortality before and after the 2003 invasion of Iraq: Cluster sample survey. *The Lancet*, *364*(9448), 1857–1864.

Rothstein, B. (2005). *Social traps and the problem of trust*. Cambridge University Press.

Rothstein, B. (2011). *The quality of government: Corruption, social trust, and inequality in international perspective*. University of Chicago Press.

Rothstein, B. O., & Teorell, J. A. (2008). What is quality of government? A theory of impartial government institutions. *Governance*, *21*(2), 165–190.

Rothstein, B., & Stolle, D. (2003). Social capital, impartiality and the welfare state: An institutional approach. In *Generating social capital* (pp. 191–209). Springer.

Rothstein, B., & Varraich, A. (2017). *Making sense of corruption*. Cambridge University Press.

Rusca, M., Schwartz, K., Hadzovic, L., & Ahlers, R. (2015). Adapting generic models through bricolage: Elite capture of water users associations in peri-urban Lilongwe. *The European Journal of Development Research*, *27*(5), 777–792.

Schiemann, J. W. (2000). Meeting halfway between Rochester and Frankfurt: Generative salience, focal points, and strategic interaction. *American Journal of Political Science*, 1–16.

Shirley, M., & Ménard, C. (2002). Cities awash: A synthesis of the country cases. *Thirsting for Efficiency: The Economics and Politics of Urban Water System Reform*, 1–42.

Steen, T., Brandsen, T., & Verschuere, B. (2018). The dark side of co-creation and co-production: Seven evils. In *Co-production and co-Creation* (pp. 284–293). Routledge.

Swyngedouw, E., Kaika, M., & Castro, E. (2002). Urban water: A political-ecology perspective. *Built Environment*, *28*(2), 124–137.

Tantoh, H. B., Simatele, D. M., Ebhuoma, E., Donkor, K., & McKay, T. J. (2019). Towards a pro-community-based water resource management system in Northwest Cameroon: Practical evidence and lessons of best practices. *GeoJournal*, 1–19.

Tortajada, C., & Biswas, A. K. (2019). *Objective case studies of successful urban water management*. Taylor & Francis.

Transparency International. (2008). *Global Corruption Report 2008: Corruption in the water sector*. Cambridge University Press.

UN-Water. (2009). Water in a changing world. *UNESCO Publications, The United United Nations World Water Development Report 3*.

Van Doorn, R., Ahya, I., Dwi, A. C. D. R., & Shen, Y. P. (2020). Indonesia-Public Expenditure Review: Spending for Better Results. *World Bank Group, Washington, DC*.

van Soest, D. P. (2013). Experiments on common property management. *Encyclopedia of Energy, Natural Resource and Environmental Economics*, 293–298.

WASA-F. (2015). *Integrated Development & Asset Management Plan-Volume 1*. The Urban Unit, Punjab, PK. https://pcgip.urbanunit.gov.pk/docs/DLIs/DLI1/IDAMP%20WASA%20Fsb.pdf

WASA-F. (2017). *Water and Sanitation agency of Faisalabad's IT Database*.

WASA-F. (2020). *WASA Faisalabad: An Overview*. http://wasafaisalabad.gop.pk/

WHO/UNICEF. (2015). *Progress on sanitation and drinking water: 2015 update and MDG assessment*. World Health Organization.

WWAP. (2003). *Water for People, Water for Life: The United Nations World Water Development Report*. UNESCO (World Water Assessment Programme).

WWAP. (2012). *The United Nations World Water Development Report 4: Managing Water under Uncertainty and Risk*. UNESCO (World Water Assessment Programme).

Zaidi, S. A. (2016). Transforming Urban Settlements, The Orangi Pilot Project's Low-Cost Sanitation Model. *Pakistan Journal of Applied Social Sciences*, *3*.

Zarei, Z., Karami, E., & Keshavarz, M. (2020). Co-production of knowledge and adaptation to water scarcity in developing countries. *Journal of Environmental Management*, *262*, 110283.

# APPENDIX

## *Appendix-I: Expert Interviews*

### Water Agency

1. What is the current biophysical condition of groundwater in the city?
2. What steps have you been taking to protect the city's groundwater?
3. Can you give a brief overview of legal and institutional arrangements governing the city's groundwater?
4. How would you describe the relationship between groundwater and the local community?
5. Do you think WASA's current water tariff system that does not cover water production expenses needs to be reformed?
6. Why the WASA's water bill collection rate is low?
7. Does WASA face obstacles or pressure from politicians or other powerful coalitions in the city while implementing its laws?
8. Do you think poor quality service and preferential treatment of some water users have created a lack of trust between WASA and the public?
9. Is WASA planning to reform its water supply service beyond its plans to expand infrastructure?
10. Would you collaborate with the local community for the betterment of the water supply service?

### Local academics

1. Which ethnic, religious, and caste groups in Faisalabad city are most influential (i.e., economically, culturally, or in self-governance)?
2. How big of a role local powerful coalitions and groups play in the provision of piped

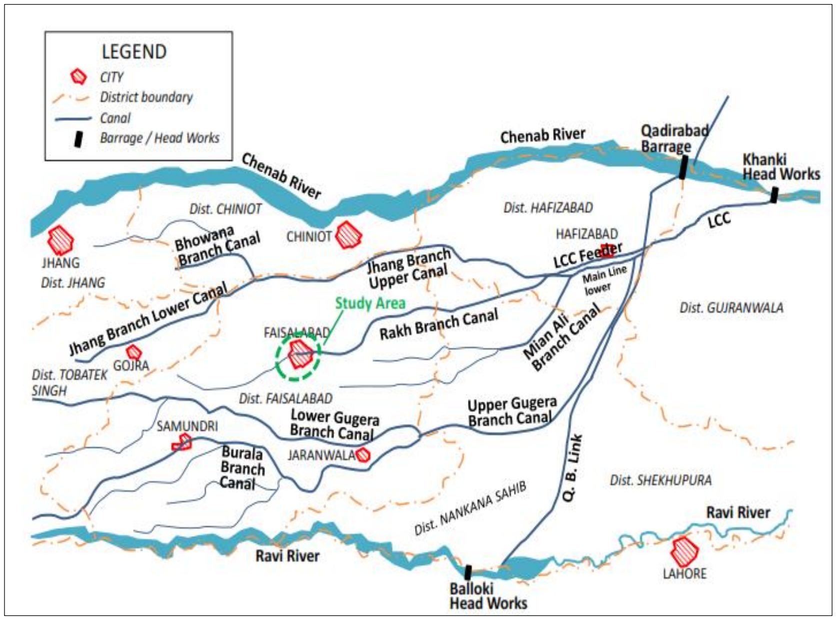
water and the performance of the water supply system in a particular neighborhood?

3. What can you tell me about the prevalence of norms like 'inter-personal trust' and 'reciprocity' in the local populous?
4. What is the impact of Faisalabad's peculiar history, customs, and culture on its present economic condition?
5. What governance problems WASA is facing, and how those challenges can be tackled?
6. Can you imagine a way in which the local community productively collaborate with the WASA?

**NGO**

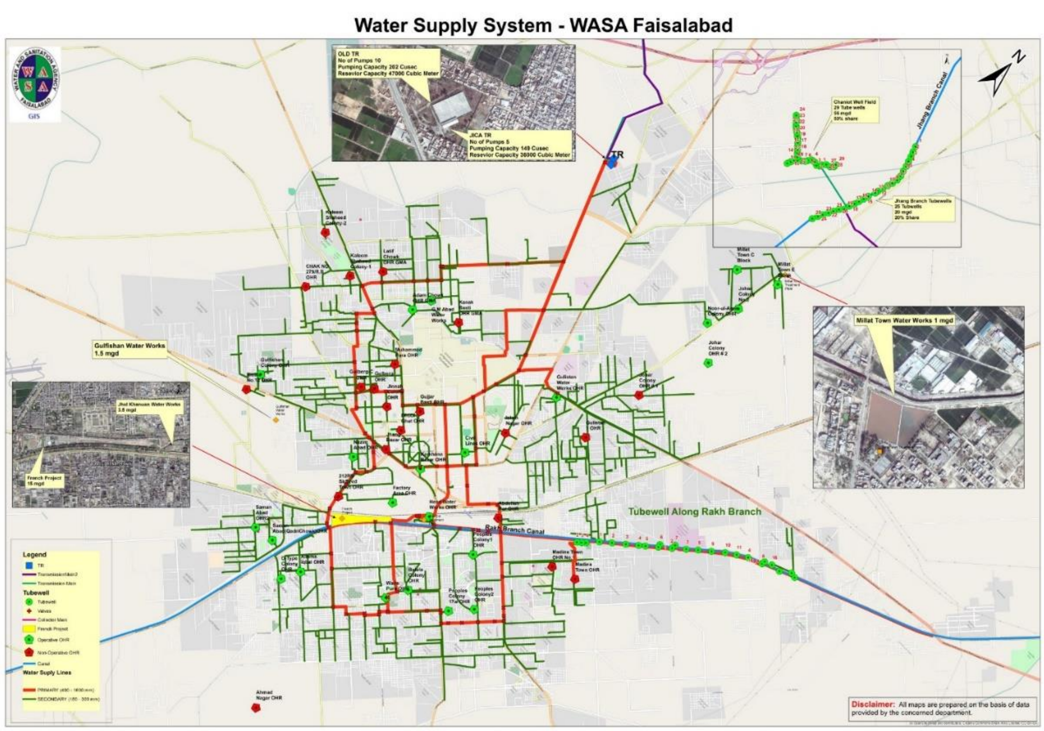
1. Kindly tell me about the efforts your NGO is making for the provision of water to the people?
2. Please tell me about the work your organization is doing on groundwater issues in the city.
3. Does WASA have any official mechanism to involve NGOs for the betterment of water supply service?
4. How would you rate the WASA's performance on water supply?
5. What efforts can WASA make in your opinion to improve its service?
6. Do you think there is a potential for WASA and community collaboration for water provision in the future?

*Appendix-II: Network of Irrigation Canals*




Network of irrigation canals in the Rachna Doab
Source: JICA, 2019b

*Appendix-III: Piped water supply network*




*Source: Water & Sanitation Agency, Faisalabad*

*Appendix-IV: CPR Experiment*

**I want to play a quick game with you that will take up to 7 minutes in total. You can earn up to 40 PKR at the end of the game. The exact amount of money you will earn depends on your own decisions and the decision of others participating in the game. Therefore, please consider your decisions carefully. Please let me know if you have any question before we start the game.**

**Decision problem:**

You are in a group with 3 other people, a total 4 members in the group. You do not know their identity, and they do not know yours. Now, please imagine that the groundwater reservoir underneath your community contains 40 gallons of water. **You can extract up to 10 gallons of groundwater.** Every gallon you do not extract will stay in the reservoir. The other three members of your group will make the same decision.
Please note you can extract water only once!

After your decision we will estimate how much money you have earned. Your earnings are composed of two elements:

**Private earnings:** You will earn 2 PKR by selling 1 gallon of groundwater. No one except you earns from the groundwater you extract from the aquifer. If you extract, for example, 5 gallons, you will get 10 PKR. If you decide to extract 10 gallons, you will get 20 PKR.

**Group earnings:** Every gallon left in the reservoir by any member of your group is worth 4 PKR, you will share this amount equally with 3 other group members. For example: If 10 gallons are left in the reservoir, your group earns 40 PKR. This amount will be divided into four, which means you will get 10 PKR on top of your private earning.

**Note:** *The amount of water extracted by the group members of first three respondents will be randomly determined based on prior data collected from real people. The amount of water extract by the group members of respondent number four and beyond will be collected from prior three interviews.*

Now I want to ask two short questions which do not affect your earnings:

I. Does the money you earn depend on the decisions of your group members?
   - No
   - Yes

-> The right answer is yes: The more groundwater your group members leave in the reservoir, the more money group earns, and the higher is the amount of money you get. This also means: The more groundwater your group members extract from the aquifer lower the group earnings will get.

II. Now please tell:
   - What will be your total private earning if you take “10” gallons of water?

   - What will be your total earnings if you and others leave their “10” gallons of water in the ground?

Comment: *As you can see, you can earn more you if you cooperate with other group members. However, in real life you do not know if others will cooperate with you.*

1) How many gallons of water you want to take out of the groundwater reservoir?

*Note: You can take any number of gallons from 0 to 10.*

**Payment Calculation**

Number of gallons respondent extracted:__________
Number of gallons group member 1 extracted:_________
Number of gallons group member 2 extracted:_________
Number of gallons group member 3 extracted:_________
Number of gallons left in the reservoir:_____________

Private earnings:_________PKR
Group earnings:_________PKR
Total earnings:_________PKR

*Appendix-V: Household Survey*

## Urban Household Interview to Understand the Groundwater and Piped Water Use behavior in Faisalabad, Pakistan

---

Date: __/__/____ Name of the Interviewer: __________________

### Socio-Economic Information

Are you a household head?

- Yes
- No

*If no, interview will not commence.*

**Respondent's Personal information**

2) Name: ___________________

3) Gender:
    - Male
    - Female

4) Age: ____ (year of birth)

5) Religion:
    - Islam
    - Christianity
    - None of the above

6) Political party (voted for in the last provincial elections):
    - PML-N
    - PML-Q/ Tahreek-Insaaf
    - PPP
    - None of the above

7) Level of education:
   - No education
   - Up to primary school (≤ 5th grade)
   - Up to secondary school (≤ 10th grade)
   - Up to high school (≤ 12th grade)
   - Undergraduate level
   - Graduate level
   - Prefer not to say

8) Average monthly household income (in PKR):
   - ≤ 20,000
   - 20,001-40,000
   - 40,001-60,000
   - 60,001-80,000
   - > 80,000
   - Prefer not to say

**Household Information**

9) How many people are in your household? ________

10) How many people 18 years and older live in your household? _______

11) How many people < 18 years old live in your households? _______

12) Ownership status of the house:
    - Owned
    - Rented
    - Other_________
    - Prefer not to say

13) Name of the community/neighborhood where the house is located: __________________________________________

14) GPS location of the household: __________

15) How long have you lived at the current location?
    - _____________years
    - prefer not to say

**General Water-Use Practices**

16) Do you have a municipal water connection in your home?
- Yes
- No

17) How much do you pay for the piped water monthly (in PKR)?
- 83
- 124
- 145
- 242
- 322
- 644
- 966
- Other________
- I do not know

18) If yes, for how many hours a day do you get water?
- _______hours
- I do not know

19) Is the quantity of municipal water enough to fulfill your daily water needs?
- Yes
- No
- I do not know

20) If the answer to questions 16 and 17 is 'No', which source among the following do you use to fulfill your 'full' or 'remaining' daily water needs?
- Groundwater Pump
- Tanker Water
- Other, please specify_______________

**If you are using a groundwater pump, then please answer the following questions:**

21) What type of groundwater pump do you use?
- Manual
- Motorized

22) If you are using a motorized pump, what is its power?
- _______________Horse-Power (HP).
- I do not know

23) For how long a day do you use your motorized groundwater pump?

- ____________min
- I do not know

24) What is your total monthly expense, including the electricity bill (if applicable) for groundwater pumping?
    - _____________PKR
    - I do not know

**If you are using tanker water, then please answer the following questions:**

25) How much tanker water do you use daily?
    - ________liters
    - I do not know

26) What is your total monthly expense for tanker water?
    - _________PKR
    - I do not know

**If you are using a source other than groundwater pump or tanker water, please answer the following questions:**

27) How much water from this source do you use daily?
    - _________liters
    - I do not know

28) What is your total monthly expense for this source of water?
    - __________PKR
    - I do not know

**Storage Tanks**

29) Do you have a water storage tank?
    - Yes
    - No

30) If yes, what is its size?
    - ________gallons
    - I do not know

31) How many tanks of water are filled by the piped water?
    - _________tanks
    - I do not know

32) How many tanks of water are filled from groundwater?

- ___________tanks
- I do not know

33) How many tanks of water are filled from tanker water?

- __________tanks
- I do not know

34) How many tanks of water are filled from other sources of water?

- ________tanks
- I do not know

## Positional Good

35) All else equal, which community between the two presented below would you prefer to live in:

a) Community A: ☐

- Municipal water supply will be interrupted to your house for 5 days a month
- To the rest of the community, municipal water will be interrupted for only 3 days a month

b) Community B: ☐

- Municipal water supply will be interrupted to your house for 7 days a month
- To the rest of the community, municipal water will be interrupted for 9 days a month

Now, please see if you consider community 'C' to the make water supply service equal/similar for everyone?

36) Community C: ☐

- Municipal water supply will be interrupted to your house for 6 days a month
- To every other house in the community, water will be interrupted for 6 days a month as well

37) Kindly state if you agree or disagree with the following statements:

| **Questions** | **Disagree** | **Do not know** | **Agree** |
|---|---|---|---|
| a) Everyone should have free access to water. | 1 | 2 | 3 |
| b) Everyone should pay for water. | 1 | 2 | 3 |

| | | | |
|---|---|---|---|
| c) There is enough water for everyone. | 1 | 2 | 3 |
| d) We will eventually run out of water. | 1 | 2 | 3 |

## **Preference of water provision mode**

38) Would you prefer a reasonably improved piped water supply?
- Yes
- No
- I do not know

Assuming you have selected 'Yes', I would like to ask you the following questions:

39) Following are the available options for piped water supply ownership. Which one would you select?
- Private company
- Municipal/State
- Membership Organization (co-op)
- None

a) Which ownership enlisted above would you prefer the most? ____________

b) Which ownership enlisted above would you prefer the least? ______________

40) Please select an alternative for water provision from the five choices presented below, keeping in mind its attributes "Non-preferential Treatment" and "Community Involvement":

| **Attributes** | **Alternative-1** | **Alternative-2** | **Alternative-3** | **Alternative-4** | **Alternative-5** |
|---|---|---|---|---|---|
| Non-Preferential Treatment | Yes | Yes | No | No | None ☐ |
| Community Involvement | Yes | No | Yes | No | |
| *a) Which alternative do you prefer the most?* | ☐ | ☐ | ☐ | ☐ | |
| *b) Which alternative do you prefer the least?* | ☐ | ☐ | ☐ | ☐ | |

41) Please state which attribute among the following is the most important for you in any water supply service?
- Ownership

- Non-Preferential Treatment
- Community Involvement
- None

42) Please state which attribute among the following is the least important for you in any water supply service?
  - Ownership
  - Non-Preferential Treatment
  - Community Involvement
  - None

43) In the light of what you have answered in questions 37, 38 and 39, do you still stand by your selection of the ownership type for the water provision service?
  - Yes
  - No
  - I do not know

a) If no, which type of ownership do you prefer the most now? ___________

b) Which kind of ownership do you prefer the least now? __________

## Corruption

44) Which alternative presented in Q.39 would you expect to be most corrupt? _________

45) Which alternative presented in Q.39 would you expect to be least corrupt? _________

46) Which type of water service ownership do you find the most corrupt? __________
47) Which type of water service ownership do you find the least corrupt? __________

48) Kindly respond 'Yes', 'No' or 'Do not know' to the following questions:

| **Questions** | **Scale** | | |
|---|---|---|---|
| a) Does WASA treat everyone equally? | No | Do not know | Yes |
| b) Do you think corruption exists within WASA? | No | Do not know | Yes |
| c) Do you think water users bribe WASA officials? | No | Do not know | Yes |
| d) Do WASA officials ask for bribes? | No | Do not know | Yes |

## Individual Attitudes - Risk and Time Preferences

**In this section, I intend to find out your risk and time preferences.**

49) Kindly state if you agree or disagree, on a scale from 1-5, with the following statements.

| Questions | Strongly Disagree | Disagree | Neither Agree, nor Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| a) I am a patient person. | 1 | 2 | 3 | 4 | 5 |
| b) In general, I am willing to take risks. | 1 | 2 | 3 | 4 | 5 |
| c) I am willing to take risks in financial matters. | 1 | 2 | 3 | 4 | 5 |
| d) I am willing to take health risks in everyday life (e.g., not wearing a helmet on motorcycle rides). | 1 | 2 | 3 | 4 | 5 |

50) Think about the period of time you have lived in this community, state if you have ever experienced one of the following events?

| Questions | Never | Rarely | Often |
|---|---|---|---|
| a) Lowering of groundwater table | 1 | 2 | 3 |
| b) Salty groundwater | 1 | 2 | 3 |
| c) Reduction in the piped water availability | 1 | 2 | 3 |
| d) Polluted piped water | 1 | 2 | 3 |

51) If you have selected options 'rarely' or 'often' in the above question, please state how much it affected your daily life?
Please rate the effect on your life on a scale from 1-5. One represents weakest affect and five represent strongest affect.

| Questions | Weakest Affect | | No Affect | | Strongest Affect |
|---|---|---|---|---|---|
| a) Lowering of groundwater table | 1 | 2 | 3 | 4 | 5 |
| b) Salty groundwater | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| c) Reduction in the piped water availability | 1 | 2 | 3 | 4 | 5 |
| d) Polluted piped water | 1 | 2 | 3 | 4 | 5 |

52) If you think about the next 5 years: how likely is it that you will be affected by these events? How high is the risk? Rate each event on a scale from 1 to 3.

| Questions | Least risk | Same risk | Highest risk |
|---|---|---|---|
| a) Lowering of groundwater table | 1 | 2 | 3 |
| b) Salty groundwater | 1 | 2 | 3 |
| c) Reduction in the piped water availability | 1 | 2 | 3 |
| d) Polluted piped water | 1 | 2 | 3 |

53) How would you rate your water related risks compared with an average person in your community/city? Rate each event on a scale from 1 to 3.

| Questions | Lower | Same | Higher |
|---|---|---|---|
| a) Lowering of groundwater table | 1 | 2 | 3 |
| b) Salty groundwater | 1 | 2 | 3 |
| c) Reduction in the piped water availability | 1 | 2 | 3 |
| d) Polluted piped water | 1 | 2 | 3 |

## Individual Attitudes - Trust

54) Please respond to the following questions according to the scale provided next to each question.

| Questions | Scale | | |
|---|---|---|---|
| a) Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people? | Can't be too careful | Neither trusted nor distrusted | Trusted |
| b) Do you think most people would try to take advantage of you if they got the chance or would they try to be fair? | Exploit | Neither fair, nor exploit | Fair |

| c) Would you say that most of the time people try to be helpful, or they are mostly just looking out for themselves? | Helpful | Neither helpful, nor selfish | Selfish |
|---|---|---|---|

*Appendix-II: Data Structure*

Data structure of the conditional logit model

| id | Alternatives | Municipal | Co-op | Private | Impartiality | Coproduction | Choice |
|---|---|---|---|---|---|---|---|
| 1 | Alternative-1 | 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | Alternative-2 | 1 | 0 | 0 | 1 | 0 | 1 |
| 1 | Alternative-3 | 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | Alternative-4 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | Alternative-5 | 0 | 1 | 0 | 1 | 1 | 0 |
| 1 | Alternative-6 | 0 | 1 | 0 | 1 | 0 | 0 |
| 1 | Alternative-7 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | Alternative-8 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1 | Alternative-9 | 0 | 0 | 1 | 1 | 1 | 0 |
| 1 | Alternative-10 | 0 | 0 | 1 | 1 | 0 | 0 |
| 1 | Alternative-11 | 0 | 0 | 1 | 0 | 1 | 0 |
| 1 | Alternative-12 | 0 | 0 | 1 | 0 | 0 | 0 |
| 2 | Alternative-1 | 1 | 0 | 0 | 1 | 1 | 0 |
| 2 | Alternative-2 | 1 | 0 | 0 | 1 | 0 | 1 |
| 2 | Alternative-3 | 1 | 0 | 0 | 0 | 1 | 0 |
| 2 | Alternative-4 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | Alternative-5 | 0 | 1 | 0 | 1 | 1 | 0 |
| 2 | Alternative-6 | 0 | 1 | 0 | 1 | 0 | 0 |
| 2 | Alternative-7 | 0 | 1 | 0 | 0 | 1 | 0 |
| 2 | Alternative-8 | 0 | 1 | 0 | 0 | 0 | 0 |
| 2 | Alternative-9 | 0 | 0 | 1 | 1 | 1 | 0 |
| 2 | Alternative-10 | 0 | 0 | 1 | 1 | 0 | 0 |
| 2 | Alternative-11 | 0 | 0 | 1 | 0 | 1 | 0 |
| 2 | Alternative-12 | 0 | 0 | 1 | 0 | 0 | 0 |

# CURRICULUM VITA

NAME: Shahbaz Altaf

ADDRESS: Department of Urban and Public Affairs
426 W Bloom St
University of Louisville
Louisville, KY 40208

DOB: Faisalabad, Pakistan - August 03, 1988

EDUCATION
& TRAINING:

B.Sc., City and Regional Planning
University of Engineering and Technology, Lahore, Pakistan
2007-2011

M.Sc., Transportation Sciences
University of Hasselt, Belgium
2015-2017

Ph.D., Urban and Public Affairs
University of Louisville, Kentucky
2017-2021

PUBLICATIONS:

Adnan, M., **Altaf, S**., Bellemans, T., Yasar, A. Shakshuki, E. (2018). Last mile travel and bicycle sharing system in small/medium sized cities: user's preferences investigation using hybrid choice model. *Journal of Ambient Intelligence and Humanized Computing, 10, 4721–4731 (2019).* doi: 10.1007/s12652-018-0849-5

Jamshed, A., Altaf, S., Javed, S., Ali, A. (2018). Evaluating the Environmental Impact Assessment of Road Rehabilitation Projects: Comparative Study of Pakistan and Vietnam. Journal of Science, Technology and Development, 37(3):122-130. doi:10.3923/std.2018.122.130

Hameed, R., Nadeem, O., Altaf. S., Ameen, F. (2014). Improving the Energy Efficiency of Existing Commercial Buildings in Lahore through Retrofitting Technique. Journal of Faculty of Engineering & Technology 21(2) 95-104.
Available at http://111.68.103.26/journals/index.php/jfet/article/view/401

INVITED PRESENTATIONS:

**Altaf, S**. Exploring Urban Water Issues of Faisalabad, Pakistan. *DOPE 2020: Dimensions of Political Ecology, Lexington, KY.*

Ingvardson, J.B., Nielsen, O.A., **Altaf, S**. Analyzing the influence of station characteristics and perceived safety on public transport ridership: A case study from the Greater Copenhagen Area. *CASPT 2018: 14th International Conference on Advanced Systems in Public Transport, Brisbane, Australia.*